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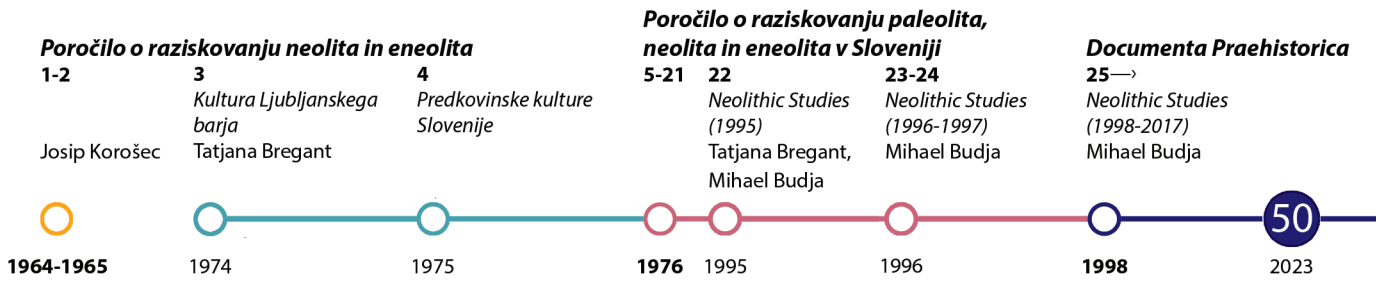
50th *Documenta Praehistorica:* a few notes

On the occasion of the publication of the fiftieth volume of the journal, it is a privilege to contemplate its development. Three events have been of decisive importance over the decades. The first was the founding of the journal by Professor Josip Korošec. The second event was a system of stable funding introduced by Professor Tatjana Bregant, who became editor of the journal after Professor Korošec's passing. The third represents the editorial concept, with which the journal was embedded in an international scientific research environment, and the programme, in which the journal presents and discusses interdisciplinary research approaches and relevant explanations of prehistory worldwide.

The journal was first published in 1964. The first two volumes were published by the Department of Archaeology of the Faculty of Arts of the University of Ljubljana. The first editor was Professor Josip Korošec. The journal focused on presenting the results of the first five-year research programme of the Department of Archaeology on the Neolithic and Eneolithic sites in Ljubljana marshes. It was no coincidence that the journal was titled *Report on Neolithic and Eneolithic Research*. A new editor, Professor Tatjana Bregant, added the subtitle *Culture of the Ljubljana Marshes* to the third volume. With the new excavations and research, the content expanded and the editors changed the subtitle of the fourth volume and the title of the fifth volume again. The journal thus became *Report on Palaeolithic, Neolithic and Eneolithic Research in Slovenia* (1976) with the subtitle *Pre-Metal Cultures in Slovenia*. Under this title the journal published for the first time interdisciplinary palaeoenviromental studies and modern ^{14}C calendar chronologies.

The 22nd volume was published bilingually in 1995 with the subtitle *Neolithic Studies* until 2017. Professor Mihael Budja became the editor and connected the journal with the Neolithic Seminars, international scientific conferences organized annually at the Department of Archaeology. Selected papers were published in the journal in Slovenian and English. The journal thus transcended the national framework and became part of the international scientific milieu. With the 25th volume in 1998, the journal was renamed *Documenta Praehistorica* and printed only in English with Slovenian abstracts. It was co-financed by the Ministry of Culture (until 2001) and the Ministry of Science and Technology of the Republic of Slovenia, and edited and published by the Department of Archaeology and the Ljubljana University Press, Faculty of Arts (*i.e.* Znanstvena založba Filozofske fakultete), and in recent years by Ljubljana University Press. It is a Diamond Open Access journal, publishing one volume per year. The journal maintains presentations, discussions and analyses of modern interdisciplinary approaches focusing on paleoclimate dynamics, archaeogenetics, paleodemography, archaeometry, biochemistry, ^{14}C modelling, social and cultural processes in prehistory.

Mihael Budja



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Understanding the local dynamics: reconstructing the direction and estimating the local speed of Neolithic expansion in the Central Balkans

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ABSTRACT – *This study addresses the dynamics of the Neolithic expansion in the Central Balkans by reconstructing its direction and speed of spread. The Inverse Distance Weighting (IDW) method is applied to the earliest radiocarbon dates from Starčevo culture sites in Serbia. Local speed estimates are derived from the earliest dates within specified spatial bins. The results confirm the assumed south-to-north direction, revealing rapid progression, particularly in the southernmost region. The possibility of pioneering scouting groups was also discussed. The results confirm the arrhythmicity of the Neolithization processes and higher local spread rates while offering new insights into Starčevo culture mobility.*

KEY WORDS – *Starčevo culture; Early Neolithic; direction of the spread; local speeds; Inverse Distance Weighting method*

Razumevanje lokalnih dinamik: rekonstrukcija smeri in ocena lokalne hitrosti neolitske ekspanzije na osrednjem Balkanu

IZVLEČEK – *V študiji obravnavamo dinamiko neolitske ekspanzije na osrednjem Balkanu in rekonstruiramo njene smeri in hitrosti širjenja. Uporabili smo metodo inverznega uteževanja razdalje (IDW) pri najzgodnejših radiokarbonskih datumih z najdišč kulture Starčevo v Srbiji. Ocena hitrosti na lokalni ravni temelji na najzgodnejših datumih znotraj določenih prostorskih enot. Rezultati potrjujejo domnevno smer od juga proti severu in razkrivajo hitro napredovanje, zlasti v najjužnejši regiji. Ocenjujemo tudi možnost začetniških izvidniških skupin. Rezultati potrjujejo neenakomernost procesov neolitizacije in velike hitrosti lokalne širitve in tako ponujajo nov vpogled na mobilnost kulture Starčevo.*

KLJUČNE BESEDE – *kultura Starčevo; zgodnji neolitik, smer širitve; lokalne hitrosti; metoda inverznega uteževanja razdalje*

Introduction

The spread of the Neolithic into Europe: models and dynamics

After arriving in the territory of Greece from southwestern Asia in the 7th millennium BC (*Perlés* et al. *2013*; *Özdoğan 2014*), the first Neolithic farmers spread to other parts of Europe following two routes. The maritime Mediterranean route led from Greece to the eastern and western Adriatic coasts, southern France, and the Iberian Peninsula. The continental route led from Greece through the Balkans to central, western, and eastern Europe. This process lasted about 3000 years (the Neolithic appeared at the latest in northwestern Europe, a little after 4000 BC) (*Price 2000*; *Bocquet-Appel* et al. *2009*). In addition to different routes, some studies clearly define different phases of Neolithic expansion from Anatolia, mostly

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based on differences in the summed probability distributions of radiocarbon dates from central Anatolia and other regions to which the Neolithic later spread (*Brami, Zanotti 2015*). According to these authors, the first phase implied the appearance of the Neolithic in central Anatolia, where it remained 'localized' for about 2000 years, after which it spread to the area of southwestern Anatolia and the Aegean basin. Around 6600–6500 BC, the Neolithic also appeared in Thessaly and Greek Macedonia, from where it spread further north. After that, around 6000 BC, the Neolithic reached the area of Eastern Thrace, from where it spread arrhythmically (*Brami, Zanotti 2015*).

Regarding the processes involving the establishment and subsequent expansion of the Neolithic, models explaining them can be built based upon either demic diffusion or cultural diffusion (or, sometimes, their combination) as the primary drivers of the phenomenon. Demic diffusion implies the expansion of populations (and changes in their size), inhabiting new areas and bringing their way of life, while cultural diffusion implies the transfer of ideas and knowledge (related to new technologies, agriculture, animal husbandry, *etc.*) to indigenous hunter-gatherer communities. When it comes to demographic models of population expansion, the following can be distinguished: the wave of advance model, the so-called leap-frog (or selective) colonization, elite dominance, infiltration, and individual border mobility, to name just some of them (*Ammerman, Cavalli-Sforza 1973; 1984*; *Renfrew 1987*; *Tringham 2000; Whittle* et al. *2002; Richards 2003; Bar-Yosef 2004*; *Pinhasi* et al. *2005*; *Davison* et al. *2007*; *Bocquet-Appel* et al. *2009; Borić, Price 2013*).

The wave of advance model (hereafter WoA) was proposed with the aim of explaining the spread of the Neolithic from the southwestern Asia to Europe and its further progress, and soon after it was first proposed it became the basis for much of the subsequent research and interpretation of the Neolithization processes. The model is an upgrade of the hypothesis proposed by Grahame Clark (*1965*) regarding the spread of the Neolithic from southwestern Asia. This hypothesis, which was based on the map of radiocarbon dates available at that time, suggests that the Neolithic first arrived in Greece and then expanded to the Balkans, eventually spreading further into Europe. The authors who defined the WoA model, archaeologist Albert Ammerman and geneticist Luigi Cavalli-Sforza (*1971; 1973*), managed to record regularities in the occurrence of radiocarbon dates, which indicated the gradual spread of the Neolithic through Europe. This observed process was explained to be a consequence of colonization, *i.e.*, demic expansion.

In a subsequent paper, the authors reinforced their argument with the results of genetic research (*Ammerman, Cavalli-Sforza 1984*). More specifically, the combination of the population dynamics model on the one hand and the spatial component on the other represents the basis of this model. The WoA model assumes that Neolithic populations grew following the logistic growth model. More precisely, the model proposes that the primary Neolithic population grew rapidly up to a certain point, after which the growth slowed down, eventually ceasing once the carrying capacity was reached (*Ammerman, Cavalli-Sforza 1984; Mooney, Swift 1999; Chamberlain 2006*).

The spatial component of the model refers to the movement of people, *i.e.* the settlement of suitable uninhabited space in the immediate vicinity. Once these spaces are inhabited within the immediate surroundings, there is continued advancement of the 'wave', *i.e.* further movement of people. The rate of Neolithic expansion, estimated by regression analysis, is ~ 1km per year (*Ammerman, Cavalli-Sforza 1984*). Criticisms of the model point out its inability to encompass the complexity of the Neolithization processes. This limitation is also evident in the occurrence of several rapid expansions in specific regions, followed by subsequent periods of stagnation. That is, some authors point out that models based on linear regression, such as WoA, conceal strong regional variations by averaging them, although they are good for explaining comprehensive patterns and the direction of Neolithic expansion at the continental level (*Brami, Zanotti 2015*).

In this context, other modes of Neolithic spread are insufficiently included, primarily the diffusion of cultural influences, especially in areas with confirmed indigenous hunter-gatherer populations. The use of genetic maps for Europe, which served the authors as confirmation of the proposed model, has since been repeatedly criticized. This criticism stems from the fact that the maps do not contain chronological data, so they cannot be unequivocally linked to a specific period. Nevertheless, most research (*Gkiasta* et al. *2003; Bocquet-Appel* et al. *2009; Fort 2012*, and others) indicates that the WoA model provides a strong

explanation of the Neolithization process at the continental level. Furthermore, recent estimates of Neolithic spread speed on a continental scale align closely with the values projected by the WoA model (~1km/yr) (*Gkiasta* et al. *2003; Pinhasi* et al. *2005*).

The rate of the Neolithic spread: previous studies

Numerous studies of the spatio-temporal patterns of the spread of the Neolithic in different parts of Europe indicate that these processes were not uniform and that they depended on many factors (geo-ecological, climatic, or cultural) specific to individual regions. More recent studies that considered the influence of climatic factors, biomes, and various geographical features in different regions indicate high variability between regions and at different time intervals (*Davison* et al. *2006; Bocquet-Appel* et al. *2009; 2012; Lemmen, Wirtz 2014; Silva, Steele 2014; Silva* et al. *2014; Weninger* et al. *2014; Orton* et al. *2016; Fort, Pareta 2020*). These studies are based on various statistical modelling techniques and often use radiocarbon dates as one of the parameters. It has already been mentioned that, according to the WoA model, the estimated speed of Neolithic expansion is about 1km per year (*Ammerman, Cavalli-Sforza 1984).* This speed varied in different periods and in different areas, and new studies have yielded estimated speeds of the spread that range from ~0.03 to as much as 29.475km per year, depending on the region (*Pinhasi* et al. *2005; Bocquet-Appel* et al. *2012; Silva, Vander Linden 2017; Fort, Pareta 2020*). For this reason, the concept based on the assumption of a constant rate of spread cannot *a priori* be applied to any region. Nevertheless, if the process of the expansion of the Neolithic way of life is observed at the continental level (the whole of Europe), it could be characterized as slow and gradual.

Another study compared the estimated rate of Neolithic spread, which was obtained by interpolating radiocarbon dates from various European and southwestern Asian Neolithic sites, with rates predicted by several different models: demic, cultural, and their combination (*Fort 2015*). The results indicated that different regions exhibited different dynamics of Neolithic spread, but also different strategies for adopting the new lifeways. Genetic research indicates that cultural diffusion played the most prominent role in certain regions, including northern Europe, the Alps, and the area west of the Black Sea (*Fort 2015.5* and cited references). On the other hand, demic diffusion was dominant in the Balkans and Central Europe (*Gkiasta* et al. *2003; Fort 2015*). When considering a blend of demic and cultural diffusion influences, the range of estimated speeds allowed for the more precise determination of cultural diffusion's contribution to the Neolithic spread in specific regions (*Fort 2015.5*). Spatial interpolation methods that included radiocarbon dates from Neolithic sites have been used in various studies to estimate not only the speed but also the direction(s) of Neolithic spread on the continental scale and at the level of individual regions (*e.g., Pinhasi* et al. *2005; Bocquet-Appel* et al. *2009; Brami, Zanotti 2015*). Another important piece of research on the Neolithic of Europe, with a focus on individual regions, involved the reconstruction of the direction and rate of the Neolithic expansion using the geostatistical method of interpolation (kriging) (*Bocquet-Appel* et al. *2009*). An important segment of the research is the inclusion of potential ecological barriers that could have influenced the direction and speed of the Neolithic expansion. Moreover, the estimates of the population density of individual areas enabled a better interpretation of the results obtained by spatial interpolation. In this case, different zones of expansion were defined, as well as centres of stagnation and further expansion. Among other things, the results indicate the non-linearity of the Neolithic expansion into (and through) Europe and define it as a process characterized by phases of expansion and stagnation (*Bocquet-Appel* et al. *2009*). This arrhythmicity of the process is also indicated by other studies (*Gkiasta* et al. *2003; Pinhasi* et al. *2005; Brami, Zanotti 2015; Porčić* et al. *2020*). In the study conducted by Marina Gkiasta *et al.* (*2003*), they employed a regression analysis that utilized the earliest dates from Late Mesolithic and Early Neolithic European sites, along with distances from the chosen centre of Neolithization (in this case, Jericho). This study aimed to test the Neolithization patterns proposed by the WoA model. The estimated mean speed of Neolithic expansion was ~1.3km/year, which is close to the originally estimated values within the WoA model (*Gkiasta* et al. *2003.51*). The initial spread of the Neolithic from the presumed centre followed a northwestern path, but regional deviations in different parts of Europe are also observed on isochron maps (*Gkiasta* et al. *2003*). An extensive investigation of the spatio-temporal patterns of Neolithic expansion, using radiocarbon dates from over 700 sites in Europe, southwestern Asia, and Anatolia, as well as the distances from 35 possible Neolithic centres, also yielded significant results (*Pinhasi* et

al. *2005*). Estimated speeds of Neolithic expansion are 0.6–1.3km/year, and based on interpolation maps, the primary zones of the Neolithization process are presumed to be in the northern Levant and Mesopotamia (*Pinhasi* et al. *2005*).

The Early Neolithic of the Central Balkans

The appearance of the Neolithic in the territory of the Central Balkans (in this paper, the term 'Central Balkans' refers to the territory of modern-day Serbia, and both these terms will be used throughout the paper) is defined as the Starčevo culture, which, according to the traditional definition, was part of the wider cultural complex Starčevo-Körös-Criş. Geographically, this heterogeneous complex included the territory of the Danube region, the right bank of the Danube (Starčevo culture), the Tisza valley in the Great Hungarian Plain (Körös culture), and Transylvania (Criş culture), *i.e.* the area of modern Serbia, northern, eastern, and central Bosnia, eastern and northern Croatia, Romania, and southeastern Hungary (*Garašanin 1979; 1982; Bailey 2000; Tasić 2009; Mester, Rácz 2010*) (Fig. 1). In an even broader sense, the Early Neolithic cultures of the region include Amzabegovo-Vršnik in North Macedonia as well as Karanovo in Bulgaria.

The beginning of the Starčevo culture is conventionally dated to around 6200 cal BC, based on the earliest dates from the Blagotin site as well as the first appearance of Starčevo ceramics in Mesolithic contexts at Danube Gorges sites (*Garašanin, Radovanović 2001; Whittle* et al. *2002; Borić 2009; 2011*). The youngest absolute dates indicate that Starčevo culture lasted until around 5300 cal BC. The latest dates slightly moved the beginning of the Starčevo culture to about 6250 cal BC. The earliest date comes from the Early Neolithic site of Miokovci-Crkvine (BRAMS-2324 7361±28, 6357–6083 cal BC 95.4% CI), located in western Serbia (*Porčić* et al. *2020*). However, this result should be interpreted with caution, due to the fact that it is a single specimen that could not be identified to the level of species but only to the genus level (*Bos* sp.). The bone was discovered at the bottom of the pit, and the possibility that these are residual remains of aurochs should not be dismissed.

There are several periodizations that define different phases within the Starčevo culture (*Milojčić 1950; Arandelović-Garašanin 1954; Dimitrijević 1974; Garašanin 1979; Srejović 1971; Tasić 2009*, to name a few), among which some clearly distinguish the Early and Middle Neolithic, with sub-phases (*Tasić 1997; 2009*). However, given that these periodizations are primarily based on changes in pottery, for the purposes of this work it was decided to avoid more detailed divisions within the Starčevo culture. Therefore, for the entire duration of the Starčevo culture (that is, the period from the earliest Neolithic appearance until the appearance of the Vinča culture) the term 'Early Neolithic' will be used.

Early Neolithic inhabitants of these areas built their settlements on river terraces, slopes near springs or streams, and mild elevations above marshes (*Garašanin 1979; Bailey 2000*). Architectural features interpreted as habitats appear in the form of semi-buried (semi-pit dwellings), buried (pit dwellings), and above-ground objects, with the first two types of objects being significantly more common (*Bogdanović 1988; Greenfield, Draşovean 1994*). Based on the available data, the size of the settlements in most cases did not exceed 5ha, and the absence of horizontal stratigraphy on most of them indicates that they were short-lived. In addition to the estimated settlement sizes, other indicators indirectly point to their possible short-term duration, *i.e.* the pronounced mobility of the Starčevo culture communities. For example, the lack of vertical stratigraphy (which would indicate the longevity of the settlement) as well as the types of architectural features, which do not indicate a major architectural investment (*Garašanin 1979; Bailey 2000.*

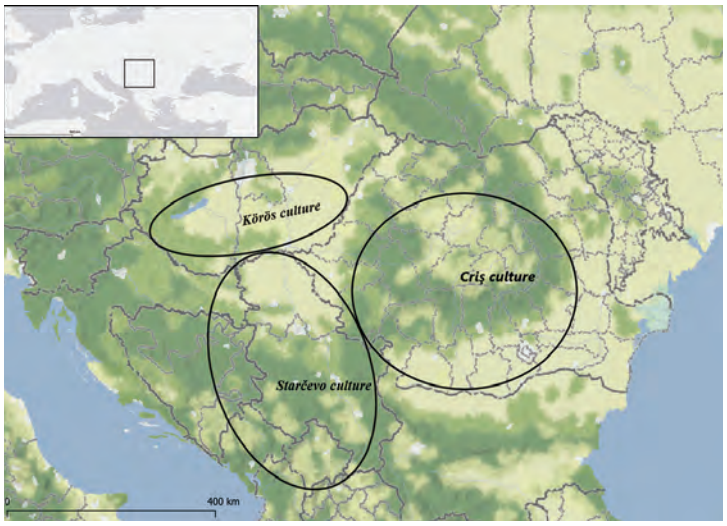

Fig. 1. Map with marked territory of Early Neolithic Starčevo-Körös-Criş cultural complex.

57; Tringham 2000.25; Greenfield, Jongsma 2008). Moreover, the faunal composition from the Early Neolithic sites indicated an economy in which cattle and ovicaprines dominated among domestic species, while archaeobotanical research at some of the sites indicated that farming had a marginal role in the Early Neolithic economy (*Greenfield* et al. *2014*). However, the lack of evidence about the (more) developed agriculture is partly due to the local development of the archaeobotany in several past decades and the treatment of botanical remains from archaeological sites, which has been significantly improving in recent years (*Filipović, Obradović 2013*; *Horejs* et al. *2019*; *Stojanović, Obradović 2016*). The variability of the identified plant species is mostly evident from the representation of wild plants, while cultivated species belong to the standard Early Neolithic repertoire (einkorn, emmer, barley, lentils, and legumes) (*Filipović 2014*).

The aim of the research

Numerous studies have dealt with the reconstruction of population dynamics, primarily changes in the population size and growth rates of Early Neolithic populations in the Central Balkans, confirming the existence of episodes of population growth and decline with high growth rates (*Blagojević* et al. *2017; Blagojević 2022; Blagojević* et al. *in preparation; Porčić* et al*. 2016; 2020; 2021a; 2021b*). One of the aspects of population dynamics that can help us better understand the intensity of changes is the speed and routes that populations used in the past in search of new spaces to settle and establish new practices. In this paper, the reconstruction of the direction and speed of the Neolithic expansion will be done using interpolation methods and by estimating the local rates of expansion. By 'local', we refer to the territory of the Starčevo culture in the restricted area of modern-day Serbia, primarily compared to the continental level. This restriction was mostly imposed by the availability of data but also justified with the fact that Starčevo culture first appeared at the territory of the Central Balkans. Within this defined area, we will observe the rate and dynamics of the spread in even smaller, 50-km-apart spatial units.

Data and method

The application of geostatistical interpolation methods in archaeology

The application of geostatistical methods in archaeology represents an important analytical tool that enables a better understanding of various phenomena within spatio-temporal frames. Geostatistics represents a set of different methods and analyses that define spatial variations and enable spatial predictions and simulations. In other words, geostatistics combines procedures for the analysis and evaluation of spatially dependent variables and is based on the principle of spatial interdependence, which implies that phenomena that are spatially closer will share more common characteristics than phenomena that are more distant (*Trangmar* et al. *1986; Lloyd, Atkinson 2004*). That is, spatially closer locations are also interdependent in a statistical sense, which is an important property of spatial data and justifies the use of interpolation in analyses (*Olivier, Webster 1990*).

Numerous studies of the Neolithic spread from southwestern Asia to and through Europe used geostatistical interpolation methods to reconstruct the spatio-temporal dynamics of these processes. The most common method used is kriging (*e.g., Pinhasi* et al. *2005; Bocquet-Appel* et al. *2009; Brami, Zanotti 2015; Fort 2015; Vander Linden, Silva 2021*). This is based on the principle of spatial autocorrelation, whereby the values of parameters in an environment where they are unknown are evaluated based on the known values of certain parameters in space (*Trangmar* et al. *1986; Wackernagel 2003*).

Given the above, the application of geostatistical methods can be considered an important tool in the reconstruction of the spatial and temporal patterns of past human communities, including the process of Neolithization. Nevertheless, one of the crucial requirements for the effective application of a specific method such as kriging is a substantial sample size, distributed relatively evenly across a large area. Past research, focused on reconstructing the speed of Neolithic expansion in the Central Balkans has predominantly relied on regression analyses. These analyses consider parameters like the estimated time of Neolithic arrival (earliest dates) and the distance from the presumed expansion centre in northern Greece (*Porčić* et al. *2020*). The disadvantage of this approach is reflected in the averaging of the estimated propagation speeds over a wider geographical area.

An attempt to apply kriging for the purposes of this research revealed noise in the data, most likely caused by the sample size as well as the uneven distribution of points (that is, Early Neolithic sites) in space. For this reason, it was decided to apply the so-

called *Inverse Distance Weighting* method (abbreviated as IDW). This method is suitable for effectively reconstructing the spread of the Neolithic in a small area with a limited sample size.

The application of the Inverse Distance Weighting method (IDW) in assessing the direction of the Neolithic spread through the Central Balkans

The IDW method is one of the simplest and, next to kriging, the most widely used spatial interpolation methods. It combines the concept of spatial proximity with a gradual change in trend in the area of interest. It is based on the same assumption on which all geostatistical interpolation methods rest – that points in space that are closer to each other are more similar than those that are more distant. Based on the known values of the parameters that are investigated at one location, the values of those parameters are predicted at nearby locations for which the data is lacking. If the points are closer, their local influence will be greater, and therefore their weight will be higher, while the weight will decrease as a function of the distance from the starting point (*Wackernagel 2003; Mitas, Mitasova 2005; Babak, Deutsch 2008; Gräler* et al. *2016; Vasić 2017*).

The simplicity of this method enables its application in different types of research as well as on many dimensions, and the estimations and predictions it provides are robust. Moreover, numerous comparative studies have shown that it often gives better results than kriging (*Babak, Deutsch 2008* and cited references). In this paper, the IDW method will be used for the spatial interpolation of the earliest dates from Starčevo sites on the territory of Serbia, with the aim of testing the hypothesis about the south-to-north spread of the Neolithic (*Whittle* et al. *2002*). Indirectly, the results of this analysis will also indicate the tempo of expansion by making it possible to visually highlight areas where the Neolithic arrived earlier or later than the assumed time for a given area.

The database for the application of the IDW method consists of georeferenced earliest dates, falling within the range of approximately 6250 to 6000 cal BC, from the Starčevo sites in Serbia (a database with all radiocarbon dates can be found in *Blagojević 2022. 186, Prilog 2*). To establish the spatial context of the study, a grid was generated within the QGIS software (QGIS.org 2021) encompassing the territory of Serbia. This grid divided the area into squares measuring 30 x 30km each (Fig. 2a and 2b). For each of the squares, the site with the earliest radiocarbon date, not younger than 6000 cal BC (more precisely, those sites with median values of the earliest dates lying in the range of around 6250 to around 6000 cal BC), was chosen. If there was more than one site within the square, the one with the older date was chosen. The medians of the calibrated values of the radiocarbon dates were compared for sites located in adjacent squares. In cases where the difference between the medians was more than 200 years, the site with a younger date was excluded from the analysis. Testing the difference between dates from adjacent squares was performed in the OxCal program, v. 4.4 (https://c14.arch.ox.ac.uk/oxcal/OxCal.html). The final database consists of the earliest dates with a total of 21 Starčevo sites from the territory of Serbia, including two sites from the Danube Gorges (Lepenski Vir and Ajmana) (Tab. 1, see below). Two analyses were performed: the first one with all the dates included and the second one with the two oldest dates from the sites of Miokovci-Crkvine and Blagotin omitted. The date from Miokovci can be considered potentially unreliable due to its unclear provenience, while the date from Blagotin has values that significantly depart (~200 years) from all other earliest Starčevo culture sites. Therefore, it was decided to check in what way those two early dates from the region of central Serbia affected the results and what potential interpretations they could point out.

Estimating the local speeds of the Neolithic expansion in the Central Balkans

Most of the studies in which the speed of Neolithic expansion has been estimated emphasize the high variability of these values in smaller, local areas. These studies indicate that larger deviations in local speeds can often be expected compared to those estimated at the continental level (*Pinhasi* et al. *2005; Bocquet-Appel* et al. *2012; Silva, Vander Linden 2017; Fort, Pareta 2020*). This paper will assess the local speed of the Early Neolithic spread on the territory of Serbia. In contrast to other studies based on regression analyses, in which the variables were the time of the Neolithic arrival to a certain territory and the distance from the centre of expansion, this paper will focus on local processes, that is, on the rate of the Neolithic expansion from the moment when these populations arrived in this area.

In order to estimate the local speed, the following parameters were used: (1) distances between spatial

groups in the south-to-north direction, each formed at intervals of 50km, as assumed to be the maximum migration distance in the WoA model, based on the ethnographic data as discussed in Ammerman and Cavalli-Sforza (*1984.78*); and (2), a measure of the central tendency of the oldest dates (median or, alternatively, mean, in cases of pairs of sites with identical median values), serving as the estimated beginning of life in the settlements. From the mentioned spatial groups, one site with the oldest date was singled out (Tab. 2). Unlike in the case of the IDW interpolation, when calculating the estimations of the local speeds a date from the site of Blagotin was not included since it significantly deviates chronologically from other sites. Its date is around 150 years older than the Crkvine-Miokovci date and approximately 200 years older than dates from other sites. The distance between sites, represented by the difference between spatial groups (50km each), was divided by their difference in medians or means for each pair. Using this approach, individual estimates of the speed of Neolithic expansion among spatial groups were obtained, following the south-north direction. Finally, the calculated average of all obtained quotients provided an estimation of the average local speed of Neolithic expansion across the territory of Serbia.

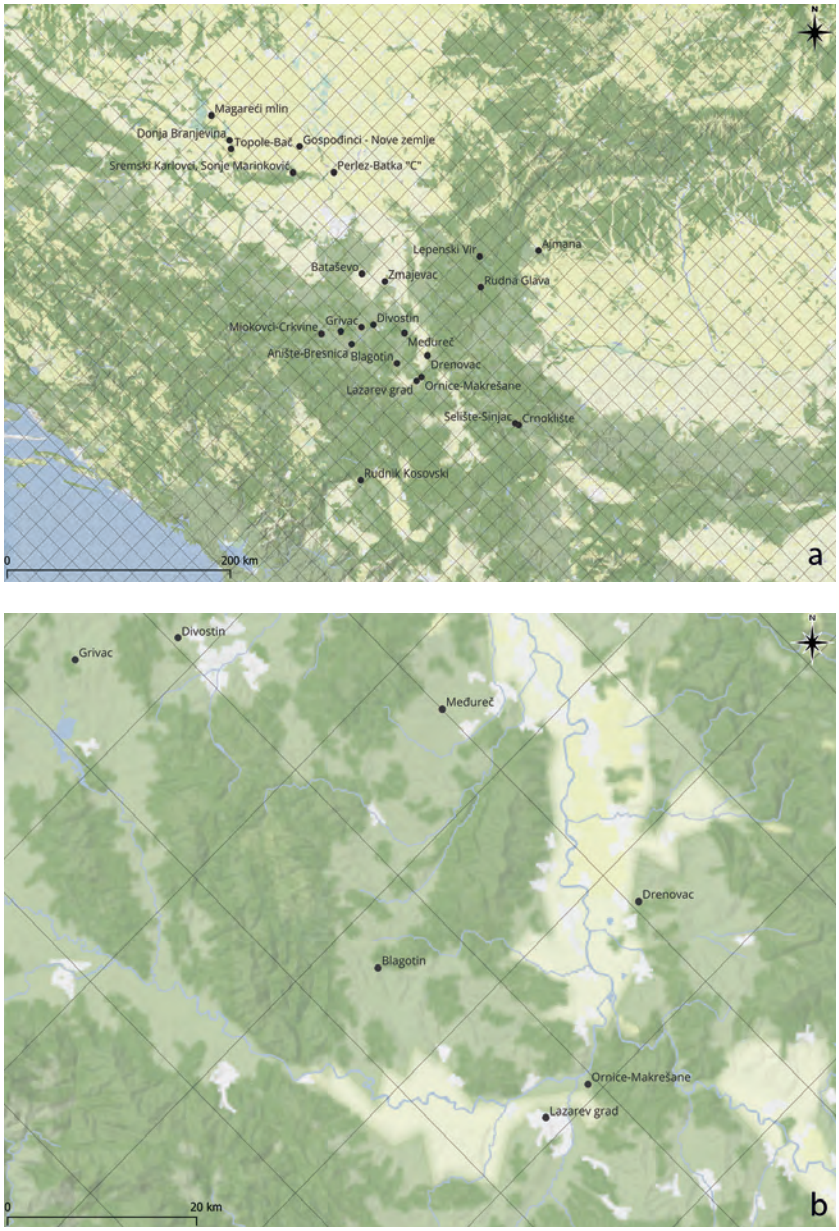

Fig. 2. Square grid with Early Neolithic sites included in the IDW analysis:* a *all sites;* b *a selected section of the map that shows the layout of squares within the grid in more detail.

It is well known that radiocarbon dates do not represent absolute values (*i.e.* calendar years), but rather ranges of values within particular confidence intervals (68% or 95%, most often). Therefore, the estimations of the speeds of the spread based on central tendency measurements represent approximate estimations. In other words, these estimations do not take into account the full uncertainty of the radiocarbon dates, and this is the greatest weakness of this approach. However, central tendency measurements (the mean and median, in this case) are usually used in this type of analysis because they provide valuable insights into the central value of a dataset. These measures help us summarize and understand the data's distribution, which is essential for making estimations and drawing general conclusions. The mean is especially useful in analysing this type of data, such as radiocarbon dates, since it is a robust measure not affected by extreme values or outliers. Considering this, the approach used in this study does give us a useful insight into the general pattern of the spread rates on a small scale.

Results

The reconstruction of the direction of Neolithic expansion

Figure 3 shows the results of spatial interpolation based on the earliest radiocarbon dates, using the IDW method. Figure 3a shows the results with all the dates included, while Figure 3.b shows the results with the two oldest dates (from the sites of Miokovci-Crkvine and Blagotin) omitted. Intervals of 50 (Fig. 3.a) and 20 (Fig. 3.b) years each, which were calculated based on the median values of the oldest dates from the Early Neolithic sites, are shown through a colour palette. Each shade corresponds to one interval, so darker shades represent older dates and lighter shades represent younger dates (that is, intervals). This approach allows for tracking the spatio-temporal trend in the establishment of the earliest Early Neolithic settlements within the territory of Serbia. In the broadest sense, this trend aligns with the assumed south-to-north direction (*Whittle* et al. *2002*). When the two oldest dates from the sites of Miokovci-Crkvine and Blagotin are included in the IDW interpolation, the results appear to be 'biased' towards these values, while all other, younger sites, seem to be smoothed out across the entire territory. On the other hand, when these dates are omitted from the analysis, more subtle differences between different sites and defined regions can be observed. The southern region stands out more clearly as the oldest one. In this case, zones with older or younger sites than expected for a given region could also be observed with greater clarity.

Site 1	Lab No., uncalibrated date with standard error, and a reference	Median and mean* values of the oldest date (cal BC)	Site 2	Median and mean* values of the oldest date (cal BC)
Rudnik Kosovski	BRAMS-2413, 7343±27; *Porčić* et al. *2021a*	6165*	Selište-Sinjac	6154*
Selište-Sinjac	BRAMS-2303, 7300±30; *Porčić* et al. *2021a*	6154*	Ornice-Makrešane	6162*
Ornice-Makrešane	BRAMS-2223, 7335±31; *Porčić* et al. *2021a*	6162	Miokovci-Crkvine	6195
Miokovci-Crkvine	BRAMS-2324, 7361±28; *Porčić* et al. *2021a*	6195	Bataševo	6156
Bataševo	BRAMS-2227, 7331±27; *Porčić* et al. *2021a*	6156	Sremski Karlovci-Sonje Marinković	6078
Sremski Karlovci-Sonje Marinković	BRAMS-2423, 7233±28; *Porčić* et al. *2021a*	6078	Topole-Bač	6034
Topole-Bač	OxA-8693, 7170±50; *Whittle* et al. *2002*	6034	Magareći mlin (Grn-15973; 7130±60; *Whittle* et al. *2002*)	6003
Bataševo	BRAMS-2227, 7331±27; *Porčić* et al. *2021a*	6156	Lepenski Vir	6046
Lepenski Vir	OxA-16005, 7190±45; *Borić, Dimitrijević 2009*	6046	Ajmana (AA-58322,7219±51); *Borić 2011*	6075

Tab. 2. Sites with the oldest dates within defined spatial groups formed at 50km used for the estimation of the local speeds of the spread. Local speeds were calculated for each pair of neighbouring sites by using the measurements of central tendency for the calibrated values (95% CI) of radiocarbon dates. The median of the oldest date was used as the primary measurement of central tendency. In cases where the medians of the oldest dates from neighbouring sites were identical, their means were used. These cases are marked with an asterisk (*) in the table.

The estimated rates of Neolithic expansion

Estimates of the rates of Neolithic expansion are given in Table 3. It's important to note that the results obtained through the application of this method are primarily indicative of the variations among the defined spatial bins (regions). This approach allows us to determine whether, and in which regions, the Neolithic expansion occurred at a faster pace than in other areas within the Central Balkans. When considering sites with very close dates the obtained scores are notably high, indicating a rapid Neolithic spread, characteristic of the southernmost regions of the territory. Other values show limited variation and do not suggest significant changes in tempo. Since the assumed direction of the expansion was south-to-north, in cases where older sites were also northern sites negative values were obtained. When these cases are included, the average estimated speed for the whole territory is 4.57km per year. However, when these cases are excluded, the average estimated speed is 1.61km per year. Both scenarios will be discussed further below.

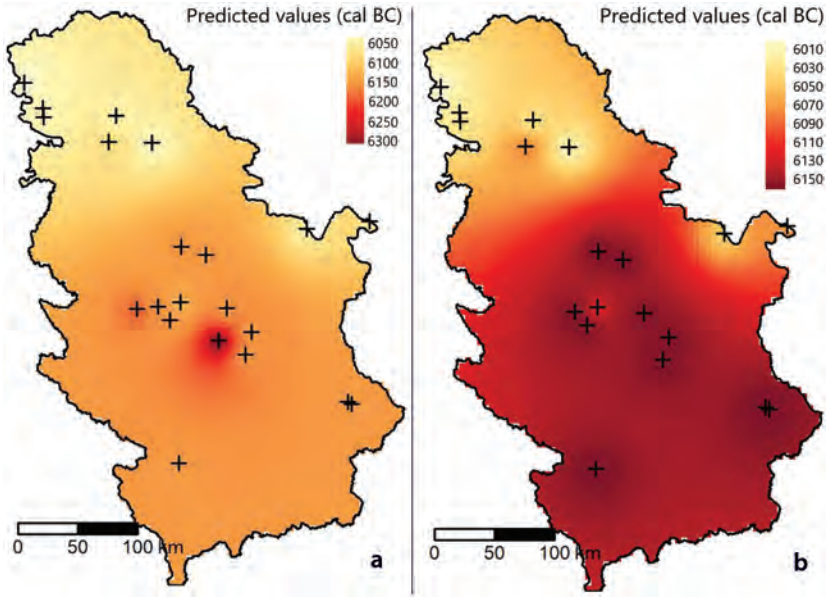

Fig. 3. Interpolation map of the oldest radiocarbon dates from the territory of Serbia, obtained by the Inverse Distance Weighting (IDW) method on a sample of 21 Starčevo culture sites.

Discussion and conclusion

The results of the IDW interpolation, which included the georeferenced earliest radiocarbon dates from the Starčevo sites (from ~6250 to ~6000 BC), confirmed the previously assumed general direction of the Neolithic spread from south to north (Fig. 3.a and 3.b). Individual zones that, in a certain sense, deviate from the assumed pattern have been singled out. Cases of sites with dates that are younger than the assumed earliest dates for the region could be explained by the degree of research that has been carried out, and this could mostly mean that none of the older sites in the specific region have been discovered or dated yet. However, the presence of sites with significantly older dates is noteworthy. This is the case for the sites of Miokovci-Crkvine and Blagotin, which belong to the region of central Serbia.

According to the reconstructed Neolithic expansion route, these Early Neolithic settlements should be younger than those in southern Serbia. However, the dates from these sites represent the oldest dates from the entire sample of Starčevo radiocarbon dates from the territory of Serbia at the current level of research (*Porčić* et al. *2021a; Blagojević 2022*). The possibility that there are undiscovered settlements in the south that would yield dates of a similar age certainly exists, but that does not account for the early establishment of a settlement in an area that, based on current data, should have been inhabited later. A possible explanation could be the existence of smaller scouting groups that established short-term settlements with the aim of familiarizing themselves with an environment suitable for future settlement. This would represent some version of leap-frog colonization, which has already been assumed in some earlier studies (*e.g., Spataro 2010*). However, we should not rule out the possibility that, at least in the case of the Miokovci-Crkvine site, we are dealing with a residual specimen, which could have belonged to an aurochs from an earlier period, considering that the dated specimen was determined only at the species level. When the two earliest dates are not included in the analysis, a slightly different dynamic is revealed that emphasizes the chronological difference between regions more but still retains zones with older and younger dates. Therefore, even though these two types of results differ, they both indicate that, although the general direction of the spread followed the south-to-north axis, it can be argued that the process was not linear but rather arrhythmic. This espe-

Site 1	Site 2	Estimated speed of the expansion (km/year)
Rudnik Kosovski	Selište-Sinjac	4.55
Selište-Sinjac	Ornice-Makrešane	-6.25
Ornice-Makrešane	Miokovci-Crkvine	-1.52
Miokovci-Crkvine	Bataševo	1.28
Bataševo	Sremski Karlovci-Sonje Marinković	0.64
Sremski Karlovci-Sonje Marinković	Topole-Bač	1.14
Topole-Bač	Magareći mlin	1.61
Bataševo	Lepenski Vir	0.45
Lepenski Vir	Ajmana	-1.72

Tab. 3. Estimated local speeds of the Neolithic expansion in the Central Balkans.

cially holds for cases of sites older than expected for a given region, as it could indicate possible pioneering, exploratory trips to the uninhabited environments.

Estimates of the local speed of Neolithic expansion indicate that this process was particularly fast in the southern region, where settlement closely correlates with the initial emergence of the Neolithic. In other regions the estimated local rates of expansion do not vary greatly, suggesting a relatively stable yet rapid pace (Tab. 3). In some cases, southern sites were younger than northern ones, and in these cases the estimated values were negative. The average value of all the estimated local speeds, with negatives included, is 4.57km/year. Previous research (*Porčić* et al. *2020*), which employed regression analyses, indicated that the estimated speed of spread within the territory of Serbia is higher than the average speed of ~1km/year assumed by the WoA model (*Ammerman, Cavalli-Sforza 1984.80*). This estimation also diverges from estimates for the Balkan region obtained in other studies (*Gkiasta* et al. *2003; Pinhasi* et al. *2005; Bocquet-Appel* et al. *2012*). The local rates of Neolithic expansion evaluated in this research indicate two possibilities. In the first case, if we omit all the negative values, the results correspond well with the estimations for the continental level and the assumptions of the WoA model. On the other hand, if we assume that some of the northern regions were indeed inhabited first, then the process in this area was significantly faster than on the continental level, and this could lead to further discussion regarding the possibility of leap-frog colonization and probably the high degree of mobility of the first Neolithic settlers. However, this could also be a consequence of the smaller number of discovered and dated Early Neolithic sites in the south of Serbia.

The high estimated rates of Neolithic expansion are often attributed to the influence of cultural transmission, specifically interactions with local Mesolithic communities (*Fort 2012*). While there are isolated cases of radiocarbon dates from certain sites (Magareći Mlin, Grabovac-Đurića vinogradi, and Gospođinci-Nove zemlje) that may suggest the potential presence of Mesolithic communities (*Živaljević* et al. *2021*), confirmation of such communities in the territory of Serbia is still lacking, except for the Danube Gorges area. The model of directional expansion proposed by Joaquim Fort (*2020*) explains the higher speeds in those cases when the possibility of interaction with the local Mesolithic population is excluded by implying the expansion of communities to areas that are closest to the direction of the advance of the front and in which the population density is low. Among other things, this model allows for the scenario in which people choose to settle in the first available areas they come across. We should also keep in mind the assumed increased mobility of communities in this period, which, among other factors, can lead to faster movement across space, quicker settling of new areas, and rapid abandonment of certain regions. The existence of smaller scouting groups is also a possible part of the Neolithization process in this area, especially if the earliest dates from the sites of Blagotin and Miokovci-Crkvine are considered.

The question of the degree of mobility of the Starčevo communities has been emphasized in numerous studies (*Garašanin 1979; Bailey 2000.57; Tringham 2000.25; Greenfield, Jongsma 2008; Greenfield* et al. *2014; Porčić* et al. *2021a; Blagojević 2022*) The estimated local speeds at which the Neolithic spread through the territory of the Central Balkans further contribute to this discussion, but they represent only an indirect indicator. The current level of research has produced a limited set of data and knowledge on this complex issue, where it is important to pay special attention to the study of settlement organization and duration. Future research should focus on these issues through detailed contextual and functional analysis at the level of settlements and individual households.

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Tab. 1. Early Neolithic sites from the Central Balkans used in the study.

Site	Context	Material	Lab No.	Uncal BP	C%	N%	C/N	d13C (IRMS)	d15N (IRMS)	d13C (AMS)	Reference
Anište-Bresnica	Trench 1, Pit 1	*Ovis/Capra*, mandible dext.	BRAMS-2331	7306±28	48.3	17.7	3.2	/	/	−21.3	*Porčić* et al. *2021*
Bakovača-Ostra	Trench 3; e.l. K	*Ovis/Capra*, scapula dext.	BRAMS-2329	7299±27	45.96	16.83	3.2	/	/	−20.5	*Porčić* et al. *2021*
Bataševo	Trench 1	*Bos taurus*, radius dext.	BRAMS-2230	7284±28	44.1	16.2	3.2	/	/	−21.3	*Porčić* et al. *2021*
Blagotin	13/3, base of pit JA2, pit dwelling 7	Red deer antler	OxA-8608	7480±55	/	/	3	−20.6	4.4	/	*Whittle* et al. *2002*
Crnoklište	Trench 3 northern extension, Pit 9	*Bos taurus*, scapula sin.	BRAMS-2290	7293±29	48.4	17.7	3.2	/	/	−21.7	*Porčić* et al. *2021*
Donja Branjevina	Trench V, 1986-1987, Pit e.l. 6	Animal bone	GrN-15974	7155±50	/	/	/	/	/	/	*Tasić 1993*
Drenovac	Trench 15, sq. 2; in the line with the eastern profile	Large mammal long bone	BRAMS-2244	7309±28	47.06	17.18	3.2	/	/	−20.7	*Porčić* et al. *2021*
Gospođinci-Nove zemlje	Feature 45-emptying	Mammalia, long bone	BRAMS-2367	7169±28	45.77	16.77	3.2	/	/	−20.2	*Porčić* et al. *2021*
Grivac	Trench B, 1969, level at the relative depth of 2m	Charcoal	Bln-869	7250±100	/	/	/	/	/	/	*Bogdanović 1994*
Magareći mlin	Semi-pit-house 1, by the hearth	Animal bone	Grn-15973	7130±60	/	/	/	/	/	/	*Whittle* et al. *2005*
Međureč-Dunjički šljivari	Trench 1, quadrant 2	*Bos taurus*, vertebra lumbalis	BRAMS-2251	7316±29	42.36	15.52	3.2	/	/	−18.6	*Porčić* et al. *2021*
Miokovci-Crkvine	Trench 3, bottom of the pit	*Bos* sp, mandible sin.	BRAMS-2324	7361±28	45.7	16.8	3.2	/	/	−21.2	*Porčić* et al. *2021*
Ornice-Makrešane	Trench 1, sq. b5; B-71	*Cervus elaphus*, radius dext.	BRAMS-2223	7335±31	42.06	15.38	3.2	/	/	−23.1	*Porčić* et al. *2021*
Perlez-Batka "C"	12/2, Grave 1, Trench 2/1975	*Homo*, tibia	OxA-8605	7145±50	/	/	3.3	−19.9	9.2	/	*Whittle* et al. *2002*
Rudnik Kosovski	Grave 1	*Homo*, cranium	BRAMS-2413	7343±27	42.6	15.32	3.2	/	/	−21.7	*Porčić* et al. *2021*
Selište-Sinjac	Trench 6, northeastern quarter; 1.3–1.5m; box 13	*Bos taurus*, Ph III	BRAMS-2303	7300±30	46.99	17.18	3.2	/	/	−20.9	*Porčić* et al. *2021*

Tab. 1. continued

Sremski Karlovci-Sonje Marinković	Grave 1	*Homo*, costae	BRAMS-2423	7233±28	42.9	15.6	3.2	/	/	−21.5	*Porčić* et al. *2021*
Topole-Bač	4/1, individual 1, Trench 1	*Homo*, costae	OxA-8693	7170±50	/	/	3.4	−19.7	8.8	/	*Whittle* et al. *2002*
Zmajevac	Trench II	*Bos taurus*, radius sin.	BRAMS-2267	7296±27	45.67	16.7	3.2	/	/	−20.4	*Porčić* et al. *2021*
Lepenski Vir	Burial 122, between Buildings 47 and 47'	Human skull	OxA-16005	7190±45	/	/	/	−19.5	9.5	/	*Borić, Dimitrijević 2009*
Ajmana	Burial 7	Human skull	AA-58322	7219±51	/	/	/	−20	10	/	*Borić 2011*

European settlement demography: a boom and bust pattern in prehistory?

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ABSTRACT - *In this paper we compare multiple types of domestic settlements from different chronological periods in prehistoric continental Europe to inform occupancy patterns and demographic trends. We focus in particular on the evidence of a boom and bust pattern that appears to be constant across all the sites studied. We find evidence of a growth plateau after 200 to 300 years of existence. But because the number of sites used is small, due to the quality restrictions of the data, the results still need to be confirmed by further investigations.*

KEY WORDS – *demography; prehistory; booms and busts; patterns*

Evropska poselitvena demografija: vzorec rasti in upada v prazgodovini?

IZVLEČEK – *V prispevku primerjamo več vrst naselbin iz različnih časovnih obdobij v prazgodovini v celinski Evropi, da bi pridobili informacije o vzorcih poseljenosti in demografskih trendih. Osredotočamo se na podatke sistema o rasti in upadu, ki se zdi konstanten v vseh naselbinah. Našli smo namreč dokaze o doseženem platoju rasti po 200 do 300 letih obstoja. A ker je zaradi slabe kakovosti podatkov število naselbin majhno in so zato podatki omejeni, je treba rezultate z nadaljnimi preiskavami še potrditi.*

KLJUČNE BESEDE – *demografija; prazgodovina; rast in upad; vzorci*

Introduction

Questions concerning population size, density and development are not novel in archaeology, but are deeply linked to interpretations of settlement function, regional organization, and socio-cultural dynamics. One may be the explanation of the other, and *vice versa*. But despite the importance of demography to archaeological research, it can be challenging to find reliable data to recreate population numbers. In recent years archaeological demography is usually approached using different proxies, such as radiocarbon datasets and summed probability density models to build population size models through time (*Crema, Bevan 2021*). Agent-based modelling can also be developed to add palynological and climatic information to these models (*Baum* et al. *2020; Bernigaud* et al. *2023*). As useful as these statistical methods are for reconstructing ancient population trends, many researchers are critical of summed probability density models for their disconnection from actual archaeological materials (*Contreras, Meadows 2014; Torfing 2016*). Because these methods focus on defining population numbers over large areas and a

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long chronological time frame, they tend to forget the actual settlements behind the dots.

A variety of European prehistoric domestic sites have been excavated, from single farmsteads to giant settlements and the first townships. How many people lived in a domestic site and for how long? Is there a smooth population increase and decrease or are we dealing with population booms and busts? Due to the limited quality of our data, these questions are mainly reflected in supra-regional or regional demographic studies, but very seldom on the site level for comparative purposes of single site 'biographies' (*cf. Müller 2015; Müller, Diachenko 2019; Großmann* et al. *2023; Schmidt, Hilpert* et al. *2021*). This is unfortunate, as the methodology for such intra- and inter-site estimations is inherent to settlement archaeology.

In this study we collected data for as many sites as possible from well-phased settlements with traces of houses, allowing the reconstruction of the number of houses for each phase. Though the number of excavated prehistoric sites has exploded in recent decades, only a few of them possess absolute chronological phasing and an estimation of the population size. We think that models can be developed on the basis of these data, and in this paper we aim at investigating settlement demography, using the number of houses, to highlight possible patterns in population development and more precisely in site developments.

The data

The data used to study and compare the demographic patterns of individual domestic sites was collected from 22 settlements across Europe (Fig. 1). These sites were selected for the quality of their documentation and their variety. They provide a minimum level of information content necessary for data analysis: a division of settlement activity into phases through absolute dating and an indication of the number of houses or population size for each phase. The sites represent different settlement types and are distributed over a wide geographical area. It is nonetheless difficult to find sites matching this data quality requirements in continental Europe.

Although most of the sites in our sample date from the Neolithic (n=9) and the Chalcolithic (n=7), the three sites selected for the European Bronze Age (n=3) and Iron Age (n=3) are good representatives for these periods. The data imbalance within these chronological time periods mostly relates to the different research strategies conducted in these settlements, which generally do not record the data quality required for this study. However, with this wide geographical and chronological range we aimed to compare different types and sizes of settlement, from different areas and time periods, to determine if their demographic development exhibits any regularity.

Of course, 22 settlements are not enough to cover the entire spectrum of possible settlement types in European prehistory. For example, we lack fortified villages and proto-urban settlements from the Chalcolithic Aegean and Iberian Early Bronze Age and foraging camps of the Mesolithic. It has not been possible to integrate such sites, as there is no information about phase categorization and house size for these. It hasso far also been difficult to assess the tell-type settlements in south-eastern Europe in the associated lowland areas. And unfortunately, despite numerous excavations, it has not been possible to obtain more precise information on the evolution and number of houses of the *oppida* of the Latenian period. We also excluded single-phase settlements that were occupied for a short time, as no development can be analysed for them. They certainly represent a separate category of very short-term ephemeral domestic activities that should be considered in future studies.

As such, 22 settlements with different characterizations could still be integrated to the dataset (*Bánffy* et al. *2016; Billamboz 2009; Brink 2009; Brozio 2016; Friederich 2011; Hofmann* et al. *2007; Isoardi 2008; Kerig* et al. *2022; Kurz 2010; Boelicke* et al. *1994; Matuschik* et al. *2023; Müller* et al. *2022; Müller* et al. *2011; Müller, Rassmann* et al. *2016; Wyss 2002;* also Suppl. 1). Langweiler 8 is an Early Neolithic Linear Pottery settlement of longhouses, which, as a central settlement in the Merzbach valley in the Lower Rhine region, shows a differentiated development (*c.* 5300–4900 BCE). The Linear Pottery site of Vráble (*c.* 5300–4950 BCE) is a large Early Neolithic settlement with several neighbourhoods. Okolište is a Late Neolithic Butmir tell settlement (*c.* 5225–4675 BCE), for which gable-parallel houses are documented in various phases of the site. Ovčarovo (*c.* 4900–4200 BCE) and Poljanica (*c.* 5000–4600 BCE) are intensively excavated Early Chalcolithic Gumelnitsa/KGK VI tells, which illustrate the classic development of south-eastern European settlement mounds with several occupancy horizons. We include cluster villages from southern Central Europe with the Middle Neolithic sites Al-

sónyék (*c.* 4800–4250 BCE), Heilbronn-Neckargartach (*c.* 5050–4550 BCE) and Friedrichshall-Kochendorf (*c.* 4700–4375 BCE). Data on large Chalcolithic settlements or mega-sites with planned, partly proto-urban structures are drawn from the Eastern European sites of Nebelivka (*c.* 4000–3690 BCE), Maidanestke (*c.* 3950–3630 BCE), Taljanky (*c.* 3950–3500 BCE), Stolniceni (*c.* 3950–3680 BCE) and Trinca (*c.* 3900–3600 BCE). We know the house layout for the southern Swedish Early Neolithic settlement of Almhov (*c.* 3800–3400 BCE), as well as for the southern German pile-dwelling site of Hornstaad-Hörnle IB (*c.* 3580–3505 BCE) or the northern German Middle Neolithic site of Oldenburg-Dannau (*c.* 3265–2930 BCE). Bronze Age settlement developments can be traced in the Alpine settlement of Cresta (*c.* 2150–1600 BCE) and in the south-central European settlements of Vráble (*c.* 2100–1800 BCE) and Bad Buchau (*c.* 1767–1495 BCE). The two latter are a large Early Bronze Age settlement and a fortified pile-dwelling settlement, respectively. For the Pre-Christian Iron Age, settlement sequences are known for the large fortified settlement of Heuneburg (*c.* 700–550 BCE) and for the *oppida* of Saint-Blaise (*c.* 700–100 BCE) and Saint-Pierre (*c.* 550–100 BCE) in the south of France.

For each site, we collected information about the number of coeval houses for each given phase. This number is given by one or more of the following:

- A complete excavation of the site including the dating of single features (*e.g.,* Cresta bei Cazis (*Wyss 2002*), Langweiler 8 (*Boelicke* et al. *1994*), Hornstaad-Hörnle (*Matuschik* et al. *2023.318*), Ovčarovo and Poljanica (*Kerig* et al. *2022*)).

- The chronological phasing of geophysical plans of the whole site by transferring chronological information from the excavated site areas. As an example, in Late Neolithic Okolište the geophysical features could be phased chronologically by target excavations on specific structures (*Hofmann* et al. *2016; Müller* et al. *2013; Müller* et al. *2011*). For Trypillia mega-sites, a similar method was used (*Müller* et al. *2016; Ohlrau 2020*), while in the LBK and Vinča sites dating based on the houses' orientations enabled a chronological interpretation of the geophysical plans of different settlements (*Hofmann, Müller-Scheeßel 2020*).

- A modelling of the site surface and of the number of houses highlighted for the excavated phases. For Saint-Blaise and Saint-Pierre the house number es-

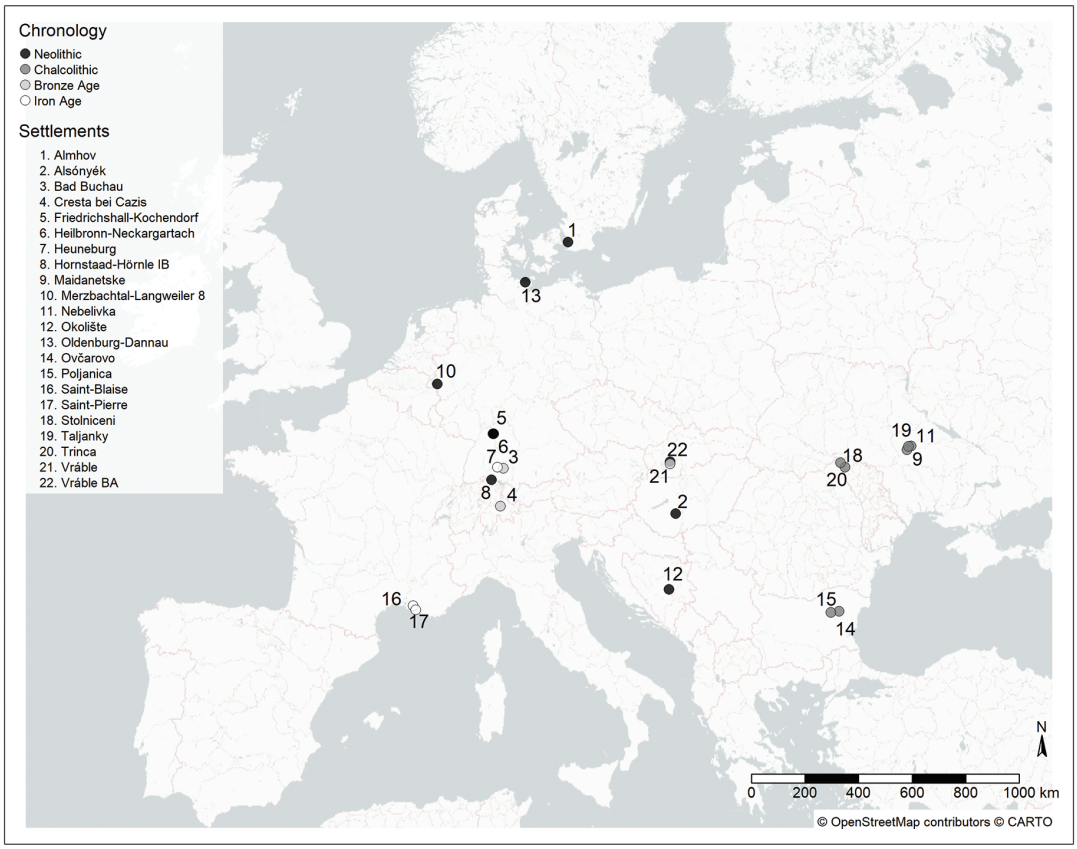

Fig. 1. Location and dating of the sites used in the analysis (Supplements 1 and 2).

timation is based on the size of the sites, the size of the houses and the public space surface area such as streets and squares (*Isoardi 2008.130*). For Siedlung Forchner (Bad Buchau), the size of the dendro-dated houses has been transferred to the enclosed space (*Billamboz 2009*).

In most cases, the duration of houses is confined to 25–50 years, which coincides with ethno-archaeological observations, experimental-archaeological data or archaeological dating (*Nikulka 2016; Ohlrau 2020; Schmidt, Hilpert* et al. *2021; e.g.,* Alsónyék *Bánffy* et al. *2016*). We calculated population numbers using house numbers and estimated population sizes for each house. The latter is based on ethnographic and ethno-historical analogies depending on the floor size or the number of fire places, and we estimate that five to 10 people can live inside a house of 40 to 70m (*Isoardi 2008.19; Nikulka 2016.40; Müller 2015*). This number is also supported by new archaeological contexts discovered in Kosenivka, Trypillia, (*Fuchs* et al. *2023*). For example, for Neolithic Oldenburg-Dannau about nine individuals per house were calculated from the surface area of floors (*Brozio 2016*), and for Late Hallstatt Heuneburg seven individuals (*Kurz 2010*).

Analysis and results

We ploted below the number of houses for each phase of the selected sites over time. In order to compare them, the chronological information used in these plots is the lifespan of each site starting from 0, in other words, the foundation of the site (Fig. 2). A pattern emerges immediately. All the settlements seem to start with a first phase of quick demographic growth or 'boom' for about 200 to 300 years, followed by a more or less quick decrease[1] or 'bust' pattern. For those with a lifespan shorter than 200 years (*e.g.,* Hornstaad-Hörnle), we can also detect a similar pattern, but with faster changes.

This visual interpretation seems to be verified by the loess regression calculation applied on all sites and all information (Fig. 3). There is a less pronounced increase in the first phases of the sites, but a global decrease of the population after 200 years of existence. In order to make sure that this observation is not due to the difference in the number of houses between sites, we did the same calculation based on a percentage of houses for each site and each period. This calculation does not change the global trend, but rather accentuates it.

From these first observations and results, it appears that the site sample can be divided into three categories: sites with a lifespan lower than 200 years, sites with a lifespan between 200 and 400 years, and sites in use for more than 400 years. Here again, the loess regression shows the same pattern – a quick increase of the population prior to reaching its peak, followed by a more or less abrupt decrease, depending on the life expectancy of the sites (Fig. 4).

Except for the first group of sites (the ones lasting less than 200 years), this maximum number of houses mostly seems to be reached within 200 to 300 years of the lifespan of the settlements. However, we can see that for some of the sites this maximum is reached later, which is the case for Taljanky in Ukraine or Saint-Blaise in France. If the loess regression calculation done on this type of site shows that indeed they reach their maximum number of houses later (around 350 years of existence), the created pattern is not radically different (Fig. 5). It still follows the global trend defined by a quick increase until the maximum is attained, directly followed by a continuous decrease until the settlement's abandonment.

The outlined global trend is also observed in each time period (Fig. 6). Nonetheless, the Iron Age and Bronze Age sites seem to grow much faster than the Neolithic and Chalcolithic ones, though this may be an effect of sample size. As noted earlier, nine and seven settlements date from the Neolithic and the Chalcolithic, respectively, but only three date to each of the Bronze and Iron Ages. However, the global pattern is similar to that found with the previous analysis: a quick increase of the population until 200 years of settlement lifespan, and then a more or less rapid and continuous decrease.

Finally, we also explored the possibility of differences observable due to settlement types. Seven types were defined based on the settlements' size, location and organization, and this last analysis shows the most differences in the pattern of evolution (Fig. 7). Tells and other centralized domestic sites seem to have a smoother development with a long-time occupation

1 In order to be able to compare the development of each site, the curves have been plotted on a logarithmic scale of 10 in Figure 2.

and a stabilization phase when they reach their maximum number of houses, before slowly decreasing. On the other hand, hillforts, mega-sites and Linearbandkeramik/Rubané sites reach their peak of occupation rather quickly before, once again, slowly decreasing. Lake dwellings and Alpine sites exhibit a different pattern because they are generally short-lived and have quick phases of abandonment.[2] However, except for these last types, all the studied settlements show a pattern with a maximum number of houses reached after around 200 years of existence (sometimes slightly before, like hillforts, and sometimes slightly after, like tells), and then a slow desertion through time before site abandonment.

Discussion

Even if not identical, the multiple analyses provided above all display a recurring pattern. Whatever the chronological period, the population size, lifespan and settlement type, all of the 22 selected sites seem to follow the same 'evolutionary' trajectory. They all show a rapid increase in the population until the maximum number of houses is reached after around 200 years, except for the one site being abandoned before 200 years. This maximum is then followed by a slower but continuous decrease until the settlement is completely deserted.

For some sites this pattern is not as clear as for others, in particular for wetland dwellings and Alpine sites. This can be explained by their small number of inhabitants but also because they display a different kind of occupancy. Indeed, they tend to be quickly abandoned and relocated in a new area not far away (*Heitz* et al. *2021; Köninger 2015*). This behaviour raises the question as to what a settlement is and how it should be delimited (*Bintliff 2000; Ebert 1992*).

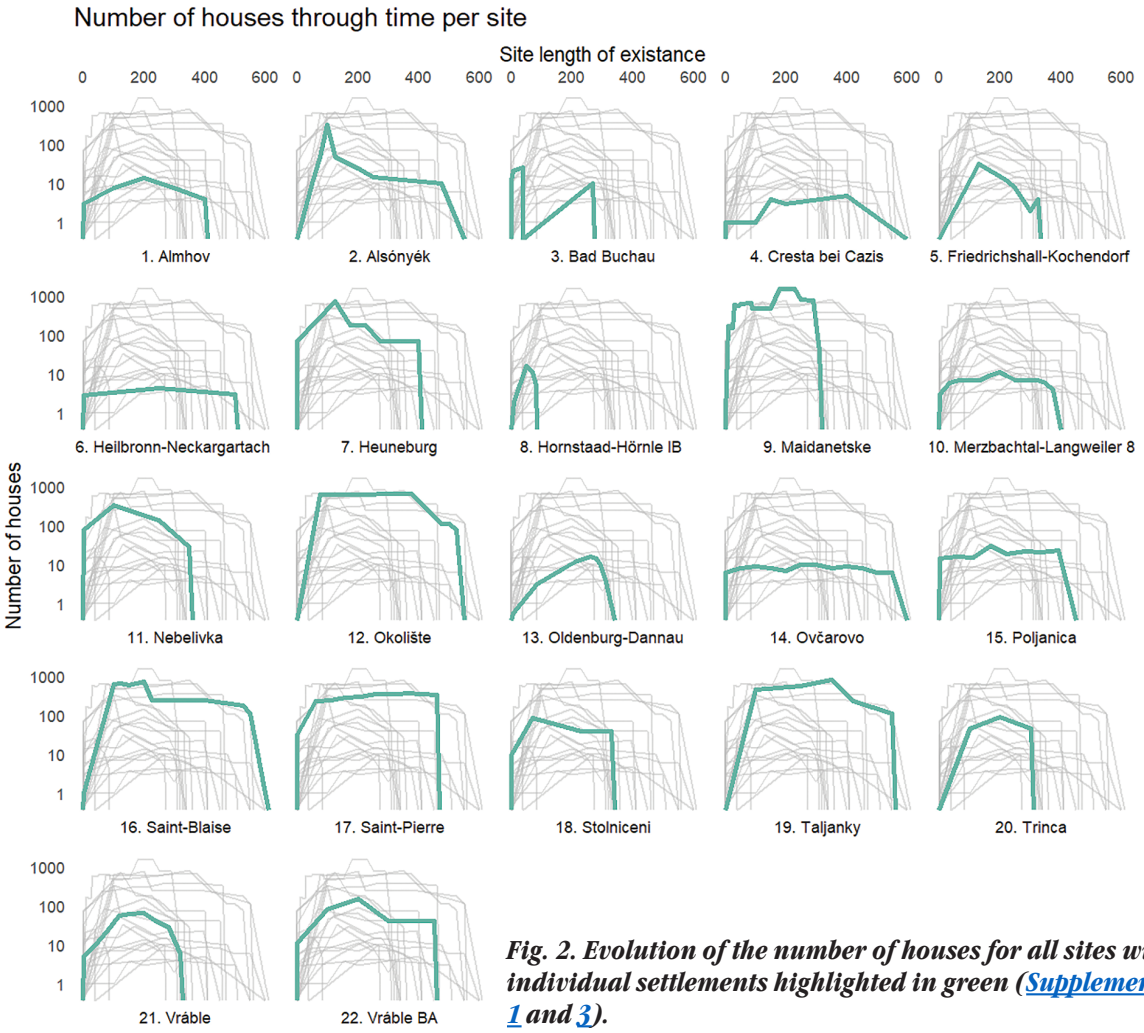

Fig. 2. Evolution of the number of houses for all sites with individual settlements highlighted in green (Supplements 1 and 3).

2 As this type of settlement is mostly dendro-dated and each site phase is defined as a site, categorizing such sites as one would make their duration comparable to that of the other sites. We chose not to do this, as explained below.

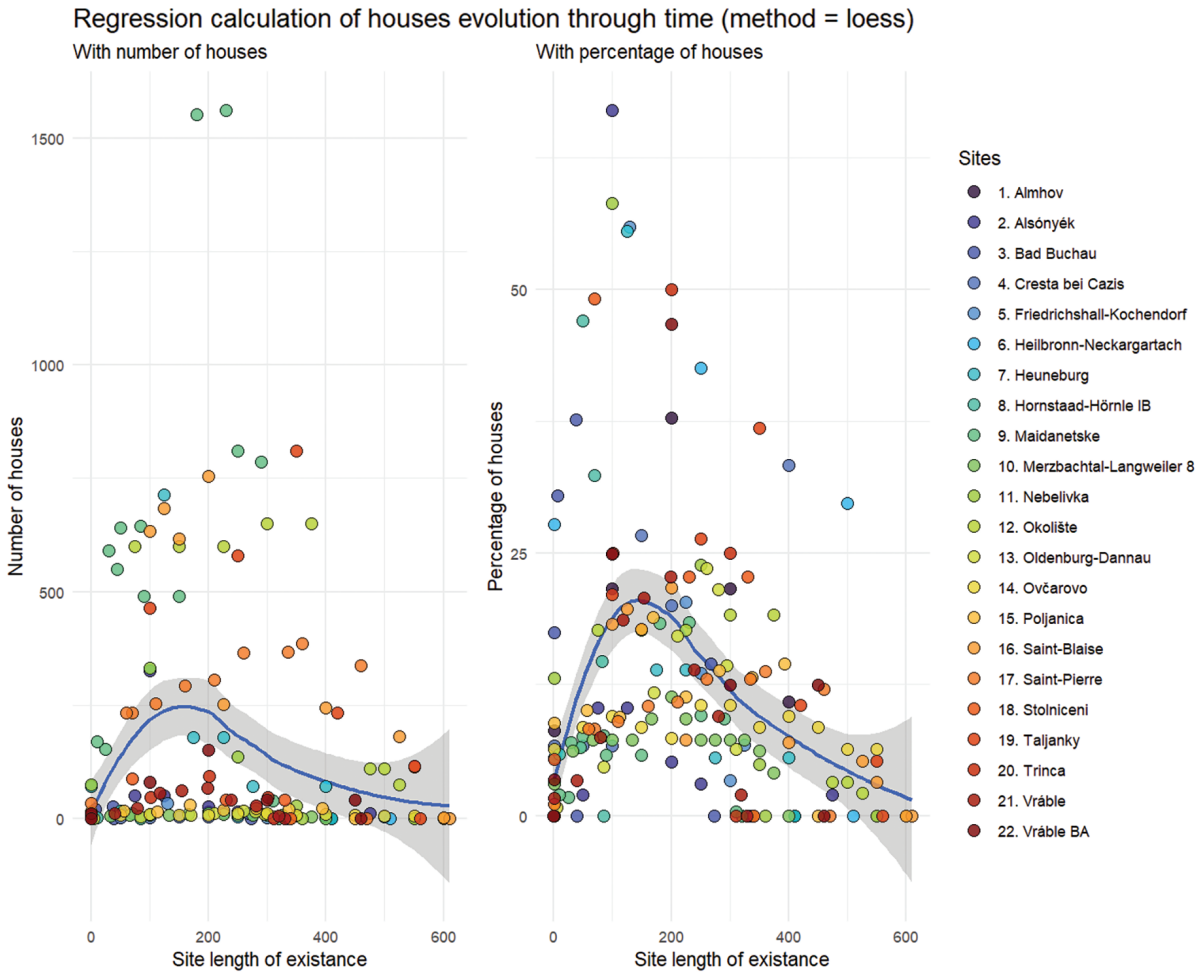

Fig. 3. Loess regression calculation of the evolution of the number of houses for all sites (Supplements 1 and 3). The figure on the left shows the actual number of houses for each phase of the sites, whereas the figure on the right shows the percentage of houses for each phase compared to the whole number of houses for the same site.

Should we or not consider every trace in a close radius as part of the same village? For simplicity, we decided to focus only on structures found in the same location.

The increase in population is most often explained by the natural growth rate of populations under sustainable ecological conditions and/or by the arrival of new settlers because of the attraction of aggregated living (*e.g.,* Vráble). However, different explanations have been offered for the population decline, linking it either to internal or external factors. These include (1) reaching a point of unsustainability by surpassing the ecological threshold; (2) reaching the original planned enclosure infrastructure; and (3) political and social tensions within agglomerated sites (*e.g.,* Maidanestke, Okolište) and destruction caused by conquering groups.

❶ In demography studies, it is currently established that sites grow until they reach a point of unsustainability, meaning that it is not possible for inhabitants to find resources anymore. Were this the case, our results would show that, in every circumstance, the resources necessary for a settlement to survive, whatever its size, are not able to grow more after 200 years of occupancy. This is relevant for food supplies (*Bernigaud* et al. *2023; Isoardi 2008.45–47*), but also related to the limitation of construction supplies and more particularly with regard to the wood needed to build and maintain houses in prehistoric temperate Europe. Indeed, after 200 years of use, the surrounding forest could be significantly reduced, preventing further settlement growth and explaining the slow decline in population numbers (*Péfau 2022; Baum* et al. *2020; Dal Corso* et al. *2019*).

❷ Furthermore, the lack of space in an elaborately built enclosed settlement could also be an explanation for the sudden stop in population growth and the consequent decline (*e.g.,* Bad Buchau). In other words,

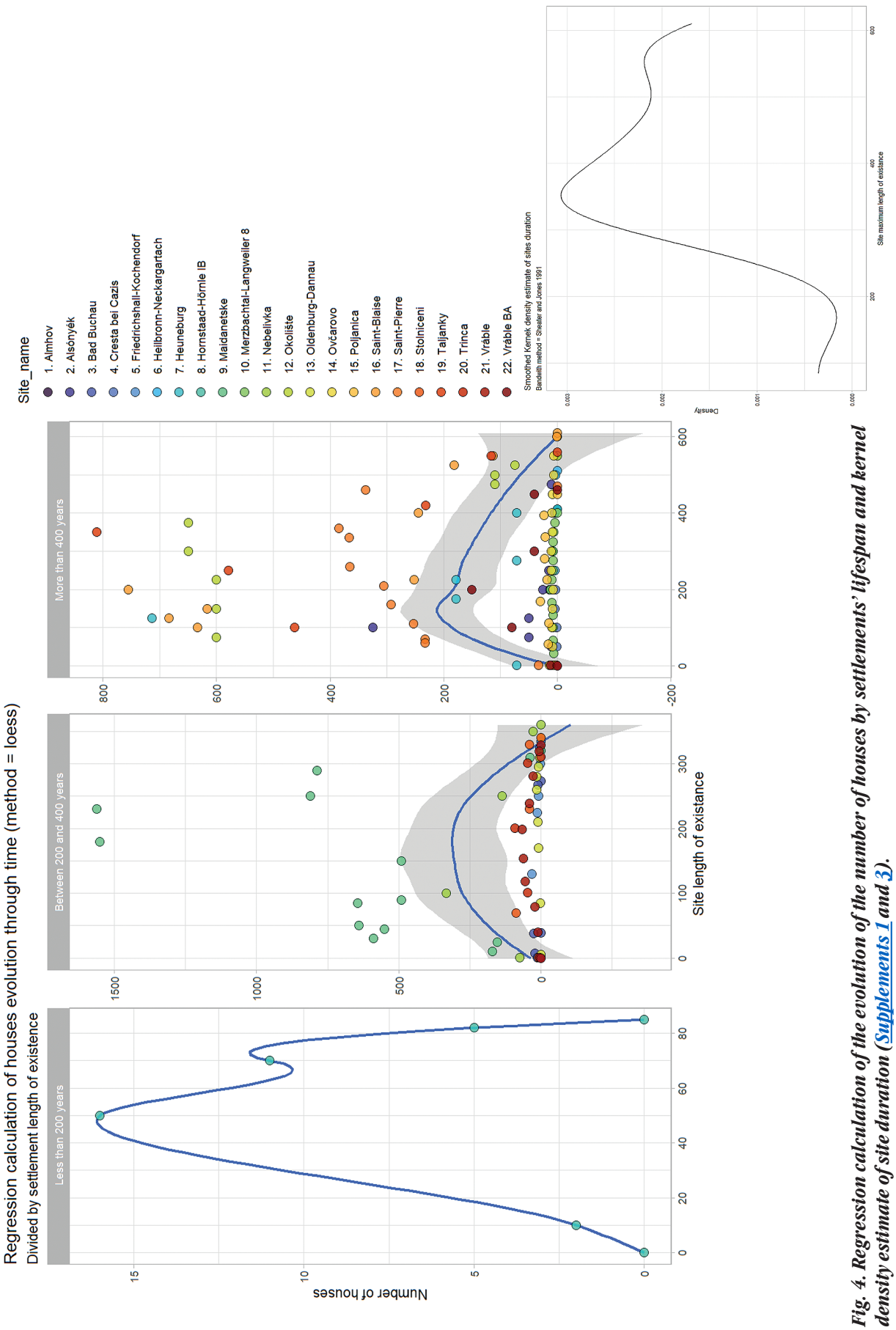

Fig. 4. Regression calculation of the evolution of the number of houses by settlements' lifespan and kernel density estimate of site duration (Supplements 1 and 3).

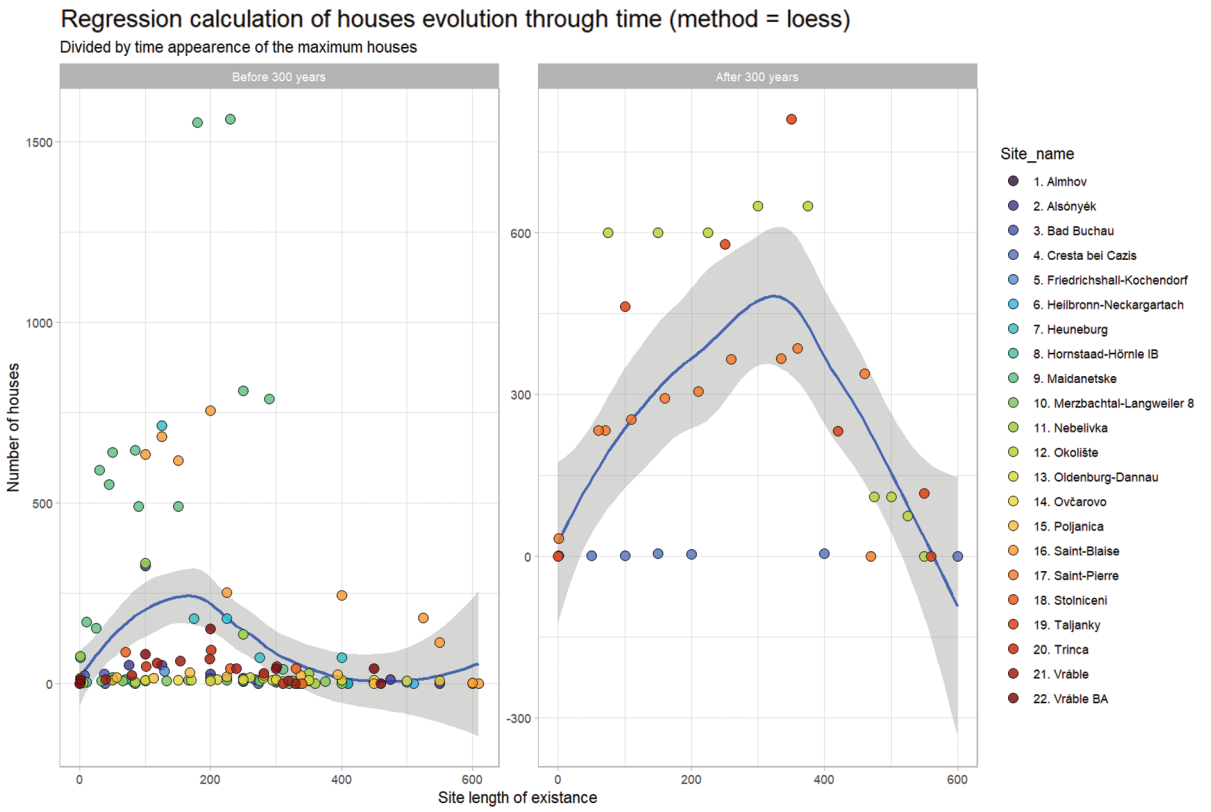

Fig. 5. Loess regression calculation for dataset sorted into two sub-groups: left, settlements where house numbers peak at or before 300 years, and right, settlements where house numbers peak after 300 years, divided by the time when the maximum of number of houses appeared (Supplements 1 and 3).

a decision made at the establishment of a village layout predetermined the limits of population growth.

❸ However, in many demographic studies, population developments alone are no longer linked to ecological thresholds. Population pressure as a prime mover for mobility has been strongly criticized (*Schmidt, Gehlen* et al. *2021*) and replaced by reasoning based on network laws, such as heritage and marriage patterns (*Müller 2017*) or cycles of political instability (*Kondor* et al. *2023*). Within our examples, the population reduction in Late Neolithic Okolište and the Late Hallstatt Heuneburg was linked in both cases to possible internal rebellions (*Kurz 2010; Müller* et al. *2011; Fernandez-Gotz 2017*), whereas in Chalcolithic Ukrainian mega-sites the phenomenon was related to political management problems (*Müller* et al. *2022*; *Hofmann* et al. *2019*). The lack of appropriate communication technologies or dispute mediation infrastructure likely influenced the collapse of these large villages. For instance, the introduction of adequate counting or writing systems, invented for an increasing population, could keep the interlinkage of the growing population possible *Kohler* et al. *2022*; *Müller* et al. *2022*).

For some sites researchers originally postulated a destruction by invaders, but at present other reasons for their sudden decline seem more probable, especially for tell sites and Trypillia mega-sites. The slow decline of the La Tène sites of Saint Blaise and Saint-Pierre can be explained by a political shift and the growing dominance in the region of the nearby Greek city of Marseille (*Isoardi 2013.16*). However, evidence of episodic war and destruction by the Roman infiltration at these La Tène sites ultimately caused their demise (*Isoardi 2013.19*).

The above observations can be described as endogegenous or exogenous factors which influenced settlement longevity, or a combination of both. The limits imposed by environmental and ecological conditions (in some cases also caused by abrupt climate change) represent an exogenous factor which, in some cases, only materializes through internal developments, including population growth. Endogenous factors, such as the social conflicts mentioned above, will in turn only materialize when the exogenous pressure, such as ecological limits, becomes effective.

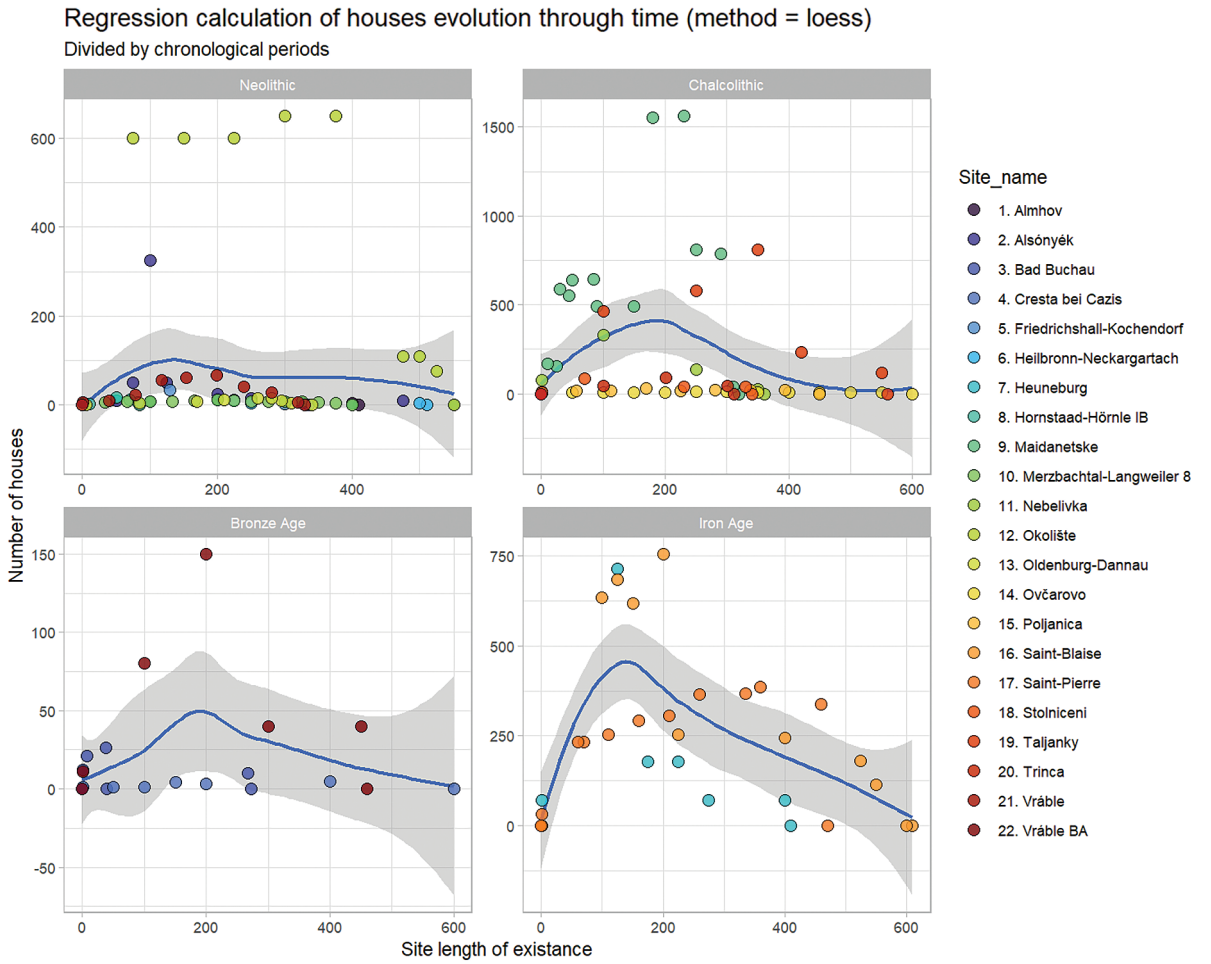

Fig. 6. Loess regression calculation of the number of houses per chronological periods (Supplements 1 and 3).

However, a more precise analysis of these interrelationships is only possible through studies on a less local and more regional or even continental scale. Even if these are available for several of the small regions concerned (*e.g.,* the Slovak Žitava valley with the Early Neolithic Vráble or the Sinyukha basin with the Ukrainian Chalcolithic mega-sites (*Furholt* et al. *2020; Müller* et al. *2016*)), where settlement changes go from dispersed to agglomerated and back to dispersed, a more detailed comparative analysis on a broader basis is required.

Indeed, it is tempting to consider the relationship between the pattern of boom and bust observed in this paper and those discussed for larger geographic and temporal scales (*Großmann* et al. *2023; Kondor* et al. *2023; Shennan 2018; O'Brien, Shennan 2009*). The The scope of the data used here, on a site-by-site basis, does not yet allow us to take this step, and requires a regional and, above all, long-term re-contextualization. In time, it will perhaps be possible to contextualize and understand the interaction and interdependencies of population changes at these different scales.

Enlarging the scope of the study could also help us answer other questions that arose over the course of our analysis. The slow but continuous decrease in population raises the question of what is happening to the inhabitants of these settlements. Are they leaving to move into another area? If this is the case, we should observe the creation of new settlements in the regional neighbourhood. We know that this is the case after the Roman conquest of Gaul, for instance, where some *oppida* were left after the creation of new Roman cities (*e.g.,* Bibracte was abandoned to the benefice of Autun). Is this process more widespread?

Or are the inhabitants dying because of deprivation and/or diseases? The birth rate may also be slowing, explaining the decrease in building new houses. These last questions could be solved by integrating graves and anthropological data into the analysis.

Conclusion

In conclusion, the present study shows a demographic tendency in which a population increase in prehistoric sites never lasted longer than about five to 10 generations (*c.* 200 years), regardless of the period and region where settlements were inhabited. There can be multiple explanations for the collapse of these sites, from societal and political to subsistence and productivity. Even though the data at our disposal in this study did not allow us to settle for one or the other as more important, it is most probable that a combination of factors influenced the pattern observed in settlement growth and decline. The slow decrease in population numbers following a quickly reached peak highlighted by our analysis probably impacted and changed the social practices within the settlements and their organization. It may also have changed their relationship with other settlements in the area, likely affecting the networks of power, communication and trade in a region. Therefore, the discovery of this pattern of 200 to 300 years is important in order to understand not only the life cycles of settlements, but also of regional trajectories.

This study was a first step in the detection of the demographic evolution of settlement sites throughout prehistory. There is still room for expanding this analysis by adding more settlements into our dataset and especially more sites from the metal ages to balance the data. Indeed, the dataset is still too small and also not diverse enough to generalize the results of this analysis to all European settlements. Structuring the sample by more explicit economic parameters would also be beneficial, by using factors such as the intensity of animal husbandry and importance of resource interdependence between producing villages. For example, including the specialized agro-pastoral subsistence economy from Alpine Neolithic settlements or late Iron Age *oppida* may explain some patterning in settlement population trajectories. Consequently, research strategies should aim to analyse many more such sites with corresponding data quality. In follow up studies, these results have to be considered on a larger scale in order to assess their involvement in the spatial organization of political, economic, and cultural networks.

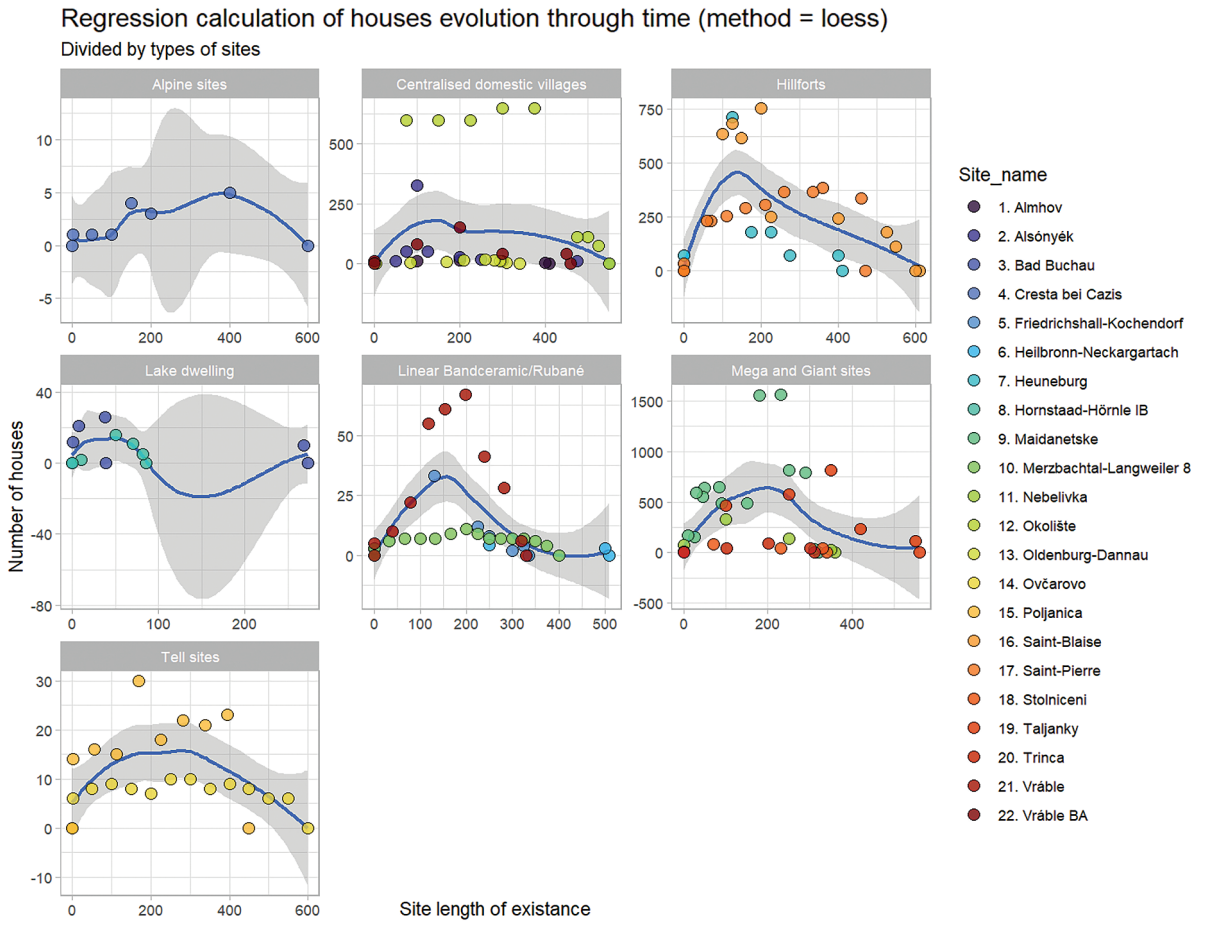

Fig. 7. Loess regression calculation of the number of houses per site types (Supplements 1 and 3).

But, as it appears, the observed pattern seems to be constant in the collected data, even when observing/examining different types of domestic settlements. Correlating with other available data, more specifically palynological and anthropological data, is required in further work to be able to more precisely identify the causes and consequences of this pattern.

Supplemental information can be found online at https://doi.org/10.4312/dp.50.22.

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Archaeology, rapid climate changes in the Holocene, and adaptive strategies

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ABSTRACT - *The article presents the concepts of repeating cycles of rapid climate variability in the Holocene, including rapid cooling cycles, cold events, ice-rafting events, and rapid climate change recorded in palaeoclimate archives. It also discusses the concepts of adaptation strategies embedded in the catastrophic scenarios of collapse on the one hand, and panarchy, resilience, and adaptation cycle on the other,* i.e. *the processes of transforming social hierarchical structures into dynamic, adaptive entities. In the rapid climate change series we focus on the 9.2 ka and 8.2 ka climate events associated with the Neolithisation process and the transition to farming. The 5.9 IRD event and/or period of rapid climate change from 6000–5200 cal yr BP are associated with the cultural, economic, and demographic collapse of the Early Neolithic Linear Pottery culture in central and western Europe. We also discuss the triad of recent weakening of North Atlantic ocean circulation, decreased solar activity, and the hypothesised transition to a cold period, the well-known historical scenario associated with the transition to Little Ice Age between 1450 and 1850.*

KEY WORDS – *Holocene; archaeology; rapid climate changes; adaptation strategies; 8.2 ka climate event; Neolithisation; Little Ice Age*

Arheologija, hitre klimatske spremembe v holocenu in prilagoditvene strategije

IZVLEČEK – *V članku predstavljamo koncepte ponavljajočih se nizov hitrih podnebnih sprememb v holocenu, vključno z nizi hitrega ohlajanja, hladnimi dogodki, dogodki s plavajočim ledom in nenadnimi podnebnimi spremembami, zabeleženimi v paleoklimatskih arhivih. Predstavljamo in analiziramo tudi koncepte prilagoditvenih strategij, vgrajenih v katastrofične scenarije kolapsa na eni strani ter panarhije, odpornosti in prilagoditvenega cikla na drugi strani, tj. procese transformacije družbenih hierarhičnih struktur v dinamične, prilagodljive entitete. V seriji hitrih podnebnih sprememb se osredotočamo na podnebne dogodke 9,2 ka in 8,2 ka, povezane s procesom neolitizacije in prehodom na poljedelstvo. Dogodek 5.9 IRD in/ali obdobje hitrih podnebnih sprememb od 6000–5200 kal pr. n. št. je povezano s kulturnim, gospodarskim in demografskim propadom zgodnje neolitske kulture linearne keramike v srednji in zahodni Evropi. Omenjamo tudi triado nedavne oslabitve cirkulacije severnoatlantskega oceana, zmanjšane Sončeve aktivnosti in domnevnega prehoda v hladno obdobje, ki je dobro znan zgodovinski scenarij, povezan s prehodom v malo ledeno dobo med leti 1450 in 1850.*

KLJUČNE BESEDE – *holocen; arheologija; nenadne podnebne spremembe; prilagoditvene strategije; 8.2 ka klimatski dogodek; neolitizacija; mala ledena doba*

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Introduction

In current discussions* of present climate anomalies and predictions, past climate variability is often overlooked. On the other hand, in archaeology the rapid climate changes of the past have not been properly contextualized or adequately conceptualized, and have often been simplistically and directly associated with the collapse of civilizations. In our paper we discuss the evolution of related concepts and interpretations, the causes of rapid climate changes and subsequent human adaptations during the last 12 000 years. Palaeoclimate archives reveal a succession of periods of varying length with cooling and droughts, warm periods, and regional heavy rainfall events. They include the well-known 8.2 ka and 4.2 ka events, the Late Antique Ice Age, the Little Ice Age, and the intervening Mediaeval Warm Period. In archaeological studies, these events are associated with global environmental catastrophes and collapses (economic, demographic, cultural, political) of cultures in prehistory and later civilizations. More recent interdisciplinary explanations have shifted the focus from a global framework to regional climate activities and from collapse to other adaptation strategies.

The first interpretations linking climate change to civilizational and cultural developments emerged in the early 20th century in the context of geographical, climatological, and archaeological studies. Sudden periods of drought and aridity were recognized as climatic and environmental factors that were associated with the catastrophic scenarios that afflicted Egyptian, Mesopotamian, and Indian civilizations, as well as with the invasion of Europe by nomadic peoples from Central Asia (*Huntington*, *Simpson 1926; Brooks 1926*). According to the adaptation scenario known as the oasis theory, climate determined the development of economic strategies, including the cultivation of plants and the domestication of animals, which were followed by agricultural development and cultural evolution (*Childe 1928*).

The catastrophe scenarios were recently replaced by the resilience and adaptive capacity scenarios, which include a society's ability to "*absorb energy and to redirect or to convert it, without losing the fundamental features and shape of the system as a whole*" and to adapt "*to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities*" (*Degroot* et al. *2021.543*). The United Nations Intergovernmental Panel on Climate Change (IPCC) has played a key role in contextualizing and promoting both concepts (*Matthews 2018*). The concept of resilience is used in very different scientific fields and contexts. It first appeared in the psychology of the individual and then spread and evolved in interdisciplinary approaches in the environmental sciences, human sciences and humanities (see below for details). The term is often understood as the opposite of vulnerability, namely, the susceptibility of a social unit to existential threats from disturbances that may lead to its dissolution or destruction (see *van Bavel* et al. *2020*). However, Martin Endreß, Lukas Clemens, and Benjamin Rampp (*2020.1*) suggested that resilience and vulnerability can be simultaneously conceptualized as complementary – vulnerability is a necessary condition for resilience, and *vice versa*.

Toward the end of the 20th century, climatologists working on the Cooperative Holocene Mapping Project (COHMAP) introduced the long-term climate change model, which covers the last 18 000 years. Using radiocarbon dated proxy data (water levels in lakes, pollen in lakes and plankton in marine sediments, changes in the height and area of ice sheets), the project documented global climate changes at 3000-year intervals. COHMAP concluded that these intervals were caused by changes in cosmic rays and decreased and consequently altered atmospheric air circulation on Earth (*COHMAP members 1988*). The first change, the Holocene interval between 13 000 and 10 000 years BP, was linked to the Neolithic Revolution and the transition to farming in the Middle East. It was seen as human beings' first response to "*a unique sequence of climatic events*" (*Wright 1993.466*).

In the 21st century the INTIMATE Project Group (INTegration of Ice-core, MArine, and TErrestrial records) and the Subcommission on Quaternary Stratigraphy (SQS) with the International Commission on Stratigraphy (ICS) suggested that two rapid climate change events – the 8.2 ka event and 4.2 ka event – represent the boundaries between early and mid-Holocene, and mid- and late Holocene. Using chemical proxy data (changes in the ratio of stable oxygen isotopes $^{18}O/^{16}O$ and water evaporation D/H), the sudden and substantial cooling and drought of the first event is best documented in the Greenland ice core NGRIP1,

* This is an amended and updated English version of the article published in Arheo (*Budja 2022*).

but is also documented globally in lake pollen and deep-sea plankton sediment records, as well as in cave speleothems. The second is not recorded in the ice core, but is well documented across all continents in pollen, lake diatom and deep-sea planktonic records, cave speleothems and altered monsoon cycles (*Lachniet 2009; Walker* et al*. 2012; 2018; Lowe, Walker 2015.428–433;* see also *Moossen* et al. *2015*).

In archaeological studies (details are below), the relations between prehistoric cultures and climate changes were determined using various theoretical standpoints and interpretative contexts, even ones that were mutually exclusive. First, the determinist model of unilinear cultural evolution and diffusion saw any change in human behavioural patterns, economic or technological development or cultural trajectories as directly associated with climate and environmental changes. On the other hand, there was also the categorical denial of the environment as a possible cause of cultural change, and any attempt to link the two was seen as environmental determinism (*Jones* et al. *1999*). Similarly, processual archaeology (New Archaeology) saw the development of prehistoric societies as entirely dependent on successfully adapting to climate and environmental changes (*Binford 1968; Tainter 1988*). Later, post-processual archaeology found studies of human-environment interaction to be determinist. This approach, according to post-processual archaeology, was based on the assumption that external environmental processes were the main contributing factor to cultural change, which does not acknowledge the historic contingency of human activity (*Hodder 1982; 2000; Ingold 2000;* for an example of the transition to farming*,* see *Gremillion* et al. *2014*). More recent interdisciplinary approaches are often limited to temporal correlations between rapid climate change and archaeological cultural change (*Rohling* et al. *2019*), and emphasize the continuum of interaction between cultural systems and environmental processes, *i.e.* environmental and cultural coevolution (*e.g.,* the concepts of a cultural niche and the archaeology of climate changes) (*Izdebski* et al. *2016; Rockman, Hritz 2020; Rick, Sandweiss 2020; Burke* et al. *2021*).

Replacing long-term climate changes with the rapid changes

In palaeoclimatology, models of long-term changes have been replaced by those focused on rapid changes with substantial decreases in temperature, including rapid cooling cycles, (as well as ice-rafting events), rapid climate change, and cold events. Gerard Bond *et al.* (*1997; 1999*) introduced the concept of cooling cycles as eight repeating cycles of rapid cooling. These were characterized as climate events associated with depositing ice-rafted debris, so-called IRD events, which occurred along the North Atlantic in the interval of ~1470 ± 500 years. Bond's group associated these with influxes of large quantities of cold glacial water, impacting the circulation of the North Atlantic Gulf Stream. These influxes were documented using stone debris transferred by icebergs broken off from the Arctic ice caps and deposited in deep-sea sediments. Using radiocarbon dating of planktonic foraminifer shells from two North Atlantic deep-sea cores, the nine IRD events in the Holocene were dated in the core VM 29-191 in the following sequence: 12.5, 11.1, 10.3, 9.5, 8.2, 5.9, 4.3, 2.8 and 1.4 cal 10^3 yr BP (*Bond* et al. *1997.Fig. 2.1*). The increased influxes of glacial meltwater into the ocean were associated predominantly with periods of low solar activity (*Bell 1971; Bond* et al. *2001*). However, new deep-sea cores in the eastern and western Mediterranean have not confirmed Bond's cycle model. Rapid cooling occurred in an interval of 2300–2500 years in the eastern Mediterranean (*Rohling* et al. *2002a*), and in intervals of 1300, 1515, 2000 and 5000 years in the western (*Rodrigo-Gámiz* et al. *2014*). These changes were exclusively associated with cycles of higher or lower solar activity and ultraviolet radiation, as well as changes in the thickness of the ozone layer, which led to temperature changes in the lower parts of the stratosphere and consequently to occasional outbreaks of polar air masses toward the south of the northern hemisphere. The consequences were increased activity of the Siberian anticyclone and the overflow of Arctic air during the winter and spring months in the Mediterranean. Rapid cooling has been documented in three deep-sea cores (south Adriatic Sea IN68-9, south-east Aegean Sea LC2 and the LC31 core west of Cyprus) in a sequence of cold events 3.0–3.8 (LC21 only), 5.8–6.7, 7.9–8.6, (9.5–10.0, Adriatic only), 11.0–13.4, and (poorly defined) 16–18 kyr cal BP (*Rohling* et al. *2002b.40*). A concurrent sequence of is also documented in the Adriatic Sea (*Siani* et al. *2013*).

The model of rapid climate changes was developed by Paul A. Mayewski *et al.* (*2004*; see also *Anderson* et al. *2007*). Using more than fifty palaeoclimate archives, they modelled a series of six sudden, sharp, and rapid global temperature declines (rapid climate change or

RCC) that were repeated over periods of 2800–2000 and 1500 years. In the Western Mediterranean, intervals of 1300, 1515, 2000, and 5000 years were later included in the model, as mentioned above (*Rodrigo-Gámiz* et al. *2014*). They are embedded in radiocarbon calendar series between 9000–8000, 6000–5000, 4200–3800, 3500–2500, 1200–1000 and after 600 cal yr BP or cal b2k. The first cooling in this series is known as the 8.2 ka event (*Alley* et al. *1997*) or the 8200 yr BP event (*Mayewski* et al. *2004.252*). It was caused by a large influx of glacial meltwater into the North Atlantic. All other rapid climate changes are associated with changes in solar activity, radiation, and solar irradiance. They are all characterized by cooling of the northern hemisphere, tropical droughts, and changes in atmospheric circulation.

A contrasting pattern has been documented in the Alps and part of central Europe in the latitudinal belt between 43° and 50° north. Pollen deposits, palaeohydrological and other proxy data from lake sediments indicate a particularly wet period at the time of the first climate event. Lake water levels show fluctuations and a sequence of rising, falling, and rising again (*Magny* et al. *2003*). A similar sequence in the Mediterranean has also been documented in relation to the 4.2 ka event. Humid periods and high lake levels during *c.* 4300–4100 and 3950–3850 BP were interspersed with periods of severe cooling and drought with low lake levels between *c.* 4100–3950 BP, although it should be noted that this activity was regional and heterogeneous (*Magny* et al. *2009a*; *2012; Bini* et al. *2019*).

In their contribution to the IPCC's Fifth Assessment Report a few years ago, Working Group I replaced the word 'rapid' with 'abrupt' in relation to climate change. They defined this as a "*large-scale change in the climate system that takes place over a few decades or less, persists (or is anticipated to persist) for at least a few decades and causes substantial disruptions in human and natural systems*" (*Stocker* et al. *2013.1448*). These changes are apparent in the collapse of individual climate system components, such as the collapse of the Atlantic meridional overturning circulation, glacier collapse, permafrost carbon release, methane clathrate release, the disappearance of tropical and boreal forests, the disappearance of summer Artic sea ice, prolonged droughts, and the collapse of monsoon circulation (*Stocker* et al. *2013.1114–1118, Tab. 12.4*).

Related to Bond's series of rapid cooling events is a model of cold events, a century-long set of global climate anomalies. The model is based on analysis of proxy data on temperature, precipitation, and glacial dynamics preserved in various palaeoclimatic archives on land, in lakes, in the deep sea, and in ice cores (*Wanner* et al. *2008; 2011; 2012*). During the Holocene, six events of sudden temperature decline have been documented. The first, the 8.2 kyr BP event, took place 8300–8100 years ago. However, it is worth noting that the estimated temperature declines related to this event occurred in different regions over a longer period of 400 to 600 years (*Rohling, Pälike 2005*). Three more follow in prehistory: the second event 6.5.–5.9, the third 4.8–4.5 and the fourth 3.3–2.5 took place 6400–6200, 4800–4600 and 2800–2600 years ago. The fifth event 1.75–1.35 and sixth event 0.7–0.15 occurred 300–600 and 1200–1800 years ago, and are associated with the so-called Dark Ages and Migration Period, and the Little Ice Age, respectively (*Wanner* et al. *2011*).

In a parallel study, Shaun A. Marcott *et al.* (*2013*) used 73 palaeoclimate archives in the northern and southern hemispheres to track global temperature trends over the past 11 300 years. A warming phase in the early Holocene (10 000–5000 years BC) was followed by a cooling at ~0.7°C in the middle (<5000 years BC) and late Holocene, reaching its lowest point during the Little Ice Age about 200 years ago. Two years later, Heiko Moossen *et al.* (*2015*) noted a similar North Atlantic trend of declining land and ocean surface temperatures. Terrestrial temperatures were highest in the early Holocene (10.7–7.8 kyrs BP), while at sea level they were highest in the mid-Holocene due to the influx of glacial meltwater (7.8–3.2 8 kyrs BP) (Fig. 1). They identified two warm periods in the early Holocene between ~8.9–~8.5 kyrs BP and ~8.1–~7.9 kyrs BP, both coinciding with periods of intense solar activity. The 8.2 ka event is unfortunately poorly documented in the core of the Danish peninsula Vestfirdir in this context. Two periods of rapid warming were also noted in the mid-Holocene at ~7.6 and ~7.3 kyrs BP. In the first, sea level temperatures increased by ~5°C (0.5°C per decade), while in the second period temperatures increased by ~4°C and persisted for 1400 years. The temperature increases were correlated with Bond cycles 5 and 4. Between ~5.8 and ~3.2 kyrs BP there was a period of decreasing temperatures and new glaciation. In the late Holocene (~3.2–~0.3 millennia ago), two warm and two cold periods were documented, the first between

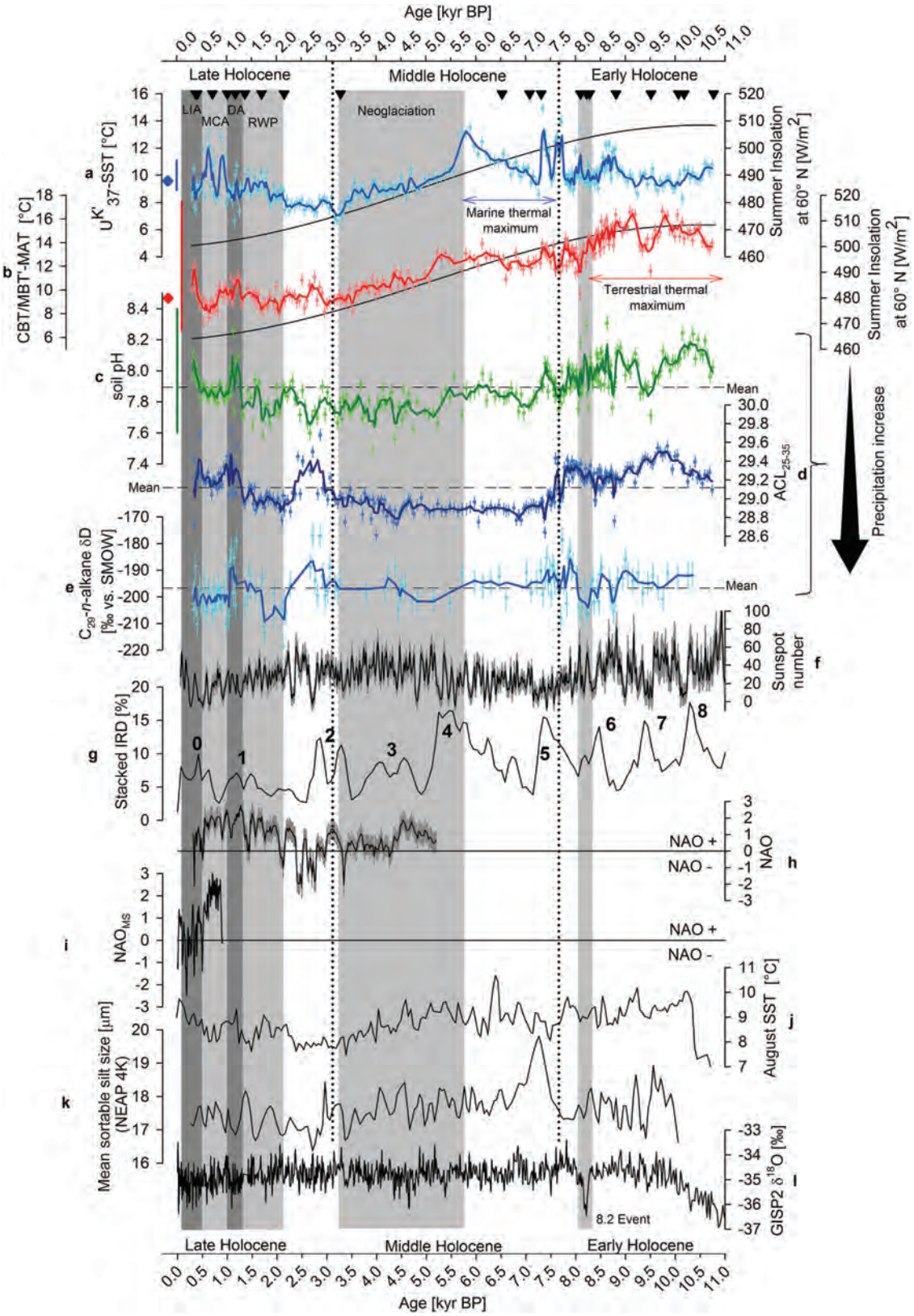

Fig. 1. A comparison of the Icelandic climate records with other North Atlantic palaeoclimate records. The Little Ice Age (LIA), Mediaeval Climatic Anomaly (MCA), Dark Ages (DA), Roman Warm Period (RWP), neoglacial period, and 8.2 ka event are highlighted in shades of grey. Reprinted from Moossen* et al. *2015. North Atlantic Holocene climate evolution recorded by high-resolution terrestrial and marine biomarker records.* Quaternary Science Reviews 129: 115, Fig.6. *Reprinted with permission from Elsevier. For an explanation of the figure legend, see https://doi.org/10.1016/j.quascirev.2015.10.013.

~2.2–~1.3 and ~1.1–~0.5 kyrs BP, and the second between ~1.3–~1.1 and ~0.5–~0.3 kyrs BP. The former was associated with the Roman Warm Period (RWP) and the latter with the Early Middle Ages (Dark Ages). A more recent Holocene palaeotemperature database is available in Darrell Kaufman *et al.* (*2020*) as well as online (*Temperature 12k Database, www.ncdc.noaa.gov/paleo/study/27330, https://doi.org/10.25921/4ry2-g808*).

Corresponding with the rapid climate changes and the cold events is a sequence of fifteen events with higher lake levels documented in 26 lakes in the northern French Prealps, the Jura and the Swiss Plateau. Radiocarbon dates determined the following sequences: 11 250–11 050, 10 300–10 000, 9550–9150, 8300–8050, 7550–7250, 6350–5900, 5650–5200, 4850–4800, 4150–3950, 3500–3100, 2750–2350, 1800–1700, 1300–1100, 750–650 years BP (*Magny 2004; Magny, Haas 2004; Magny* et al. *2006; 2009b*).

Periods of high precipitation have been documented in the central Mediterranean at *c.* 10 200, 9300, 8200, 7300, 6200, 5700–5300, 4800, 4400–3800, 3300, 2700–2300, 1700, 1200 and 300 years BP. In the middle Holocene a contrasting pattern of precipitation regimes is notable, with wet winters and dry summers documented north of the parallel 40° north, and wet winters and wet summers documented south of it. In the late Holocene the pattern reverses (*Magny* et al. *2012; 2013; Peyron* et al. *2013*).

Rapid climate changes in archaeological studies

In archaeology a variety of theoretical approaches and interpretive contexts have been used to establish links between prehistoric cultures and climate changes (a detailed review and examples follow below, see also *Trigger 1971; 1996*). From the beginning, these links were embedded in a deterministic view of unidirectional cultural evolution and diffusion, in which any change in human behaviour patterns, economic or technological developments, and cultural trajectories was seen as directly correlated to climate and environmental changes (*Clark 1936; Childe 1958; Shennan 2005*). Similarly, the New Archaeology viewed the development of prehistoric societies as entirely dependent on how successfully they adapted to such changes (*Binford 1968; Tainter 1988*). In contrast, post-processual archaology assumes that it was human activities that triggered such changes, including changes in the natural environment (*Hodder 1986; Tilley 1994*).

Similarly, interdisciplinary studies have consistently associated the dynamics of archaeological landscape change and cultural change during the Holocene with climate and environmental change at regional and global scales (reviewed in *Berglund 2003; Brown, Bailey, Passmore 2015*). The correlations were created by ^{14}C dating of archaeological settlement contexts and palaeoclimate archives. The latter are preserved in a variety of environments: glacial (ice cores), geological (marine and terrestrial), and biological. A key element in these archives is the proxy data on past climate fluctuations, including stable oxygen and carbon isotopes, dust particles, various gas concentrations in air bubbles in ice; glacial and periglacial deposits, surface erosion, palaeosols, volcanic eruptions; biochemical markers in animal and plant plankton fossils, stable oxygen and carbon isotopes in deep-sea sediments and sapropel deposits; pollen and plant macrofossil remains in marine and terrestrial sediments, diatoms, ostracods, insects, and stable isotopes in lake sediments; stable oxygen and carbon isotopes in dripstone; the circumference of tree rings and the stable carbon isotopes they contain; and stable carbon isotopes deposited in fossil cereal grains. The proxy data allow the reconstruction of long prehistoric sequences of temperature and precipitation periods and shifts, solar irradiance and associated climate fluctuations, changes in sea and lake levels, and changes in vegetation cover (*Bradley 1999; Briffa 2000; Sachs* et al. *2000; Barber* et al. *2004; Jones, Man 2004; Magny* et al. *2004; Marino* et al. *2009; Steinhilber* et al. *2012; Riehl* et al. *2014*).

The first comprehensive correlation between rapid climate changes, archaeological cultures and past cultural dynamics on a global scale appeared in a palaeoclimate interpretative context. It was grounded by statistical analyses of anomalies in the distribution of 815 radiocarbon dates related to pollen distribution, sea level changes, and peat accumulations in palaeobotanical records, and 3700 ^{14}C dates associated with 155 archaeological settlement and cultural sequences (*Wendland, Bryson 1974; Bryson 1988*).

Deterministic catastrophe interpretations, which assumed rapid climate change as the cause and demographic and civilizational collapse and dark periods as the consequences, remained dominant. The best known examples are the end of the Fifth and Sixth Dynasties in Egypt, the invasion of Egypt by the Sea Peoples in 1177 BC; the end of Mycenaean Greece, the decline of the Hittite and Akkadian empires, the end

of the Third Dynasty of Ur in Mesopotamia (*Carpenter 1966; Bell 1971; Bryson* et al. *1974*; *deMenocal 2001; Cline 2021*). These were all associated with sudden cooling and drought, and the desertification of the regions. The legitimacy of the perception of catastrophic events was based on the postulate that the dark ages and climate fluctuations were a factor in history (*Bell 1971*).

Much attention has been focused on the Tell Leilan event, the gap in the settlement sequences in tell sites (Tell Leilan, Tell Brak, Tepe Garwa) in northern Mesopotamia about 2200 years ago that marks a rapid change in climate, desertification of the region, the collapse of the irrigation-based economy, and the resulting collapse of the Akkadian Empire (*Weiss* et al. *1993; Courty, Weiss 1997; Weiss, Bradley 2001; Cullen* et al. *2000; deMenocal 2001.669*). A similar scenario was assumed for the collapse of Classic Maya culture (*Hodell* et al. *1995; deMenocal 2001.670; Haug* et al. *2003*).

However, Karl W. Butzer (*1972; 1975; 2012; Butzer, Endfield 2012*) pointed out the conceptual weakness and interpretive limitations of the deterministic approach. As an alternative to the postulate of climate as the sole cause of the collapse of past civilizations, he proposed an interdisciplinary approach, which he called cultural ecology, emphasizing pre-industrial societies still affected the ecological balance in their regions, leading to an economic, demographic and cultural slippage that resulted not in collapse but in cultural and economic adaptation to the new environment. A similar view is also found in the French Annales approach, where it is emphasized that the impacts of climate change on past societies were indirect and hardly noticeable. The Little Ice Age and the outbreak of the plague at the end of the 16th century, as well as the widespread crisis in 17th century Europe, were cited as examples. Le Roy Ladurie (*1971.17*) claimed that famines, pandemics, migrations, insufficient food production, and high food costs are not and cannot be facts which are strictly climatic. Crawford S. Holling (*1973*), on the other hand, introduced to ecology the concept of resilience, emphasizing that all natural systems have the capacity to absorb environmental and climatic disturbances without changing dramatically. However, resilience is limited, and when changes reach a critical point the system will transform and adapt to the new conditions.

A paradigm shift

In the mid-1970s the palaeoclimatologist Wallace S. Broecker (*1975*) was already warning about pronounced global warming, while the palaeo-oceanographer John Imbrie and his daughter Katherine Palmer Imbrie (*1979*) were predicting that the use of fossil fuels would lead to a super-interglacial age, unlike anything experienced in the last million years. With the publication of the IPCC's first report and assessment of the state of the climate system, including projected future changes, in 1990, acceptance of the global warming scenario increased rapidly. The shift in paradigm from rapid global cooling to global warming was based on new proxy data, and the correlation between past gas concentrations in the atmosphere and the climate changes in ice and deep-sea palaeoclimate archives, the application of General Circulation Models (GCM) to atmosphere and ocean circulation, and the increase in global atmosphere temperatures in the last century (*Chambers, Brain 2002; Alley* et al. *2003*). The IPCC's fourth report, comprised of the working reports of three different work groups (the second dealt with impacts on the environment and human adaptation to climate change), emphasized that the growing concentrations of greenhouse gases after 1750 were the consequence of human activity. Neither the concentrations of carbon dioxide (CO_2) or methane (CH_4) in the past 650 000 years, nor the concentrations of nitrous oxide (N_2O) in the past 16 000 years, have ever been as high as they are now (*Parry* et al. *2007; Bernstein* et al. *2008*). The increased concentrations of carbon dioxide and methane in 8000–5000 BC were linked to the Neolithic beginnings of agriculture, decreased forest areas in Europe, and the spread of rice fields and their irrigation systems in India and China (*Ruddiman 2003*).

In contrast, the rapid decline in average surface temperatures and salinity in the Labrador Sea water column that began in the second half of the 20th century remains a major challenge in predicting rapid cooling (*Lazier 1995; Dickson* et al. *2002*). The temperature and salinity declines indicate a weakening of the Atlantic Meridional Overturning Circulation (AMOC), which transports warm/cold water and low/high salinity water from one part to another (thermohaline circulation). This circulation is key to heat redistribution on our planet and, together with the atmospheric circulation (North Atlantic Oscillation, NAO; Arctic Oscillation, AO; and Mediterranean Oscillation, MO), has been a major influence on global climate vari-

ability in the past (see below). Changes in circulation have been associated with changes in solar activity (*Usoskin 2008; 2017; Usoskin* et al. *2016*), on the one hand, and rapid changes between warm and cold periods in the Younger Dryas (12 900–11 600 years BP) (*Rahmstorf 2002; Caesar* et al. *2021*), Medieval Climate Anomalies (*c.* 900–1300 AD), and the Little Ice Age (1450–1850 AD) (*Bradley* et al. *2003; Velasco Herrera* et al. *2015; Zharkova* et al. *2015; Fogtmann-Schulz* et al. *2021*), on the other.

It should be noted that glacial periods and interglacial periods are not uniformly cold or warm. The Greenland palaeoarchives indicate considerable climate variability and a succession of cold and warm periods, but also transitions that may have been so brief that they were overlooked in earlier studies. Such transitions can last decades or a century, as can warm periods followed by cold periods of several centuries or millennia. More than ninety events, *i.e.* climate oscillations and abrupt climatic events that relate well to stratigraphic and temporal boundaries in the proxy data, have been documented in three chronologically synchronized Greenland ice core records – NGRIP, GRIP, and GISP2 – dating back to 120ka b2k2 (*i.e.* 120 thousand years BP) with high stratigraphic and temporal resolution. All events occur in irregular succession, and 25 sudden and rapid transitions from cold to warm periods, which can last several decades, are particularly striking during the last glaciation. Temperatures range from 5°C to 16°C. Warm periods last from a century to several millennia, and temperatures decrease gradually. Cold periods are characterized by a more stable climate, and their duration is similar to that of warm periods (*Rasmussen* et al. *2014*). Macrofossil plant and animal remains in the Lena River delta on the Arctic Ocean and sediments from Kotokel Lake near Lake Baikal in Siberia confirm high annual temperatures during warm periods of the last ice age. Chironomidae larvae prove that summer temperatures were between 1.5°C and 3.5°C higher than today (*Tarasov* et al. *2021; Wetterich* et al. *2021*).

The sequences of Medieval Climate Anomalies (known as the Medieval Warm Period and Medieval Climatic Optimum) between 900 and 1300 AD and the Little Ice Age between 1450 and 1850 AD are also informative in the interpretative context of paleoclimatology, historical climatology, and regional paleoclimate modelling. Interpretations of the former rely on statistical analysis and reconstruction of past climate from proxy data, while the latter relates historical data and proxy data on a limited scale.

The collection of global proxy data and the regional reconstructions of rapid (decades-long) climate changes should also be mentioned (*Goose* et al. *2006; Ludwig* et al. *2019; Pfister* et al. *2018*), since changes at the global scale are not necessarily synchronous. Awareness of their short- and long-term impacts on society (*Mann 2012; Parker 2013; White* et al. *2018*) therefore remains as important as predicting trends in climate variability (*Jones, Osborn, Briffa 2001; Bradley* et al. *2003; National Research Council 2006; PAGES 2k Consortium; Neukom* et al. *2019*). Indeed, it is hypothesized that the trajectory from the Mediaeval Warm Period to the Little Ice Age was a global scenario that could be repeated in the present, since the past increase in global surface temperature was certainly not due to human activity in the pre-industrial period (*Lamb 1965; 1982*). The trajectory can also be described as a transition from settling and dairy farming in Greenland and Iceland during the Medieval Warm Period, to famines and plague epidemics in southeastern Europe during the Little Ice Age (*Xoplaki* et al. *2001; Mann 2002a*).

Recent paleoclimatological studies have focused on the asynchronicity of climatic events and the fact that average surface temperatures during the Middle Ages in the northern hemisphere were never as high as in the second half of the 20th century and early 21st century. The warmest period was between 950 and 1100, but temperatures at that time were between 0.1°C and 0.2°C below the average temperatures measured between 1961 and 1990 (*Jones* et al. *1998. 468–469*). The magnitude of warming today is global, but the Middle Age warm periods were asynchronous and regional. They occurred in the northern hemisphere between 830 and 1100, and between 1160 and 1370 in the southern. Similarly, the cooling and transition to the Little Ice Age occurred first in the Arctic, Europe, and Asia, and only later in North America and the southern hemisphere, as indicated by paleoclimate proxy data. The major climate fluctuations and the onset of the Little Ice Age on a global scale, with variations in solar magnetic activity, changes in atmospheric air circulation and ocean currents, and volcanic eruptions (*Mann* et al. *2008. 13255; PAGES 2k Consortium 2013.342*; see also *Bradley* et al. *2003; Wanner* et al. *2008*). A solar activity cycle immediately before the Wolf Minimum between 1260 and 1270 marks the beginning of the transition to a cold period.

We mentioned earlier the correlative processes of recent weakening of North Atlantic ocean circulation, decreased solar activity, and the hypothesised transition to a cold period (*Thompson, Wallace 2001; Rahmstorf 2002; Mörner 2015; Velasco Herrera* et al. *2015; Caesar* et al. *2018.195*). The triad contradicts the claims that "*[t]here is no impending little ice age*" (Ask NASA Climate 2020) and that "*[t]here were no globally synchronous multidecadal warm or cold intervals that define a worldwide Medieval Warm Period or Little Ice Age*" (*PAGES 2k Consortium 2013.339*). However, climate reconstructions of the past 2000 years based on palaeoclimate proxy data on surface temperatures (tree rings, pollen, corals, lake and marine sediments, ice cores, stalagmites, and historical data) at 511 sites in different regions of the world show "*a clear regional expression of temperature variability on the multidecadal to centennial scale, while a long-term cooling trend before the twentieth century is evident globally*" (PAGES 2k Consortium 2013.344).

Not to be overlooked is the critical commentary on the Intergovernmental Panel on Climate Change (UN) reports on climate trends in the 21st century published by a group of interdisciplinary researchers in the special volume titled *Pattern in Solar Variability, their Planetary Origin and Terrestrial Impacts* in the journal *Pattern Recognition in Physics* (*2013*; http://www.pattern-recogn-phys.net/special_issue2.html).

They wrote that "*[o]bviously, we are on our way into a new grand solar minimum. This sheds serious doubts on the issue of continued, even accelerated warming as claimed by the IPCC project*" (*Mörner* et al. *2013.206)*. The journal was discontinued a year later, in 2014, by the publisher Copernicus Publications for "*malpractice in scientific publishing*" (https://www.pattern-recognition-in-physics.net/). It is noted that the co-editor of the journal was Sid-Ali Ouadfeul of the Algerian Petroleum Institute, the articles were considered scientifically questionable, and the editors corrupt. However, we have already entered a period of decreased solar activity known as the Modern Grand Solar Minimum, which will last from 2020 to 2053. It is believed to be similar to the Maunder Minimum associated with cold periods of the Little Ice Ages (*Mörner 2015; Zharkova 2020*).

The politicization of global warming, global warming models (including factors such as greenhouse gases, tropospheric aerosols, solar and volcanic activity, and land use changes), and the global climate system are well presented in *The Palgrave Handbook of Climate History* (see *Brönnimann 2018; Oreskes* et al. *2018; Zorita, Wagner 2018; Zorita, Wagner, Schenk 2018*).

We have already mentioned that the Little Ice Age between 1450 and 1850 was not a uniform cold period. Large climatic variations are documented for the years 1675–1715 and 1780–1830. The largest are embedded between 1697–1708, in a period of extremely harsh climatic conditions and probably the coldest decade in the northern hemisphere during the last millennium. Average winter temperatures were 3–4°C and spring temperatures were 2°C lower than in the 20th century. Palaeoclimatological models of summer temperatures and dendrochronological data have shown that the summers of 1695, 1698, and 1699 were among the coldest in the northern hemisphere in the last 600 years. On the other hand, there were also extremely hot summers during this period, in 1707 and 1710. Long winters and frosts, as well as rainy summers and floods, posed many problems for agriculture. Snow, which lingered in the Balkans and eastern Mediterranean until late spring, made sowing impossible and caused the loss of winter cereals, while crops were destroyed by droughts, early hoarfrost, and autumn snow. Advancing glaciers covered several villages and pastures in the Alps. Fodder became scarce and many livestock perished at this time. Famines in the British Isles, Scandinavia, western and southeastern Europe, and the eastern Mediterranean caused several plague epidemics and had a major impact on demographic change (*Jones* et al. *1998; Briffa* et al. *1998; Luterbacher* et al. *2001; Slonosky* et al. *2001; Xoplaki* et al. *2001; Mann 2002b.504–509; Bradley* et al. *2003*).

The beginning and end of the Little Ice Age coincide with periods of low solar activity known as the Spörer Minimum (1440–1460) and Dalton Minimum (1809–1821). A period of great climate variability and extremely harsh climatic conditions in between coincides with the Maunder Minimum (1675–1715). Palaeoclimatologists have linked solar cycles and low solar activity to the weakening of the Atlantic Meridional Overturning Circulation (*Slonosky* et al*. 2001; Rahmstorf 2002; Steinhilber, Beer 2011; Velasco Herrera* et al. *2015; Mörner 2015; Zharkova 2020;* see also *Mörner, Tattersall, Solheim 2013; Mörner* et al. *2013*), and altered atmospheric circulation (North

Atlantic, Arctic, and Mediterranean Oscillations). This relates to the fluctuation of atmospheric pressure and air mass movement between the Icelandic low-pressure area (Icelandic cyclone) and the Azores and Siberian high-pressure area (Azores anticyclone and Siberian anticyclone), which affect the climate in Eurasia, the Mediterranean, and the Arctic. Fluctuation indices describe the changes and differences in air pressure and intensity, as well as the direction of air mass movement in these areas. Positive North Atlantic Oscillation index values indicate that air pressure over the Atlantic and western Europe is higher than average. Westerly winds are stronger and moving northward. Temperatures are significantly higher and western Europe is wetter, while most of the Mediterranean experiences periods of decidedly dry weather. With a negative index, the westerly winds are weaker and the influence on the climate reverses. During the negative phase of the Arctic Oscillation, air pressure is higher than average over the Arctic and lower over the North Atlantic. Cold polar air moves south across the Mediterranean Sea to North Africa. These two phenomena are particularly pronounced in the cold part of the year (*Marshall* et al. *2001; Shindell* et al. *2001; Thompson, Wallace 2001*; *Wanner* et al. *2001; Dünkeloh, Jacobeit 2003; Toreti* et al. *2010; Roberts* et al. *2012; Tubi, Dayan 2013*).

We can see a similar climatic scenario the late Middle Ages. According to Bruce M. S. Campbell (*Campbell 2016*), it was embedded in the period 1270–1470 and had three key episodes. The first, between 1260/70 and 1220, was associated with the Wolf Solar Minimum and the end of strong solar activity and above-average global temperatures. The second, middle episode occurred between 1340 and 1370 and is characterized by greatly reduced solar activity, significantly narrower tree rings between 1342 and 1354, and severe cooling in the northern hemisphere with an influx of polar air southward, weakening monsoons and drought in South Asia, and stronger monsoons and floods in Africa. Similar climatic events continue in the third episode between 1370 and 1470, which partially coincided with the Little Ice Age and was characterized by high and low solar activity (the Chaucerian Maximum and the Spörer Minimum). Campbell has linked this triad to significant economic decline, the Hundred Years' War in western Europe, the collapse of the Eastern Roman Empire, the wars of conquest of the Ottoman Empire, the end of the Silk Road (an intercontinental economic, trade, technological, and cultural network and long-distance travel route), famines, ectoparasites that decimated sheep and cattle herds, and plague epidemics in animals and humans. He characterized these processes as "*interactions between nature and society*" and called them "*the great transition*" (*O.c. 1*). He introduced the perception of a global historical trajectory where natural processes are the main triggers for demographic, economic, social, political, and cultural change. A year later, Geoffrey Parker (*2013*) also linked climate events and natural disasters in the 17th century, during the Little Ice Age, to global economic, health, demographic, and political crises. In this context it is also worth mentioning the connection between a cooling cycle in the Late Antique Little Ice Age of 536–660 and the Justinian Plague, the transformation of the Eastern Roman Empire, the migration of the Pannonian Avars and the Slavic peoples, the decline of the Sasanid Empire and the Eastern Turkic Khaganate, and the political upheavals in China (*Büntgen* et al. *2011; 2016*) (Fig. 2).

Concerns about human impact on the recent warming of the Earth's atmosphere and the growing knowledge of the frequency, rate, and extent of climate changes in the past led to a series of reflections on past environmental catastrophes and how humans responded to them. In this context, the catastrophe approach and the concept of collapse became very popular as a single-cause interpretive hypothesis, linking rapid cooling cycles, droughts, and floods to the collapses of earlier hunter-gatherer communities in southwest Asia, Bronze Age civilizations in the Aegean, eastern Mediterranean, and southwestern Asia, the Akkadian Empire in Mesopotamia, the Old Kingdom in Egypt, pre-Columbian Maya and Moche civilizations in Central and South America, and the Norse Greenland societies (*Arneborg* et al. *1999; Cullen* et al. *2000; Gill 2000; deMenocal 2001; Van Buren 2001; Hodell* et al. *2001; 2005; Williams 2002; Haug* et al. *2003; Stanley* et al. *2003; Dillehay* et al. *2004; Fagan 2004; Diamond 2005; Rodning 2010; Parker 2013; Brooke 2014; Campbell 2016; Kaniewski, Van Campo 2017; Bar-Yosef, Bar-Matthews, Ayalon 2017*). Jared Diamond (*2005.3,6,20*) was the only one of these authors to point out the complexity of these processes and the overlooked fact that examples of past civilization collapse (population decline and/or decline in political, economic, and social complexity over a significant area over an extended period of time) were not necessarily the cases of true ecological collapse, but of collapse caused by unsustainable survival strategies, poor management of natural resources, and ecosystem degradation.

Conceptualization adaptation strategies

Collapse is the most radical adaptation strategy used by past societies (*Tainter 2000a.332*). Using systems theory and catastrophe theory, Colin Renfrew (*Renfrew 1979a; 1979b*) defined it as an allactic type of cultural change characterized by two developmental trajectories: anastrophe and catastrophe. The former is associated with an increase in organizational complexity and centralization, the emergence of new bureaucratic and other forms of power structures, and consequently the increased use of economic resources. The latter relates to the disintegration of centralized and socially structured complex societies and their regressive reformulation into fragmented and disjointed chiefdoms and tribal communities. In both cases, the key elements are bifurcations, points of separation where the system chooses its own trajectory,

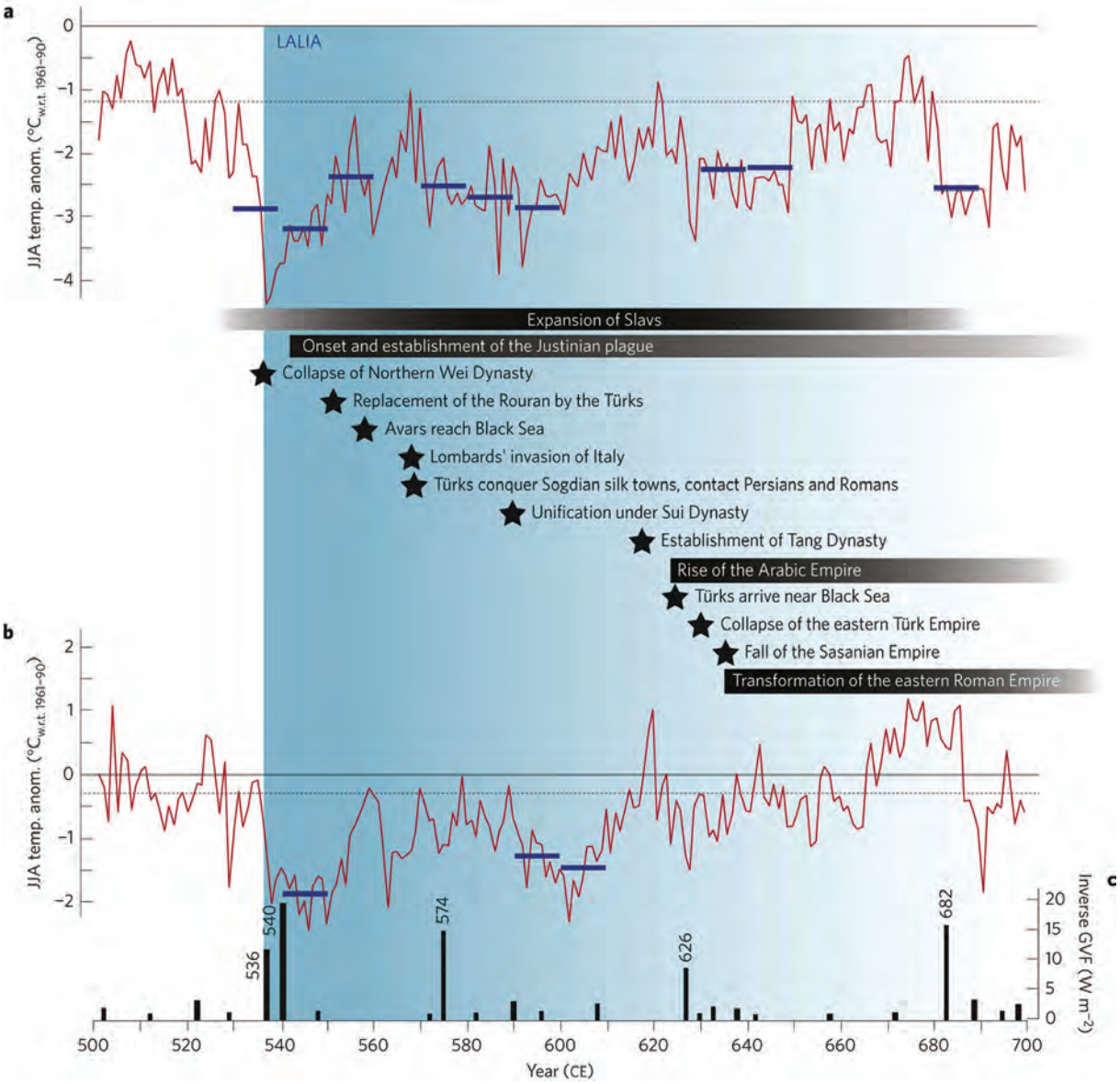

Fig. 2. Cooling and historical events during the Late Antique Little Ice Age. Reprinted from Büntgen* et al. *2016. Cooling and societal change during the Late Antique Little Ice Age from 536 to around 660 AD.* Nature Geoscience 9: 234, Fig. 4. *https://doi.org/10.1038/ngeo2652. Reprinted with permission from Springer Nature License. For an explanation of the figure legends a-b, see O.c. 234, Fig. 4.* a–c *Reconstructed summer temperatures from the Russian Altai* (a) *and the European Alps* (b)*, together with estimated volcanic forcing14* (c)*. Blue lines highlight the coldest decades of the Late Antique Little Ice Age that range among the ten coldest decades of the Common Era (AD). Horizontal bars, shadings and stars refer to major plague outbreaks, rising and falling empires, large-scale human migrations, and political turmoil. Black dashed lines refer to the long-term reconstruction mean of the Common Era (AD).

always bounded by the old systemic postulates of politics, economics, technology, and value. Bifurcations also mean points of destabilization, where even small internal and/or external triggers (climate change, political and economic aberrations, war, and migration) can produce large but gradual changes. Collapse is thus a transformational process that can take centuries, returning to less structured and less connected tribal communities. However, Renfrew also predicted that in marginal areas some of the earlier social structures would survive, triggering a process of renewed transformation into complex and centralized communities.

Joseph A. Tainter (*1988*) also defined the collapse of complex prehistoric and historical societies as a political process in which the society rapidly loses its achieved level of social and political complexity within a few decades. This leads either to its demise or to a new cycle of development. Similar to Renfrew, Tainter also assumed that this process is related to the economic effect of marginal return and how societal elites can facilitate short-term adaptation to a changing natural environment through economic strategies and intensive resource use. However, through misguided economic policies and overdeveloped social structures the elites can also trigger collapse (*Tainter 2006a*). Tainter built on James G. Miller's (*1978*) Living Systems Theory, according to which living systems are organized into interacting and interconnected subsystems, their interaction and interplay and relationship with the environment. The basic premise is that nature is a continuum of complex life organized in different patterns that are repeated at all levels of the system. However, Tainter (*2000b; Tainter, Crumley 2007*) pointed out an important difference in this context. In contrast to ecological systems, social systems develop a complexity and sustainability that are connected to the environment through an interface, *e.g.,* the process of problem solving. Thus, sustainability depends not only on the stability of the ecological system, but primarily on successful problem-solving processes. Sustainability is not the passive maintenance of equilibrium (*i.e.* stasis) in the sense of fewer and fewer people using fewer and fewer natural resources, but the achievement of rapid development and continuous functioning of the systems, organizations, and technologies needed to solve problems. This, of course, leads to increased complexity and an increased expenditure of labour, time, money and energy.

For Tainter complexity is therefore an economic function and a fundamental problem-solving tool. Complexity in human social systems correlates to *"structure and behavior, and/or degree of organization or constraint",* and the "*variety of mechanisms for organizing these into a coherent, functioning whole*" (*Tainter 1988.23; 2006b.92*). He defined sustainability as "*maintaining or fostering the development of the systemic contexts that produce the goods, services, and amenities that people need or value, at an acceptable cost, for as long as they are needed or valued*" (*Allen, Tainter, Hoeckstra 2003.26*). According to the economic principles of diminishing returns and marginal utility introduced by the neoclassical school of economics, such problem solving can only be successful within a certain period. Gradually, the point is reached where further investment in complexity no longer yields an adequate return, and higher input leads to lower output. When marginal utility is reached, each further investment in complexity contributes less to the total return than the previous investment. After an extended period of diminishing returns, problem solving becomes ineffective, sustainability becomes unstable, and societies become vulnerable. Problem-solving trajectories can span decades, generations, or centuries. They can lead to three outcomes: collapse, adaptation and recovery at a lower level of complexity, or maintenance of sustainability by increasing the level of complexity and using alternative resources. Sustainable development, then, is the ability of a society to maintain the continued functioning of its political and social structures, its hierarchy, and its continued access to economic resources (*Tainter 2006b.92; 2014.202*). As examples, he cites the collapse of the Akkadian Empire, the Eastern Roman Empire, and the Maya civilization on the one hand, and the resurgence of the Byzantine Empire and colonial Europe on the other.

An interpretative approximation to sustainability is resilience, or the ability of a system to adjust its configuration. Timothy F. H. Allen, Joseph A. Tainter, and Thomas W. Hoekstra (*2003.26*) caution against distinguishing between these two terms, as sustainability involves the ability to maintain the continuity of social systems and the conditions under which they function, whereas resilience is the ability to reconfigure social systems and adapt them to function under new circumstances. Resilience, then, is the abandonment of the principles of sustainable functioning. In contrast, Fikret Berkes *et al.* (*2003.2,6*) erase the distinction by defining sustainability as a dynamic

process and the ability of societies to adapt to climate and environmental changes. At the same time, they understand sustainability as "*maintaining the capacity of ecological systems to support social and economic systems*". They link resilience to the ability to adapt to changes within cycles of growth and renewal.

We have mentioned elsewhere (*Budja 2015*) that Crawford S. Holling introduced the concept of resilience to ecology in the early 1980s. Later it was associated with the adaptive cycle and the hierarchy of ecological and social systems (*Holling 1986*). He called it panarchy[1] and embedded it in the context of adaptive change theory (*Holling, Gunderson, Ludwig 2002.21–22*). For Holling and Lance H. Gunderson, panarchy is "*a representation of a hierarchy as a nested set of adaptive cycles. The functioning of these cycles and the communication between them determines the sustainability of a system*" (*Holling 2001.396; Gunderson, Holling 2002; Gunderson* et al. *2002.14–16*). In other words, we are talking about a hierarchical structure in which natural and social systems are interconnected in a continuum of adaptive cycles of growth, accumulation, restructuring, and renewal that does not have a "*rigid, predetermined path and trajectory*" at the level of households, villages, or regions (*Holling, Gunderson 2002.51*; see also *Gunderson* et al. *1995; Folke* et al. *1998*).

Panarchy in this context objectifies a cycle with four phases of processes and events (Fig. 3). The first, the r-Phase, is characterized by exploitation, rapid migration to uninhabited or sparsely populated areas, rapid population growth, new technologies, and survival strategies. The second, the K-Phase, is characterized by a period of conservation or stagnation, mismanagement, and increasing rigidity. The third, the Ω-Phase is a period of release or creative destruction and chaotic problem solving, economic disincentives, collapse, and resettlement. The fourth and final phase, the α-Phase, is a period of reorganization and renewal (*Gunderson, Holling 2002; Berkes* et al. *2003; Walker, Salt 2006.163; Folke 2006; Scheffer 2009; Aimers, Iannone 2014*). It should be noted that due to sudden, unpredictable, and prolonged events and processes that occur outside of these cycles, especially in the adjustment phase, complete collapse and permanent disruption of the system continuum is possible. Holling (*2001.399*) associates this with extended and cataclysmic events.

Panarchy is thus a model for the transformation of hierarchical structures into dynamic adaptive units that respond to even small perturbations in the transition from the growth phase to the Ω-Phase of collapse and transformation, and in the transition to the α-Phase of rapid growth. Cross-scale dynamics and interactions are emphasized, where revolt is followed by creative destruction and leads to a memory process. This leads to transformation and renewal. Memory preserves both history and experience about how the system works, providing "*context and sources for renewal, recombination, innovation, novelty, and self-organization following disturbance*" (*Folke 2006.259*). In other words, social (collective) long-term memory preserves information about under-

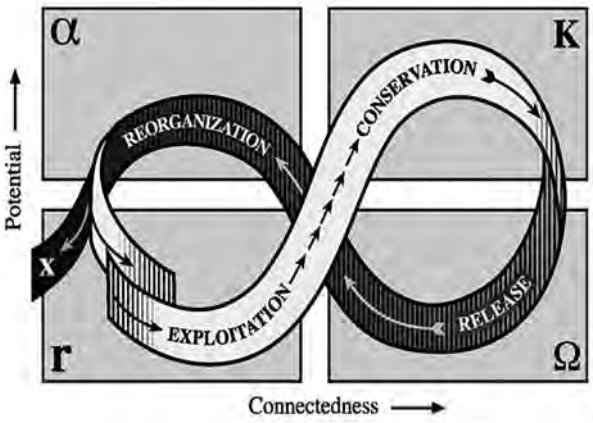

Fig. 3. Holling's continuum of adaptive cycles (*Holling 2001.394, Fig. 4*). Four ecosystem and economic functions (r, K, Ω, α) and the cycle of events are shown. The Y-axis denotes the potential for resource accumulation and the X-axis denotes the degree of linkage between the variables. The x marks the exit from the cycle and indicates the transition to a less productive and less organized system. Short, closely spaced arrows indicate a slowly changing situation; a long dotted arrow indicates a rapidly changing situation.

1 The term Panarchy was coined from the words 'pan' and 'hierarchy', illustrating the correlation between change and permanence, the predictable and the unpredictable. Gunderson and Holling (*2002.5*) bring together the name of the Greek god Pan, representing change and unpredictability, and the word hierarchy, signifying structures that maintain system integrity and allow for adaptive evolution. It is worth pointing out that the term panarchy has been used in philosophy since as early as 1591. It was introduced by Franciscus Patricius in his work *Nova de universis philosophia*, which comprises four parts: *Panaugia*, *Panarchia*, *Pampsychia*, and *Pancosmia*. As part of the systems theory, it stands in contrast to hierarchy. See also Sundstrom and Allen (*2019*).

standing the dynamics of past environmental change and also about experiences related to rapid climate change and subsequent adaptations (*McIntosh* et al. *2000.24*). Panarchy is simultaneously creative and conservative, striking a dynamic balance between rapid changes and traditions on the one hand, and disturbances and interactive cross-scale dynamics on the other. The system simultaneously conserves and evolves (*Holling 2001*). Resilience thus means the ability to continually reformulate existing social structures, hierarchies, and economic practices and to restart the cycle again and again – that is, to preserve the capacity for sustainable development (*Smit, Wandel 2006; Nicoll, Zerboni 2020*; for an overview and critique of these concepts see *Soens 2020*).

John Haldon and Arlene Rosen (*2018*) developed a new approach to Formal Resilience Theory (*i.e.* Theory of Adaptive Change) using examples from late antiquity and the early Middle Ages. The basis of the theory remains the adaptive cycle in which the Social-Ecological System functions in several stages that range from "*increasing complexity, interconnectedness, and conservatism (growth or r-phase*)" to the stage where "*networks are over-connected (stability, K-Phase), limiting the system's ability to respond effectively to exogenous or endogenous stress points of stress*". This is followed by the Ω-Phase (catastrophic shift), a release that "*opens the system to many possible responses, new and/or traditional*". The Ω-Phase quickly transitions to the α-Phase, which is "*highly resilient and loosely structured, resulting in reorganization of the system and leaning to a new equilibrium with different key characteristics from those that previously dominant*" (*Haldon, Rosen 2018.277*). Catastrophic system-wide change occurs only when most of the various cycles of adaptation fail.

Historical geography and palaeoecology have also placed collapse into historical trajectories of vulnerability and environment-culture interaction scenarios. These maintain the supposition that the collapse of past civilizations is the direct consequence of climate change, referring to different economic development and demographic models based on the evolutionary paradigm of the gradual, continual and unilinear development of past societies. At the beginning of the vulnerability trajectory, they embedded the extremely vulnerable Mesolithic hunter-gatherers and Neolithic farmers, followed by less vulnerable complex and centralized and then highly productive agrarian-urban societies. However, the latter become vulnerable again in overpopulated regions and when resource areas are overexploited. In the former, the collapse of the entire cultural-demographic system is the only response to climatic events. It is in the latter that the development of adaptive practices appeared, the beginning of which is associated with the onset of the agricultural revolution at the end of the 18th century (*Messerli* et al. *2000*).

In the context of environment-culture interactions, Paul Coombes and Keith Barber (*2005*) present four different responses of past societies to climate and environmental change. The first is the collapse of settlements and abandonment of marginal lands due to subsistence degradation, causing local populations to fall below minimum sustainable levels. In the second, there is a partial decline of settlements in marginal areas because the subsistence base deteriorates, so that the local population remains above the maximum sustainable level. In the third scenario, environmental changes lead to a sudden change in modes of agricultural production, accompanied by advances in technological and socioeconomic complexity. The scenario is based on the model of Ester Boserup (*1965; 1988*) in which demographic growth and limited economic resources (intensive use and/or loss of subsistence resources due to climatic anomalies) forced past societies to innovate and reform their production methods. The fourth response predicts the general collapse of social structures in both core and peripheral regions. It is based on the cascading failure of past complex social systems, using the key concepts of fractals and self-organized criticality from theoretical physics. It involves a simple, repeating pattern of critical events in the natural environment, politics, economics, and social relations (*Brunk 2002*). Any of these events can cause the gradual decline of a social system. For this reason, Coombes and Barber (*2005.309*) believe that the general collapse of a self-organizing system can be caused by any critical event, but they agree that the collapse of the Mesopotamian and Central American civilizations was the result of rapid climate change and associated global cooling and drought.

There has been much discussion about the definitions and relationships among the concepts of vulnerability, adaptation, and resilience, and it has been pointed out that the third has often been defined ambiguously or flexibly and cannot be related to the former two (*Brand, Jax 2007; Haldon, Rosen 2018*). The interpretative context for all three remains dominated by

collapse and disaster (*Gallopín 2006; Endfield 2012; 2014; Van Bavel* et al. *2020.2–42*).

Recent attempts to apply panarchy and adaptive cycles in archaeology have appeared in three publications. The first, *Resilience and the Cultural Landscape* (*Plieninger, Bieling 2012*), is a compilation of studies on cultural landscapes shaped by human-nature interaction. The second, *Adaptive Cycles in Archaeology* (*Bradtmöller, Riel-Salvatore, Grimm 2017*), focuses on prehistoric archaeology, which "*provides a wide spectrum of examples from which we can learn about sustainable and resilient behaviours of given groups as well as about the successful transformations of human systems that managed to maintain their integrity in the face of challenging ecological fluctuations and social turning points*" (*Grimm, Riel-Salvatore, Bradtmöller 2017.1*). The editors warn of the problems in correlating cultural and climate sequences on the one hand, and the definition of complexity on the other. Also problematic is the application of two of Holling's (*2001*) key parameters that allow the system to change in adaptive cycles, namely internal connectedness and potential. In archaeological interpretations, these are transformed into complexity within prehistoric mental and socio-ecological systems. A later work proposed replacing the two parameters with complexity proxies: subsistence, demographic trends, social organization, and technological development/innovation (*Bradtmöller, Grimm, Riel-Salvatore 2017.5–7*). The third publication, *Archaeology, Climate, and Global Change*, a special issue of the *Proceedings of the National Academy of Sciences of the United States of America* (117/15, 2020; http://onlinedigeditions.com/publication/?m=25371&i=657377&p=1&ver=html5), contains five articles on adaptation strategies related to climate change in the past on a global level. The role of archaeology is discussed in the context of interdisciplinary studies of past, present, and future climate changes and related ecological challenges (*Rick, Sandweiss 2020*). Finally, it is worth noting a number of articles that use millennia of prehistoric and historic regional cultural trajectories and climate dynamics to critically consider the validity and usefulness of Formal Resilience Theory and provide a new approach to the concept of adaptive cycles (*Allcock 2017; Haldon, Rosen 2018; Izdebski, Mordechai, White 2018; Xoplaki* et al. *2018*).

We have to mention resilience and the associated adaptive cycle in the context of human ecodynamics, *i.e.* the study of long-term change in socioecological systems. The study includes a human behavioural ecology and a cultural niche construction (*Fitzhugh* et al. *2019*). Human ecodynamics is defined as "*an umbrella term to describe humans and their environments as made up of landscapes and seascapes, and it involves collaboration between archaeologists ... and researchers from other human, social, and natural sciences*" (*Holm 2016.307*). It is not an interpretive model, although the authors and the editors of *Human Ecodynamics in the North Atlantic: A Collaborative Model of Humans and Nature through Space and Time* (*Harrison, Maher 2014.3–4*) ambitiously assign it the role of a new paradigm that, through an interdisciplinary research approach, enables us to understand past human-environment interactions and formulate predictions about how humans will respond to climate change, which could lead to various forms of adaptation and growth, but also to collapse. However, the approach can be characterized as an interdisciplinary study of the coevolution of natural and socioeconomic systems in different environments over time, with archaeology playing the central role in understanding the relationships between people and their environment and in identifying problems related to the sustainable development of modern societies (*Van der Leeuw, Redman 2002*; *Degroot* et al. *2021*). Most important in this context is the collection, comparison, and correlation of palaeoclimate proxy data from archaeological records on local and regional levels (*Kirch 2005; Fitzhugh* et al. *2019.1085–1086*; *Sandweiss 2017*).

It is also worth mentioning the attempt to define an archaeological event in the context of past climate changes and its importance in predicting an uncertain future. Relying on the Badiou's, Žižek's, and Deleuze's philosophical conceptual reflections and seven interpretive postulates, Lull *et al.* (*2015.30*) labelled the event as a concept that should be avoided in archaeology and, in particular, should not be included in the prediction of future events because "*it is not necessary to forecast an uncertain future, since the future of past events is also past to us*".

Finally, let us present the definitions of resilience and adaptation given by the IPCC, which should be generally accepted in interdisciplinary research. Here, resilience is defined as *"[t]he capacity of social, economic and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity and structure while also*

maintaining the capacity for adaptation, learning and transformation", and adaptation is the human "process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities" (*Matthews 2018.1812*). Interestingly, similar definitions of resilience as a community's ability to withstand and recover from stresses, and the postulate that the resilience of societies and their ecosystems plays a key role in ensuring our continued development in the future, appeared decades ago in an archaeological study of Aegean prehistory (*Weiberg 2012.150*). The concepts of panarchy, adaptive cycles, and resilience are presented in this study as a substitutes for systems theory, and as a conceptual tool to bridge the gap between processual and post-processual archaeology.

Rapid climate changes, prehistoric cultures and the collapses or adaptations

Little thought has been given to equating the adaptive cycle with the cultural cycle and introducing the latter into archaeology. Andreas Zimmermann (*2012*) introduced the cultural cycle as a proxy for external factors (climate change) associated with the mobility of agrarian, pre-state societies. He placed it in the context of cultural evolution and linked it to the concepts of developmental stages, cultural transformations, and Childe's (*1936*) revolutionary trajectory of civilization, known as the Neolithic-Urban-Industrial Revolutions. For central Europe, therefore, cultural cycles and epochs are assumed to overlap with a four-stage demographic model with the population growth from 1 person per 100km^2 in Mesolithic hunter-gatherer societies to 0.6 to 1.8 persons per 1km^2 in the Neolithic, Bronze Age, and Iron Age to 24 to 25 in the Roman period, after the Migration Period and before the Industrial Revolution, and to 50 persons after the Industrial Revolution (*Zimmermann 2012.251, Fig. 1*; see also *Widlok* et al. *2012*). The Neolithic Pfyn and the Linear Pottery cultures contributed a few years later to the description of the cultural cycle as a succession of four panarchic phases. Demographic trends, which can be deduced from the number of coexisting settlements, houses and wooden palisades, served as a variable to delimit and confine the phases. They were correlated with rapid climate fluctuations, *i.e.* the IRD 5b event (*Gronenborn 2012; Gronenborn* et al. *2014*) that is well documented in palaeoclimate archives but considered insignificant (*Peters, Zimmermann 2017*).

Of particular interest is on the other hand the relationship between the culture cycle and the theory of gene-culture coevolution and dual inheritance transmission (*Cavalli-Sforza, Feldman 1981; Boyd, Richerson 1985*), which is based on Darwin's concept of evolution and contrasts with Binford's (*Binford 1972. 431*) concept of culture as an extrasomatic adaptation to the environment, and thus also with Spencer's concept of evolution (*Budja in preparation*).

In prehistoric archaeology and palaeoclimatology, more attention has been paid to the correlative processes of Neolithisation and the sudden cooling events 9.2 ka and 8.2 ka, and the related palaeoclimatic archives in the eastern Mediterranean, western Asia Minor, southern Balkan Peninsula and Apennine Peninsula (*Magny* et al. *2003; 2013; Rohling, Pälike 2005*; *Rohling* et al. *2009*; *Pross* et al. *2009; Dormoy* et al. *2009; Peyron* et al. *2011; Tubi, Dayan 2013; Magny, Combourieu-Nebout 2013; Francke* et al. *2013; Siani* et al. *2013*). The 8.2 ka event is radiocarbon dated in the Greenland ice core between 8300 +10/–40 and 8140 +50/–10 BP (*Rasmussen* et al. *2014*). In explaining the correlation between the 8.2 ka climate event and the appearance of the Neolithic in Asia Minor and Europe, two scenarios have been proposed. The first assumes that rapid cooling cycles and droughts caused cultural, economic, and demographic collapse, the abandonment of settlements in the Levant, southwestern Anatolia (Catalhüyük), and Cyprus, and the migration of Neolithic farmers to southeastern Europe (*Clare* et al. *2008; Weninger* et al. *2009; 2014; Özdoğan 2014*; see also *Budja 2007*). In the second, settlement abandonment and interruption do not occur as frequently, and are documented in only a few Neolithic settlements (four out of 83). It is assumed that Early Neolithic farmers developed new social and adaptive strategies and that there was no migration to distant areas (*Flohr* et al. *2016*). Both scenarios are based on stratified Neolithic settlements and associated radiocarbon dates, as well as on the relevant palaeoclimate archives. The first scenario includes 42 settlements and 735 radiocarbon dates (*Weninger* et al. *2014*), and the second includes 83 settlements and 3397 radiocarbon dates (*Flohr* et al. *2016*). Parallel studies focused on regional precipitation regimes during the otherwise dry and cold period of the 8.2 ka event and the presumed colonization of Europe in the Early Neolithic (*Gauthier 2016*), as well as palaeohydrological and sedimentological transformations (erosion) of settlement deposits and stratigraphic superpositions directly linked to the

process of Neolithisation in the eastern Mediterranean (*Berger* et al. *2016*).

Bond's 5.9 IRD event (*e.g.,* Gronenborn's IRD 5b event) and Mayewski's 6000–5200 cal yr BP period of rapid climate change are also associated, on the one hand, with the cultural, economic, and demographic collapse of the first agricultural communities (Early Neolithic Linear Pottery culture) in central and western Europe (*Shennan, Edinborough 2007*). On the other hand, the application of the theory of adaptation, resilience, and adaptive cycles (*Gronenborn* et al. *2014; 2017; Peters, Zimmermann 2017*) has shown that rapid climate change did not have an immediate and catastrophic effect, but was only one of several destabilizing factors. For example, periods of drought and changing precipitation regimes coincide with population declines and changing settlement patterns (smaller settlements and fewer houses). The periods with more precipitation coincide with population growth. The periods with the strongest climatic fluctuations (5140/30 and 5090/80 den BC), when droughts alternate with periods of mostly heavy rainfall and periods of unusually high temperatures (5106/05 den BC), are associated with the construction of enclosures (*i.e.* village fortifications), social unrest, and violence in the eastern regions of the Linear Pottery culture cultures. In the western regions, the wetter periods after 5098 den BC also coincide with the greatest population growth. Cultural decline and population collapse follow the end of climatic fluctuations, the IRD 5b event (*Gronenborn* et al. *2014; 2017; Peters, Zimmermann 2017*). In the southern Carpathian Basin, the event was identified as the 7.1 ka BP rapid climate change and associated with the collapse of the Starčevo culture, the migration of the Linear Pottery and Vinča cultures, and the emergence and abandonment of the tell sites (*Botić 2021*).

The most recent approach is based on the assumption that more people = more sites = more ^{14}C dates, and on the statistical correlations between population fluctuations and palaeoclimate records derived from high-resolution speleothems in Central Europe from the Late Neolithic to the beginning of the Middle Bronze Age (5500–3500 cal BP) (*Großmann* et al. *2023*). The authors suggest that they found statistical correlations between population fluctuations and climate. Warm and humid periods, which increase subsistence yields and reduce the risk of crop failure, are associated with increases in population. Colder and drier climates, on the other hand, are associated with population declines and increased risk of crop failure, marking upheavals such as the dissolution of Late Neolithic societies and the emergence of a stratified society with great social inequality.

Bernhard Weninger *et al.* (*2009.48–49*; see also *Jung, Weninger 2015*) linked Mayewski's periods of rapid climate change in 6000–5200 and 3000–2930 BP with the collapse of Copper and Bronze Age cultures (abandonment of settlement VIIb9 at Troy) in southeastern Europe and parts of Anatolia. In Mesopotamia, the periods are associated with the absence of seasonal monsoons, droughts, and cooling cycles. The first of these periods is thought to have caused the collapse of the Uruk culture in Mesopotamia and, two centuries later, the collapse of the Jemdet Nasr culture (*Brooks 2006; 2011; 2013*). In the central Sahara, the collapse of livestock and transhumance is noticeable, and settlement patterns disintegrated, as the number of settlements found above 23° latitude decreases significantly, and they are only in oases (*Vernet, Faure 2000; di Lernia 2002; Brooks 2011*; *di Lernia et al. 2020*). In central China, along the Yellow River, and also in Inner Mongolia, the above anomalies have been associated with a series of rapid and severe cooling cycles, changes in the South Asian monsoon regime, and the collapse of the agriculture and livestock cultures Liangzhu, Shijiahe, Shangdong-Longshan, and Laohushan (*Zhang* et al. *2000; Wu, Liu 2004; Xiao* et al. *2004*). In contrast, the collapse of Bronze Age culture occurred in radiocarbon-dated Ireland after rapid climate change had ended, and is associated with economic and social disintegration caused by the transition to a new technology (iron metallurgy) and the formation of new economic practices and social networks (*Armit* et al. *2014*).

At the theoretical level, there have been some attempts to conceptualize an archaeology of climate change based on the premise that societies have faced more than climate and environmental change in the past, and therefore this cannot be the only explanation for their collapse. Regional environmental variability and the economic, social, and emotional responses of past societies were emphasized. These can be seen in changing subsistence strategies and the formation of sacred sites and ritual landscapes (*Van de Noort 2011a; 2011b*). In contrast, Toby Pillatt (*2012.31*) proposed moving away from climate and society. His proposed key terms are weather, landscape, and social memory. He refers to weather as "*the material condition of landscape*" and landscape as "*the mate-*

rial manifestation of the relation between humans and the environment" (*O.c. 42*). Social memory is directly related to resilience theory, which serves as a conceptual and symbolic foundation that allows for the transmission of environmental behaviours from one generation to the next. Past human actions have thus always depended on how the environment was perceived, which then became collective knowledge based on past experiences and stored in collective memory.

Finally, the modern archaeological-environmental approach recognises archaeology and cultural heritage not only as a source of information about man's

Spring 1676	Balkans: severe cold
Winter 1679/80–April 1680	Ionian Sea: continuous rainfall, litanies South Aegean: severe cold, snowfalls
Winter-spring 1682	West Greece: drought, lack of grain, famine
Winter 1682/83	Greece: severe cold, frost, death of animals, destruction of crops, high prices, famine
Winter 1684/85	Ionian Sea: continuous rainfall, floods, destruction of buildings, high prices
Winter 1686/87	Greece: harsh cold, freezing of lake of Ioannina for 3 months, famine
1690	Serbia, Bosnia-Herzegovina: high prices, famine Athens: long dry period
1691	Crete: harsh cold, drought, grain did not grow
1691–1694	Crete: bad harvest, famine, high prices olive-oil
Autumn 1695–winter 1696	Aegean Sea: drought, no harvest, church litanies
1699/1700	Greece: very cold and long-lasting snow cover, snow cover over the Cretan mountains the whole 1700; bad harvest Thessaly: death of animals
Winter 1708/09	Serbia: severe cold, famine, plague, death of people
1710	Former Yugoslavia: bad harvest, famine
Autumn 1710–winter 1711	Ionian Sea: warm and dry, drying up of wells Ioannina; Arta: locusts
November 1712–summer 1714	Greece: drought, bad harvest, high prices, famine Thessaloniki: plague
Winter 1713/14	North Greece: drought, severe cold, bad grain harvest Serbia: severe cold, death of people
1715	Greece: great famine
1780	West-north Greece: heavy rainfalls, flooding, destruction of buildings (mostly mud constructions), high prices Crete: famine, plague
Winter 1782	Greece: harsh cold, freezing of lake Karla, destruction of olive-trees, fruit trees, death of animals Bosnia-Herzegovina: plague, death of people
Winter 1789/90	Serbia: excessive snow cover, death of people and animals
Winter-spring 1805	North Greece: heavy rainfall, death of cattle, deficient harvest
Winter 1807/08	North-central Greece: severe cold, freezing of lake Kastoria
Winter 1828/29	Greece: severe cold, long-deep snow cover, freezing of lake Kastoria, destruction of trees, death of animals

Fig. 4. The years 1675–1715 and 1780–1830 with crop failures, famines and plagues, and weather/climate events. Italics indicate the historical events and the extreme weather/climate events that the authors associate with the strong Siberian anticyclone and the westward Arctic air flow in winter and spring in the Mediterranean region. Reprinted from* Xoplaki E., Maheras P. , and Luterbacher J. 2001. *Variability of Climate in Meridional Balkans During the Periods 1675–1715 and 1780–1830 and Its Impact on Human Life. Climatic Change 48: 597, Tab. II. https://doi.org/10.1023/A:1005616424463. Reprinted with permission from Springer Nature License.

environment in the past, but also as a "*guide for expanding the capacity of modern global climate responses to address the complexity of man's social environment today*" (*Rockman, Hritz 2020.8296*). In this context, archaeology is not the only discipline that Dagomar Degroot *et al.* (*2021*) embed in the interdisciplinary package of science they call the history of climate and society, it also includes geography, history, and palaeoclimatology. The authors argued that interpretations of past climate are often based on fragmented and disconnected historical records, data on past climate fluctuations (*i.e.* proxy data in palaeoclimate archives), and estimates based on different statistical models that may differ substantially with respect to different time and space scales on a global scale. This can lead to a misperception of the causal mechanisms, magnitude, timing, and evolution of past climate changes. The authors rejected catastrophic scenarios but acknowledged that climate changes have had disastrous impacts on societies in the past (see also *Degroot 2018*). Using the concept of resilience and archaeological and historical examples from the Late Antique Little Ice Age and Mediaeval Little Ice Age, the authors present five pathways (strategies) of resilience that allowed societies in different regions to survive and thrive. These are: (i) the exploitation of new opportunities, (ii) resilient energy systems, (iii) trade and empire resources, (iv) political and institutional adaptations, and (v) migration and transformation (see also *Degroot* et al. *2021. Supplementary Information, Fig. 2*). The similarities with the panarchy model are of course not coincidental, although the authors do not mention it. However, they point out that their approach is key to explaining events in the past and predicting future events.

In place of a conclusion

The historical record of rapid climate anomalies and their consequences in the Balkans and eastern Mediterranean during the Little Ice Age in the 17th, 18th, and 19th centuries, which coincided with periods of lower sunspot activity (Maunder Minimum), North Atlantic ocean circulation, altered atmospheric circulation and strong volcanic eruptions, is instructive. Eleni Xoplaki *et al.* (*2001*) presented sequences of extreme events in different regions described as harsh and long winters and long periods of hot and dry and/or cold and wet periods with floods, during which crops did not grow; fields, orchards, pastures and meadows were destroyed; and domestic animals died. Food shortages, famines, plague epidemics, population decline and even depopulation of some regions were the result (Fig. 4). On the one hand, we can see these events as a sequence that occurred several times in the past and that are usually noted in archaeological records as interruptions in ^{14}C sequences and population and cultural trends. On the other hand, it allows us to verify the theoretical concepts of panarchy, and the cycles of adaptation and resilience that are thought to have been developed by pre-industrial societies.

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Prehistoric farming in the south-eastern Baltic (Kaliningrad Region, Russia): new data and state-of-the-art

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ABSTRACT – *The article presents an overview of the currently available palaeoecological data on the prehistoric anthropogenic impact on the environment and emergence of farming in the south-eastern Baltic, an area poorly studied in palaeoenvironmental and archaeological terms. The recently obtained palynological data from the lake and bog sediments along with the existing archaeological finds allow us to consider several stages of prehistoric farming in the south-eastern Baltic. The first indications of forest management – the creation of open deforested areas, wood burning and probably cultivation (propagation) of hazel appear during the Mesolithic, 10 300–6500 cal BP. At about 6500–5200 cal BP, evidence of the first agricultural activity and local animal husbandry emerges. From 5200 cal BP onwards, farming probably occupies a permanent place in the subsistence strategy of the ancient population of the south-eastern Baltic.*

KEY WORDS – *prehistoric farming; palynology; subsistence strategies; hunter-gatherers; south-eastern Baltic*

Prazgodovinsko kmetijstvo na jugovzhodnem Baltiku (Kaliningrajska regija, Rusija): novi podatki in najnovejše raziskave

IZVLEČEK – *V članku predstavljamo pregled trenutno dostopnih paleoekoloških podatkov o prazgodovinskem antropogenem vplivu na okolje in pojavu kmetovanja na jugovzhodnem Baltiku, ki je sicer paleookoljsko in arheološko slabo raziskano. Nedavno pridobljeni palinološki podatki iz jezerskih in barjanskih sedimentov omogočajo, skupaj z arheološkimi najdbami, razmislek o večstopenjskem prazgodovinskem kmetijstvu na jugovzhodnem Baltiku. Prvi znaki gospodarjenja z gozdovi – ustvarjanje odprtih, izkrčenih območij, požigalništvo in verjetno gojenje (razmnoževanje) leske se pojavijo v mezolitiku, 10 300–6500 let pr. n. št. Približno 6500–5200 let pr. n. št. se pojavijo dokazi o prvih kmetijskih dejavnostih in lokalni živinoreji. Od 5200 let pr. n. št. naprej ima kmetovanje verjetno stalno mesto v strategiji preživetja pri prebivalcih na jugovzhodnem Baltiku.*

KLJUČNE BESEDE – *prazgodovinsko kmetovanje; palinologija; strategije preživetja; lovci-nabiralci; jugovzhodni Baltik*

Introduction

Farming as a phenomenon that changed the life of humankind is the subject of intensive study in all regions of the world (*Ellis* et al. *2021; Dubois* et al. *2018*). It is particularly complex and of great interest to study this phenomenon outside the area of known early agricultural cultures, in 'non-steppe' regions, such as the forest zone of the temperate latitudes of Europe. The last two or three decades have seen a qualitative

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leap in our knowledge about the emergence of early agricultural practices in this area. While at the end of the 20th century the general scientific consensus was that farming in this region was not established before the Iron Age (*Dolukhanov 1987*), palynological and archaeological research in the last two decades has made it possible to document much earlier emergence of farming practices, from the Neolithic period. Some of the earliest datings have been obtained in Germany (6300–6000 cal BP), Scandinavia (7200–6200 cal BP), and Lithuania (6400–6300 cal BP) (*Piličiauskas* et al. *2012*; *Alenius* et al. *2013; Rösch, Lechterbeck 2016).* At the same time, archaeological and palaeogenetic data suggest that in the forest areas of temperate latitudes the life strategies of hunter-gatherers (HG) most likely persisted for quite a long time, at least till the end of the Neolithic (*Jones* et al. *2017*; *Mittnik* et al. *2018*). This is particularly true for the eastern coast of the Baltic Region (the modern territories of the Baltic states), whereas the more southern territories (Germany, Poland) were much more actively involved in early farming and agricultural land use processes in the Neolithic (*Kriiska 2009; Jones* et al. *2017*; *Grikpedis, Motuzaite Matuzeviciute 2017*; *Piličiauskas* et al. *2017; Minkevičius* et al. *2020; Nowak* et al. *2020*). In this regard, the palaeoecological study of the southern part of the Eastern Baltic (Kaliningrad Region, Russia) becomes of great interest since this territory is located at the very edge of the interplay of more southern 'early agricultural' and northern 'hunter-gatherers' cultural and environmental areas.

The early prehistory of the study area is poorly understood archaeologically due to the lack of detailed archaeological research. Despite the dozens of Stone Age sites discovered during archaeological prospection, their firm cultural attribution is still absent (*Druzhinina 2010*). Some progress has been achieved in the study of the late Mesolithic – Neolithic Zedmar archaeological complex and culture (*Dolukhanov 1975; Timofeev 1996*), as well as in the study of the Neolithic – Bronze Age Primorskaya culture (Corded Ware culture group) sites (Pribrezhnoe, Ushakovo) (*Zaltsman 2019*). The archaeological research carried at these sites included a detailed study of substantial archaeological find collections, dwellings, zooarchaeological material, and use-wear analysis of tools, providing information about the husbandry activities of the ancient population that lived here. Although this information alone is not enough to draw conclusions regarding the emergence of prehistoric farming in the south-eastern Baltic, the combined archaeological and newly obtained palaeoenvironmental data make it possible to consider this issue. The preconditions for prehistoric farming in the south-eastern Baltic have been discussed by Pavel Dolukhanov (*1987*), Olga Druzhinina (*2003*), Galina Levkovskaya and Vladimir Timofeev (*2004*), but it is only in the last few years that more reliable data have been made available to advance the study of this issue.

The aim of the paper is to provide an overview of the existing evidence for the prehistoric farming in the southern part of the eastern Baltic (Figure 1). Recently published results of the Kamyshovoe and Chistoe lake sediments (*Druzhinina* et al. *2023*) and Kozje peat bog (*Napreenko* et al. *2021*) studies are considered together with the archaeological, palynological and zooarchaeological data obtained earlier from the sites, attributed to the Zedmar and Primorskaya Corded Ware cultures (*Timofeev 1996; Zaltsman 2019*). This paper is also thought to be a starting point for considering several questions regarding the emergence of prehistoric farming in the eastern Baltic. When did local HG become acquainted with the experience of farming? Was there coexistence with farming communities, and if so for how long, and why did the coexistence of HG and early farmers continue in the area? Were the skills and achievements of both subsistence strategies (hunting-gathering and farming) exchanged, and were the strategies mixed, or is there evidence of one strategy displacing the other? Is there any chance of tracing back agricultural practices (such as the cultivation and propagation of wild plants other than those 'steppe' crops brought to the area) to HG? Which factor – climate, cultural influences, demographic processes – proved decisive for the initiation and eventual transition to farming?

Study area, materials and methods

At present, the study area is located in a transitional zone from temperate marine to moderate continental climate with mild, variable winters and relatively cool summers. The mean annual temperature in this area is 7.9°C. The mean annual precipitation is around 750mm (*Druzhinina* et al. *2023*).

The palaeoenvironmental data considered in this paper were obtained from the Kamyshovoe and Chistoe lakes and Kozje peat bog study in 2021–2023 (*Napreenko* et al. *2021*; *Druzhinina* et al. *2023*). We also

refer to palynological studies at Zedmar Palaeolake compiled some decades ago (*Levkovskaya, Timofeev 2004*).

Lake Kamyshovoe (N 54°22'; E 22°42'; 192 masl; 40.8 km^2) and Lake Chistoe (N 54°38'; E 22°72'; 202 masl; 17.9km^2) occupy the late glacial depressions within the terminal moraine ridge of the Weichselian (Vistulian) glaciation, while Zedmar Palaeolake (N 54°36'; E 22°04'; 100 masl) is located more at the foot of the morain hills. A hilly relief with a great number of lakes and mires is a characteristic feature of this area. The sediments forming relief are mosaic: glaciofluvial sand, gravel interlayers and boulder loam (till). Pine, fir and mixed forests, as well as alder carrs are the main types of vegetation (*Druzhinina* et al. *2023*). The Kozje raised bog (N 55°25'; E 21°39'; 2 masl) occupies an area of 1400ha. The modern landscape surrounding the bog is represented by flooded black-alder carrs, dunes, floodplain meadows and fens, underlain with sands and till (*Napreenko* et al. *2021*). Detailed geochronological and palynological studies have been carried out at all the locations, with descriptions of the methods used presented in previous papers (*Levkovskaya, Timofeev 2004; Napreenko* et al. *2021; Druzhinina* et al. *2023*).

The archaeological materials considered in the article were obtained during excavations of the Zedmar archaeological complex, attributed to the Zedmar culture (*Timofeev 1996*), as well as Pribrezhnoe and Ushakovo sites belonging to the Primorskaya Corded Ware culture group (*Zaltsman 2019*). Archaeological research at these sites was complemented by a detailed geochronological and zooarchaeological studies. While the Zedmar archaeological complex is situated at the shores and islands of the eponymous palaeolake, the Pribrezhnoe and Ushakovo sites are located at the shore of the Vistula Lagoon (N 54°38'; E 20°20'; 8 masl). The area is composed if sand and silt underlain by till. Pine forest represents the modern vegetation, while small depressions are occupied by swamps.

Results

Kamyshovoe Lake

The study of the Kamyshovoe sediment sequence (*Druzhinina* et al. *2023*) showed that the first signs of anthropogenic impact on the landscape could be traced to the Mesolithic (Fig. 2.A, see below).

The presence of local open spaces in the woods was recorded, as evidenced by the peaks of *Artemisia* (wormwood), *Calluna* (heather), *Pteridium* (bracken fern), *Juniperus* (juniper), Poaceae (grasses), and so on. A significant amount of *Corylus* (hazel) found in the pollen record, coinciding with the elevated values of geochemical indicators of wood fuel burning (Ba, Sr) (*Druzhinina* et al. *2023*), supports the idea of the deliberate burning of forest for exploration and mobility purposes, as well as for the propagation of edible and usable plants. Since the Neolithic, the variations in palaeobotanical data indicated much more pronounced land cover instability: the amount of ruderals (*Artemisia*), dry pastures (*Calluna, Pteridium, Juniperus*) and wet meadows (*Cyperaceae*) increased, while the diversity of herbs also rose. Microcharcoal data combined with the pollen data representing ruderals, open habitats, and dry pastures revealed the variable intensity of human activity with peaks at ~6300, 5900, 5700, 5200, 4700, 4300, 4000 cal BP, while TiO_2 as an indicator of soil erosion showed a gradually increasing trend from ~6000 cal BP (*Druzhinina* et al. *2023*). At approximately 6300 cal BP, *Plantago lanceolata* appeared as a reliable grazing and hey-harvesting indicator. *Pteridium* peaks

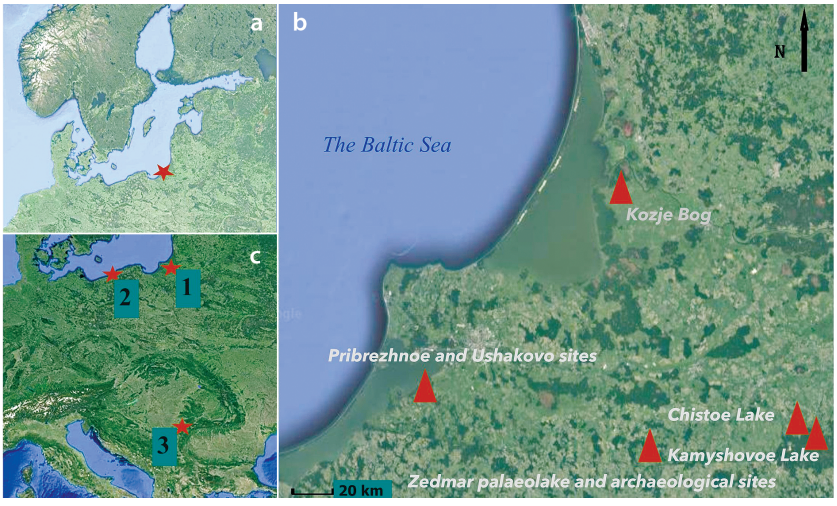

Fig. 1. **a** ***Location of the studied area in Europe;*** **b** ***location of the studied sites in Kaliningrad region (south-eastern Baltic, Russia);*** **c** ***regions and sites mentioned in the text:*** **1** ***south-eastern Baltic;*** **2** ***northern Poland, Dąbki archaeological site;*** **3** ***the Balkans.***

were noted, coinciding with peaks of microcharcoal and *Onagraceae* (fireweed). In the Kamyshovoe sequence, the appearance of Cerealia was noticed since the beginning of the Bronze Age, at ~3800 and *Secale* at 2800 cal BP. Both intervals were marked by a simultaneous increase in ruderals and *Pteridium* curves on the pollen diagram.

Chistoe Lake

The analyses of the Chistoe lake sediments (*Druzhinina* et al. *2023*) revealed the traces of the anthropogenic impact on the vegetation from the Mesolithic, when a sharp rise of *Corylus* pollen by up to 25% around 8000 cal BP was recorded (Fig. 2.B). The early farming activities could be traced back to the end of the Neolithic. The first pollen of Cerealia, *Centaurea cyanus*, and *Cannabis*-type were found in the samples dated to 4600 cal BP. From this time on the curves for weeds and plants of open habitats tended to increase, as did the curves for cultivated plants; conversely, the pollen spectra for spruce showed a decrease. The decrease in *Picea* could be due to the fact that coniferous-broadleaved forests, which occupied areas with rich soils, were felled or burnt for arable farming or other purposes. The presence of *Chamaenerion angustifolium* and *Ericales* was also detected in the spectrum, and this might indicate the post-pyrogenic character of the birch forests that appear simultaneously in the pollen record, while the presence of *Isoetes* spores might be an indicator of soil erosion around the lake due to vegetation disturbance (burnt areas, settlements, ploughing, *etc.*).

Later, in the Bronze Age, and along with the constant and increasing presence of Cerealia, the growing representation of *Picea* on the background of a decreasing percentage of *Betula* and Onagraceae were observed. Most likely a change in the agricultural technology took place or other terrains, different from spruce forests, were used for farming activities. The increased amount of segetal (*Centaurea cyanus, Chenopodium album, Cannabis*, *etc.*) and ruderal (species of *Asteraceae*, *Chenopodiaceae*, *Plantago, Polygonum, Urtica*, *etc*.) weeds indicated that the area of arable land was expanding.

Kozje Bog

The pollen data from the Kozje Bog *(Napreenko* et al. *2021)* do not provide unequivocal evidence of any anthropogenic impact on vegetation in the Mesolithic, but from the second half of the Neolithic signs of farming are clearly visible (Fig. 2.C). Cereal pollen first appears in the record around 5100 cal BP and does not disappear from the spectrum, except for the time interval around 3500–2600 cal BP. The absence of Cerealia pollen in this period might be related to a change in peat composition in the studied sediments, which may negatively affect pollen grain preservation. It could also be that a change in the water level of the site, recorded in the altered peat composition, forced the population to farm in areas with a more favourable water regime. *Secale* appears in the pollen spectrum for the first time around 3700 cal BP and is accompanied by a simultaneous peak in *Plantago*. From 2600 cal BP onwards, *Plantago* is also consistently present in the spectrum (*Napreenko* et al. *2021*).

Zedmar Palaeolake and Zedmar prehistoric sites

The Zedmar Palaeolake is a location where several archaeological sites have been found and comprehensively studied (*Timofeev 1996*; *Levkovskaya, Timofeev 2004*). Bones of cattle, goats/sheep found at the Zedmar archaeological complex provided the first zooarchaeological evidence of domestication and small scale local cattle breeding in this part of the Baltic region, from at least ~6000 cal BP. Other important archaeological finds from this site comprise the bone and horn tools for soil tilling, identified by use-wear analysis, and at least, two dozen of these have been found. The earliest dating of the tools is 6950–5550 cal BP (Le-3921) (*Timofeev 1996*). Pollen of Cerealia and *Fagopyrum* accompanied by pollen of segetal and ruderal weeds (*Brassicaceae*, *Chenopodium, Plantago lanceolata*) was fixed in the cultural layers attributed to different phases of the Neolithic and detected in several locations at the Zedmar complex. The earliest archaeological layer containing Cerealia and *Fagopyrum* pollen is dated to 5990–5710 cal BP (Le-1389; Bln-2165). Along with Cerealia and the abovementioned segetal and ruderal weeds, hemp pollen was also identified in the samples. Starting from no later than 4400 cal BP Cerealia pollen was constantly present in the records. The layers in which Cerealia pollen was associated with the Corded Ware culture group finds are dated to 4050–3630 cal BP (Le-1320; Le-1255) (*Levkovskaya, Timofeev 2004)*.

Pribrezhnoe and Ushakovo sites

Pribrezhnoe and Ushakovo 1–4 sites belonging to the Primorskaya Corded Ware culture group (CWC) embrace the interval of late Neolithic (*Zaltsman 2019*).

The Pribrezhnoe site is the best studied of these. The thickness of the cultural layer ranges from 0.20 to 0.70m. It is saturated with finds of pottery fragments or crushed vessels, items made of stone and amber, flint flakes, charcoals and fragments of burnt bones. According to Edvin Zaltsman (*2019*), at an early stage of the settlement's existence the settlers had gained control over the extraction of amber, which soon became one of the important resources in their livelihood. Archaeological artefacts obtained at the settlement reflect the mixed economy: hunting sea animals, fishing, and farming. The latter is represented by finds of mattocks, quern stones, as well as bones of domesticated animals and the charred grains of *Triticum* found in the pits (*Zaltsman, 2000; 2019*). The ^{14}C dates associated with the finds place them into the interval 5250–4850 cal BP (Le-6218; Ki-11352; Ki-10581). Grain grinders were found inside dwellings or directly next to them. They were generally rounded-flattened or had oblong outlines, although elongated pistillate shapes were not uncommon. Round grinders were made from boulders of crystalline rocks. The surfaces of the pestle grinders were well finished, and they were made of light brown sandstone. The millstones were made of sandstone or hard crystalline rock and had a concave working surface (Fig. 3).

Ushakovo 1–4 sites provide evidence for cattle breeding and crop processing: bones and the molar fragment of a cow (*Bos taurus*) and tur (*Bos primigenius*), as well as numerous grinders, grain graters, and pestles, were all found here. The ^{14}C dates associated with the finds can be placed in the interval from 5100–3750 cal BP (Ki-18096; Ki-18693) (*Zaltsman 2019*).

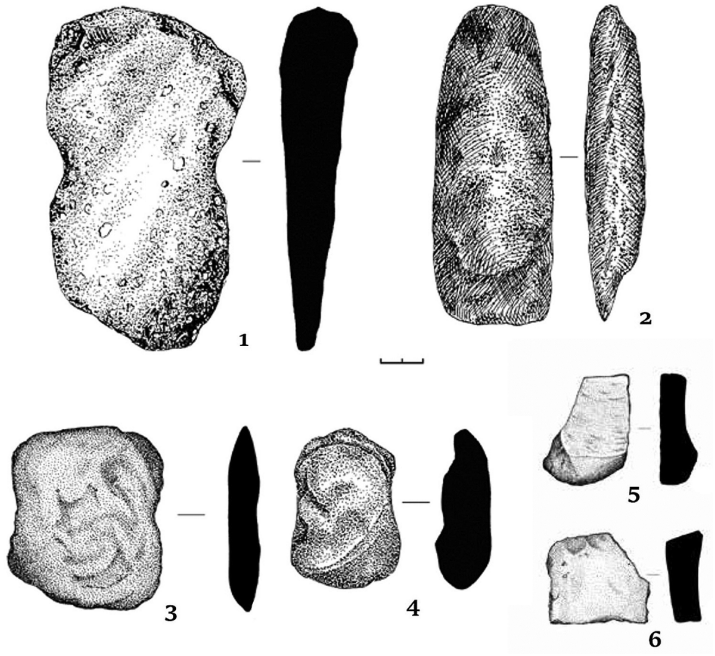

Fig. 3. Pribrezhnoye Site, Primorskaya Corded Ware culture. Stone mattocks (1–4); quern stones fragments (5, 6) After Zaltsman (2019).

Discussion

Stages of prehistoric husbandry

Recent research provided new data showing the anthropogenic impact on vegetation and landscapes in the south-eastern Baltic since the Mesolithic. The correlation of the results from the Kamyshovoe and Chistoe lakes and Kozje peat bog studies, considered together with the complex of data from the archaeological sites Zedmar, Pribrezhnoe and Ushakovo, allow us to identify several stages in prehistoric farming with increasing anthropogenic pressure (Tab. 1).

The first stage covers a considerable part of the Mesolithic period and the beginning of the Neolithic. At that time localized deforestation occurred, and the forest may have been purposefully burned to enable hunting and mobility, as well as to spread certain plant species, of which hazel was probably the most important. The deliberate burning of the forest to spread hazel (*Corylus*) – which played an important role in the Mesolithic diet, was used for various economic purposes and as fuel – is a phenomenon known in archaeology and palaeoecology (*Bishop* et al. *2015; Gross* et al. *2019*). Possibly indicative of precisely this process is the *Corylus* pollen curve in Lake Kamyshovoe, which fluctuates between 20 and 40% throughout the Mesolithic until a sharp decline around 7500 cal BP. The simultaneous high content and peaks of hazel and fern (*Pteridium aquilinum*, up to 18%) in the Kamyshovoe palynological spectrum should also be noted. In its natural habitat, this fern is rarely an aggressively expanding plant, but human activity contributes to its widespread occurrence in burnt areas, abandoned fields and pastures. This phenomenon is also observed in the spore-pollen spectra of Lake Chistoe, although the rise in *Corylus* pollen (up to 25%) is observed later, from 8500 cal BP. The evidence for hazel cultivation and simultaneous forest firing in the surrounding landscape was obtained by studying the palynological data and the

relevant layers of the archaeological sites situated in the neighbouring territories of north-eastern Poland (*Wačnik* et al. *2020*). Here, the intensive use of hazel is confirmed by the macrobotanical remains of hazelnuts and wood found in archaeological layers, while simultaneous spore-pollen spectra reveal an increase in the microcharcoal curve and plants of open habitats (*Poaceae*, *Artemisia,* Chenopodiaceae, *Rumex* (sorrel)) as well as *Pteridium aquilinum*. It is worth noting that the fern itself formed part of the Mesolithic diet (*Divišová, Šída 2015*).

In the next stage, during the first half of the Neolithic period, the intensification of anthropogenic pressure on the environment seemed to be growing. The increasing number of plants-indicators of anthropogenic activity (weed, pasture, and meadow plants) attests to the larger extent of open spaces and wood exploitation. *Pteridium* peaks coinciding with peaks on the microcharcoal curve, along with *Onagraceae* (cypress), appear throughout the period, indicating continued burning of forests. At the same time, hazel decreases in the pollen spectrum, but still accounts for up to 15–20%. This may simultaneously indicate that the share of hazel in the Neolithic economy was still significant, but also that forest burning was carried out for purposes other than *Corylus* propagation. It is interesting to note that the decline in hazel may be related not only to its use as food, but also as a source of fibre and raw material for basket weaving

STAGES OF HUMAN IMPACT	MAIN ASPECTS	INDICATORS	DATE cal BP
Initial stage of anthropogenic pressure	Local deforestation	Plants-indicators of open habitats and pastures, as well as *Pteridium* and *Corylus* (Kamyshovoe) Elevated values of geochemical indicators of fuel (wood) burning (Ba, Sr) (Kamyshovoe)	~10 300–6300
	Signs of propagation of plants	Over-representation of *Corylus* (Kamyshovoe, Chistoe)	~10 300–6300
Intensification of anthropogenic pressure and fist evidence of husbandary	Increased exploitation of woods	Increasing percentage of NAP and instability in the vegetation cover; plants indicators of open habitats and pastures, ruderals (Kamyshovoe, Chistoe)	7000–4100
	Increased fire activity	Peaks of microcharcoal, Ba, Sr (Kamyshovoe)	since ~6300
	Domestication of animals	Bones of cattle, goats/sheep, found at archaeological sites (Zedmar) Peak of *Plantago lanceolata* (Kamyshovoe)	~6000 ~6300
	Land cultivation	Bone and horn tools for soil tilling (Zedmar) Increased soil erosion - TiO_2 value (Kamyshovoe) Segetal and ruderal weeds (Brassicaceae, *Chenopodium*, *Plantago lanceolata*) (Zedmar)	6950–5530 since ~6000 5990–5710
	Cultivation of Cerealia	Pollen of Cerealia (Zedmar)	5990–5710
Expansion of agriculture	Increased exploitation of woods	Ruderals, segetals and open habitats plants (Kamyshovoe, Chistoe, Kozje Bog, Zedmar)	since 5000–3700
	Increased fire activity	Increasing trend of microcharcoal, Ba, Sr curves (Kamyshovoe)	since ~4000
	Domestication of animals	Bones of cattle found at archaeological sites (Ushakovo)	4250–3750
	Land cultivation	Higher rate of soil erosion - TiO_2 value (Kamyshovoe) Stone tools for soil tilling (Pribrezhnoe)	since ~4000 5250–4850
	Cultivation of Cerealia	Pollen of Cerealia (Kozje Bog) Pollen of *Secale* (Kozje Bog) Pollen of Cerealia (Chistoe) Pollen of Cerealia (Kamyshovoe) Pollen of Cerealia (Zedmar, CWC layers) Charred *Triticum* grains (Pribrezhnoe) Stone tools for grain processing (Pribrezhnoe) Stone tools for grain processing (Ushakovo)	5100 3700 4600 3800 4050–3630 5250–4850 5250–4850 5100–3750

Tab. 1. Stages of anthropogenic impact on the prehistoric landscapes of the south-eastern Baltic.

and utensils. Indeed, the spread of pottery in the Neolithic may have reduced the need for hazel for these purposes. During this stage the first evidence of husbandry appeared, as represented by the bones of domesticated animals (cattle, goats/sheep) and tools for soil cultivation found at the Zedmar archaeological complex. *Plantago lanceolata*, which is considered to be one of the most reliable indicators of agriculture and, in particular, grazing, is also recorded in the pollen spectrum. The presence of Cerealia pollen in the archaeological layers of Zedmar points to the earliest attempts at cereal cultivation in this period.

In the second half of the Neolithic period, from 5200–5100 cal BP, a new stage of the prehistoric farming activities is observed. It is probably from this period onwards that agriculture started to expand in scale and importance in this part of the Baltic. This is visible in numerous indicators of cereal cultivation: from the pollen records of different sites to archaeological evidence presented by the finds of stone mattocks, grinding stones, pestle grinders and charred grains of wheat. This period is characterized by continuing anthropogenic pressure on landscapes. The number and variety of indicators of anthropogenic activity (*Plantago, Artemisia, Chenopodium, Circium, Taraxacum*, *etc.*) is increasing, and the number of microcharcoal as indicator of forest clearing and other activities is also growing. It is important to note that during this period (around 4600–4200 cal BP) a visible decline of *Corylus* is observed in the pollen records of the Kamyshovoe and the Chistoe lakes. One might assume that at this stage a significant change in subsistence strategy took place, and the role of traditional resources, such as hazel, diminished and the proportion of other resources, such as cultivated grasses, increased.

Emergence of agriculture in the south-eastern Baltic in the light of multi-proxy data

A widespread scientific paradigm explains the emergence of agriculture in the forest zone of Europe as an integral part of the process of Neolithization, which included the introduction of agricultural crops, appropriate implements for tillage, and a sedentary lifestyle by adventurous cultures of agriculturalists and pastoralists (*Oross* et al. *2020*). However, the degree and forms of adaptation of the Mesolithic and the Neolithic HG populations to the latest cultural and socio-economic changes connected with the introduction of land-use remain open, despite decades of scholarly debate (*Divišová, Šída 2015; Piličiauskas* et al. *2017*). The term 'Forest Neolithic' is used to characterize the cultural and socio-economic processes taking place in the temperate forest zone of Europe (and especially in the Baltic), implying the preservation of the HG lifestyle, but using pottery and small-scale animal husbandry (*Wačnik* et al. *2020*). Morten E. Allentoft *et al.* (*2022*) reveal profound differences in the spatiotemporal Neolithization dynamics across Europe, documenting a broad east-west distinction along a boundary zone running from the Black Sea to the Baltic. While to the west of this line the Neolithic transition was accompanied by large-scale shifts in genetics from local HG to farmers with Anatolian-related ancestry, to the east of this divide no ancestry shifts were observed until 5000–4800 cal BP. For the territory of the southern part of eastern Baltic situated at the edge of the southern 'early agricultural' areas, the scientific issue of the Mesolithic and the Neolithic HG adaptation to the changes associated with the introduction of agriculture, becomes particularly interesting.

The results of regional palaeogenetic studies carried out in recent years allow us to consider the available palaeoecological and archaeological data in a new light (*Jones* et al. *2017*; *Mittnik* et al. *2018*). The research carried out on the anthropological materials of the eastern Baltic showed that carriers of the Mesolithic, and later Neolithic, HG genome continued to exist in the eastern Baltic area longer than in the rest of Europe, without the infusion of external genetic component (*Mittnik* et al. *2018).* The study of extensive local anthropological material has revealed that the infusion of genes of agricultural cultures did not occur before the late Neolithic and it is associated with the population of the Corded Ware culture (*Mittnik* et al. *2018*). In the archaeological understanding, this means that the transition from the Mesolithic to the Neolithic in the eastern Baltic does not coincide with a large-scale change in population and a dramatic change in economy, as observed in Central and Southern Europe. There, for instance, in the neighbouring Poland, Neolithic communities of farmers represented by the Linear Band Pottery culture (Linearbandkeramik, LBK), appeared much earlier, around eight to seven thousand years ago (*Nowak* et *al. 2020*).

Meanwhile, all late Neolithic individuals from the Baltic (dated to *c.* 5150–3700 cal BP) already carry the genetic component that was introduced into Europe with the pastoralist migration (an admixture be-

tween Early and Middle Bronze Age pastoralists from the Yamnaya culture of the eastern Pontic Steppe and Middle Neolithic European farmers) in varying amounts, and the majority also carries the component associated with Anatolian farmers (*Mittnik* et al*. 2018*). Therefore, we can probably assume that changes in subsistence strategy of the south-eastern Baltic society observed by palaeoecology and archaeology, and related to the increasing role of agriculture from about 5200–5100 cal BP onwards, can be connected to the inflow of a new population: agriculturalists from the Corded Ware culture (Tab. 1).

There is another important outcome of this palaeogenetic result. In the palaeoecological understanding it can mean that the traces of the prehistoric farming such as deforestation, animal husbandry, soil tilling, cultivating of plants, dated prior 5200–5100 cal BP may be associated with the local Mesolithic and Neolithic HG, that is, representatives of the 'Forest Neolithic'. With regard to this, the following issues arise: How did the process of incorporating agricultural practices into the lifestyle of the local indigenous population take place? Moreover, was there a possibility and necessity, even before the arrival of agriculturalists, to practise, along with animal husbandry, the local-scale cultivation of plants (*e.g.*, cereals)?

In order to move forward on these questions, it is necessary to elaborate on the role of plant resources in the life of HG and, separately, on the possibilities of domestication of wild cereals from the Mesolithic onwards in the broader context of Europe. The overview presented by Michaela Divišová and Petr Šída (*2015*) is one example of an exhaustive review of the botanical macroremains found in Mesolithic settlements, demonstrating how large and diverse the number of plant species constituting the diet of HG was, as well as the wider human use of plants, such as for housing, vessels, sources of fibres for cordage and textiles, dyeing, medicinal use, *etc.* Even if we narrow the importance of plant resources among HG to food, research in the last decade shows how large this role may have been. At least several tens of plant species represented by seeds, fruits and nuts (*Corylus avellana*, *Sambucus* sp., *Quercus* sp., *Trapa natans*, *Rubus* sp., *etc*.), roots, tubers and rhizomes (*Pteridium aquilinum*, *Typha latifolia/angustifolia*, *Allium* sp., *Sagittaria sagittifolia*, *Polygonum* sp., *Phragmites australis*, *Schoenoplectus lacustris, Nuphar lutea*, *etc.*), as well as parts of plants, which could have been used as green vegetables (*Chenopodium album, Urtica dioica*, *Phragmites australis, Rumex crispus, Rumex* sp., *Atriplex* sp., *Stellaria media*, *Polygonum* sp., *etc*.) are detected in the archaeological context of the Mesolithic and the Neolithic (*Divišová, Šída 2015*). The latest data on plant microresidue, starch and phytoliths in the teeth of buried people in the Balkans dating from the Palaeolithic and Mesolithic (*Cristiani* et al. *2016; 2021*) have called into doubt *"the deep-rooted idea that the diet of hunter-gatherers during the Palaeolithic and Mesolithic periods primarily consisted of animal proteins. In addition, it highlights the active role the eating habits of foragers might have played in introducing certain domesticated plant species that have become primary staples of our diet today"* (*Cristiani* et al. *2021).* These researchers give an extra value to this whole issue by suggesting that in the Balkans foragers were already consuming certain species of wild cereal grains 11 500 years ago, before agriculture arrived in Europe. This also provides further justification for revisiting the palynological evidence of the Mesolithic cultivation of cereals, which exists in many parts of Europe, from France to Estonia, but so far has not been adequately used when considering questions of early farming (*Divišová, Šída 2015*).

The results of Emanuela Cristiani *et al.* (*2016*) also showed that several millennia before the introduction of agriculture to Central Europe the Mesolithic population there was already eating domesticated cereals (*Triticum monococcum, Triticum dicoccum, Hordeum distichon*), which means that cereals entered the diet of HG as a result of exchange or 'trade' with crops-farmers from Southwest Asia separately from the other 'attributes' of Neolithization. Researchers argue that domesticated plants were transmitted independently from the rest of the Neolithic novelties from 8600 cal BP onwards, reaching Balkan foragers through established social networks between them and farmer groups. The question arises as to what extent cultural and economic ties may have spread far and wide from the regions with early consumption of domesticated cereals such as, for example, the Balkans. Could it be that the knowledge and experience of consuming domesticated cereals was spread as far as to the Baltic or other distant territories? The answer to this can be illustrated, for example, by archaeological discoveries made at the prehistoric settlement of Dąbki in northern Poland (the Baltic Region) (*Kabaciński* et al. *2015*). This settlement is a key studied site existing during the period of transition from the Mesolithic to the Neolithic

on the Baltic Sea coast around 6800–5500 cal BP. The interdisciplinary research showed that the site was probably the centre of regular long distance exchanges of goods and products (fur, amber) with the more southern territories, as evidenced by the finds of pottery from numerous cultures, including those from the Balkans, imported over distances of *c.* 900km. The sharing of knowledge between the early agricultural societies and foragers about plant resources may thus have helped introduce domesticated plant species into forager societies in Central Europe, and there did not seem to be any obstacles to the further movement of this knowledge across long distances.

Assuming that the consumption of plant resources, including wild or domesticated cereals, occupied a certain (essential?) place in the subsistence strategy of the Mesolithic and Neolithic forest population of the Baltic region, the mechanism which ensured the flexibility and adaptability of their lifestyle, enabling the local population to maintain it for thousands of years in the changing climate and landscapes of the Early and Middle Holocene (*Borzenkova* et al*. 2015*), becomes clearer. It is likely that it were not *"the incidental and opportunistic use of plants for food", but "patterns of plant use ... in terms of wild plant food husbandry"* (*Divišová, Šída 2015*), and, probably, this is exactly what is reflected in the numerous traces of human activity detected by palaeoecological studies in the south-eastern Baltic in the Mesolithic and the first half of the Neolithic, before the appearance of farmers from the south and east. If early farming was indeed practised by the local population, this may have played a role in the fact that the increase in the proportion of cultivated cereals in the diet and then the transition to larger-scale farming from the late Neolithic period with the arrival of the Corded Ware culture population appeared more natural and integrated into the existing way of life. This assumption is probably reflected by the second important outcome of the palaeogenetic analysis, showing that after the migration of agricultural cultures to the Baltic area "*local foraging societies were, however, not completely replaced and contributed a substantial proportion to the ancestry of Eastern Baltic individuals of the latest Neolith and Bronze Age*" (*Mittnik* et al. *2018*). The researchers conclude that this 'rebirth' of HG ancestors in the local population through mixing between foraging and farming groups resembles the same phenomenon observed in the European Middle Neolithic and is responsible for the unique genetic signature of modern Eastern Baltic populations.

Obviously, research into the problem considered in this paper and further progress in understanding of the role of plant resources in HG subsistence strategies, plant cultivation by HG and the importance of this for the development of agriculture in the forest zone will require not only a broader base of archaeological evidence with regard to the presence or absence of 'early agricultural' cultures in the area (Linear Band Pottery, Funnel Beaker, Corded Ware). Perhaps even more important is the expansion of analytical methods in solving this problem. Besides the application of a wide range of palaeobotanical methods (pollen, macroremains, phytoliths, *etc.*) to culture-bearing layers and palaeoenvironmental sequences, re-evaluation and additional research of the available anthropological material by microresidue, starch and phytolith analysis is also possible. Phytolith analysis can also be successfully applied at the archaeological sites with a sandy culture-bearing layer (which is probably the majority in the Baltic), in which organics are not preserved (*Piperno 2006*; *Golyeva 2008*). But the most important thing is to keep in mind the idea that our ancestors may have had versatile applied knowledge of the environment which enabled them to actively participate in the transformation of landscapes and to build adequate subsistence strategies, involving not only hunting, fishing and animal husbandry, but also the cultivation and use of plant resources.

Conclusions

The recently obtained palaeoecological data leads to new insights about the anthropogenic impact on landscapes and 'early farming' activities in the south-eastern Baltic region and allows us to assume the existence of three major stages in the husbandry of the prehistoric population in this area.

The first stage covers most of the Mesolithic and the beginning of the Neolithic periods, 10 300–6000 cal BP, and provides indications of forest management with the creation of open deforested areas, wood burning and probably the cultivation (propagation) of hazel as one of the most important plant resources of the Mesolithic. Then, in the first half of the Neolithic, from about 6500–6000 cal BP, evidence of the first agricultural activity and local animal husbandry emerges, with tools for tillage, palynological evidence of plant cultivation and soil erosion, and bones of domesticated animals. Later, from 5200–5100 cal BP onwards, farming probably occupies a perma-

nent place in the subsistence strategy of the ancient population of the south-eastern Baltic. The spread of agriculture in the third stage is most likely associated with the farmers of the Corded Ware culture.

Undoubtedly, the accumulation of data from archaeological, palaeobotanical and palaeogenetic disciplines will help to significantly correct and detail the picture we have at the moment.

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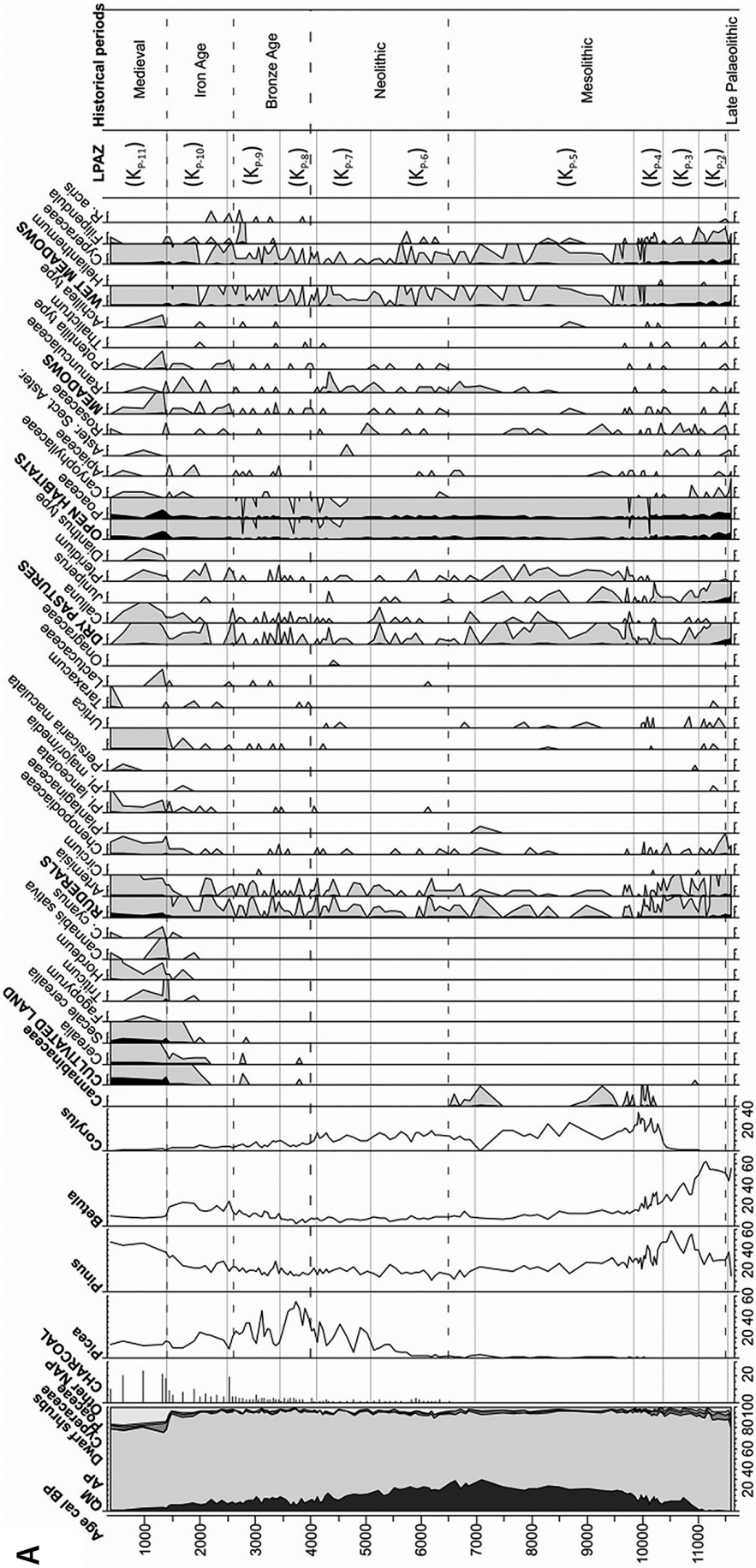

Fig. 2. Vegetation dynamics against historical periods inferred from the pollen data of Lake Kamyshovoe (A), Lake Chistoe (B) and Kozje Bog (C). After Druzhinina et al. *(2023) and Napreenko* et al. *(2021).*

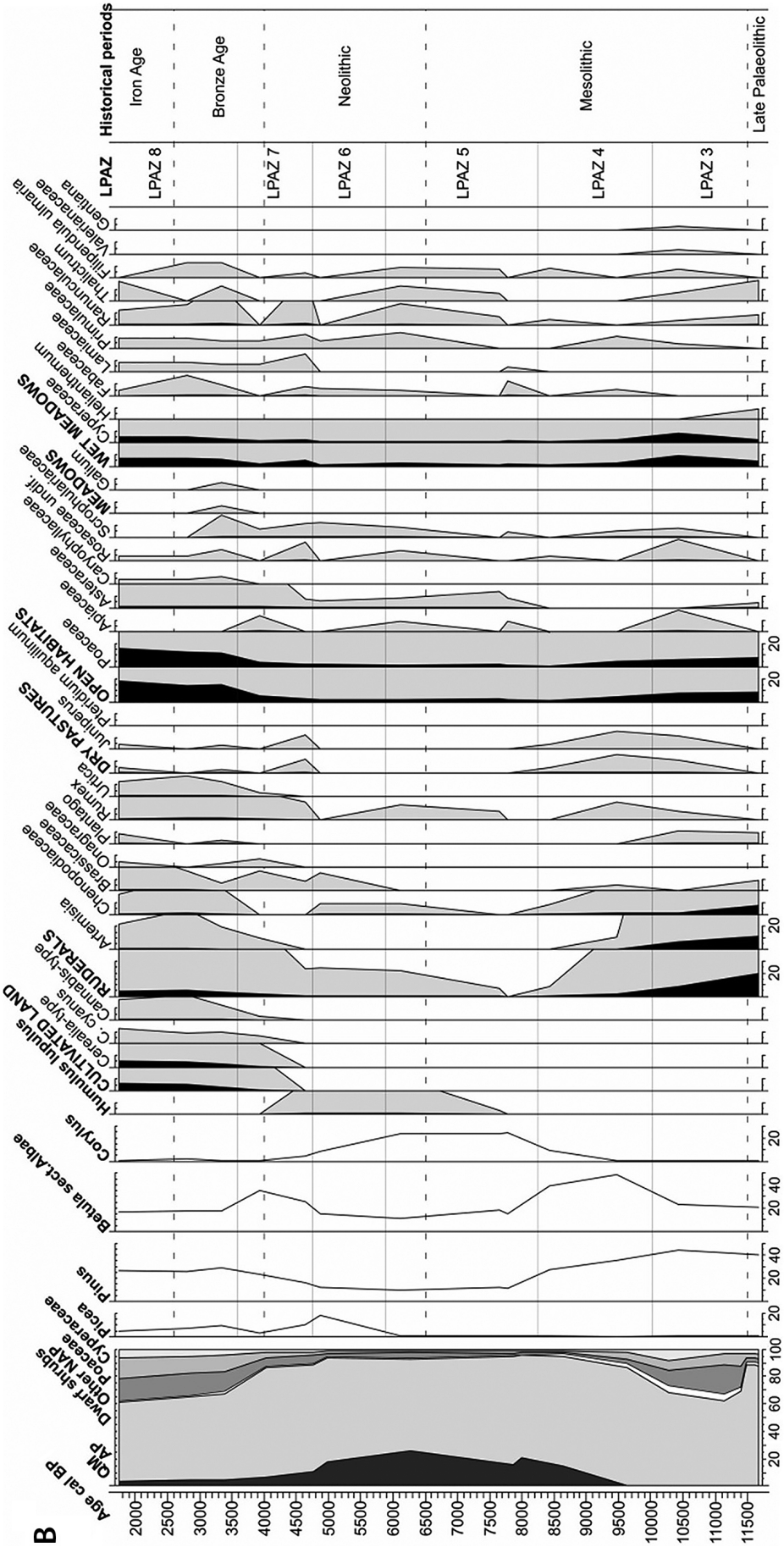

Fig. 2. Continued

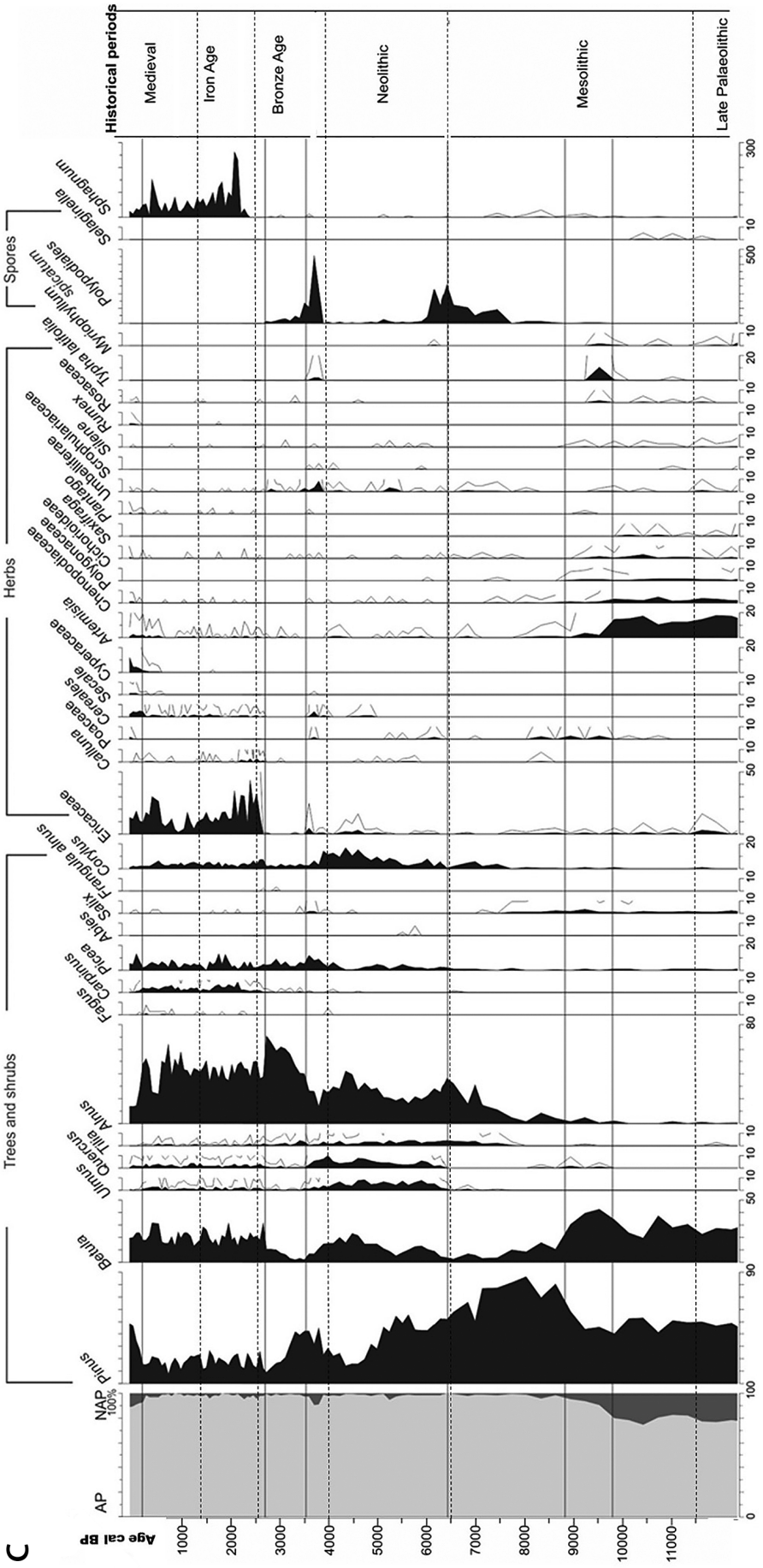

Fig. 2. Continued

On the 'pseudo-ditch' system of the Late Neolithic Öcsöd-Kováshalom settlement complex on the Great Hungarian Plain

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ABSTRACT – *The well-known Late Neolithic tell-like settlement of Öcsöd-Kováshalom on the Great Hungarian Plain gained a completely new context when a triple enclosure consisting of segments (hence the name 'pseudo-ditch') was discovered in 2018. Followed by two small excavation campaigns, this paper gives account of the construction stages, various digging and filling actions, of the chronology and of the structured deposits that marked the closing event of these long-lasting communal activities. A comparison with European Neolithic enclosures supports the interpretation on the diversity of the numerous ditch systems, and do not allow any generalizing views – it rather speaks for the freedom of local communities in their choices within their respective cultural frameworks.*

KEY WORDS – *Late Neolithic; Carpathian basin; pseudo-ditch system; site formation processes; geochemical analysis; chronological modelling*

O sistemu 'navideznih jarkov' poznoneolitskega naselbinskega kompleksa Öcsöd-Kováshalom v Veliki madžarski nižini

IZVLEČEK – *Znana poznoneolitska naselbina Öcsöd-Kováshalom v Veliki madžarski nižini je dobila popolnoma nov kontekst, ko so leta 2018 odkrili trojno ograjo, sestavljeno iz segmentov, zato tudi ime 'navidezni jarek'. Po dveh letih manjših izkopavanj v članku predstavljamo gradbene faze, različna kopanja in zasipanja, njihovo časovnico ter strukturni depozitom, ki označujejo zadnji dogodek v dolgem nizu skupinskega delovanja. Primerjave z neolitskimi ograjenimi prostori v Evropi podpirajo razlago, ki vključuje raznovrstnost številnih sistemov jarkov, ne dopuščajo pa posplošitev – govorijo le o svobodnih odločitvah lokalnih skupnosti v njihovih kulturnih okoljih.*

KLJUČNE BESEDE – *pozni neolitik; Karpatska kotlina; sistem navideznih jarkov; proces formiranja najdišča; geokemične analize; kronološko modeliranje*

Introduction

In the central, flatland part of the Carpathian basin (so called Alföld, Great Hungarian Plain), mainly east of the Tisza River, tell settlements emerged in the first half of the 5th millennium cal BC. This region lies at the northern periphery of the south East European cultures building settlement mounds. The Alföld is known by these well-known tells, being excavated (and alas, only sporadically published) in the last 80

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years – but little was known about the immediate and larger environment around these tells until recent times.

One of the phenomena discovered in recent decades is the ditch system around tell sites (*Raczky* et al. *2011; Gyucha* et al. *2022*). The Öcsöd-Kováshalom settlement, lying in the Middle Tisza region, has been excavated since the early 1980s, but the multiple and intersecting pseudo-ditches were discovered no earlier than 2018 (*Füzesi* et al. *2020a*).

The pseudo-ditches consist of several pits forming discontinuous circles (*Andersen 2015; Whittle* et al. *1999*). The internal chronology is one of their most important questions: due to the circular form of the enclosures they were apparently planned in advance, and yet the individual segments may have been traces of separate events in time (*Lefranc* et al. *2017*).

The Öcsöd-Kováshalom settlement is now being interpreted together with its enclosure system. This paper summarizes an important stage of this interpretation process, the test excavations and analyses revealing much of the series of community events in the early centuries of the 5th millennium cal BC. We give a detailed description of the test excavations cutting the ditch system as well as results of the scientific analyses from samples taken. Our goal is to add new considerations to the interpretation of intersecting, pseudo-ditches in the Neolithic.

Archaeological research at Öcsöd-Kováshalom

The Late Neolithic Öcsöd-Kováshalom site is located on the Great Hungarian Plain, at the confluence of the Tisza and Körös Rivers. Its long research history can be divided into four phases. The first phase is marked by a collection of relevant data in the site catalogue of Nándor Kalicz and János Makkay's extensive summary of the Linear Pottery Culture on the Great Plain (*Kalicz, Makkay 1977.140*: the site was registered as No. 207 Kunszentmárton-Érpart).

These early references facilitated intensive topographic research at the site in 1980, accompanied by coring for systematic stratigraphic study. This research revealed that Öcsöd-Kováshalom consists of a tell-like settlement surrounded by a horizontal settlement part with several intensively occupied areas along a one-time river bank. The appearance of this type of settlement was a novel observation in the area of the Tisza-Herpály-Csőszhalom cultural complex of the early 5th millennium BC. The following excavations at the Öcsöd site were conducted as field schools of the Institute of Archaeology, Eötvös Loránd University (ELTE) until 1987, the first results of which were summarized in an international exhibition and accompanying series of publications (*Raczky 1987; 1990; 1991*).

A new research phase began in 2016, marked by the integration of the Öcsöd-Kováshalom site into the Late Neolithic settlement pattern of the Tiszazug micro-region at the Körös-Tisza confluence, and its evaluation within this extended interpretive context (*Raczky, Füzesi 2016*). Such an investigation became feasible only after the Hungarian Archaeological Topography project had published its results on the Tiszazug region (*Kovács* et al. *2017*). Statistical analysis of the Tisza culture ceramic material showed the internal relationships of Öcsöd in another summarizing work (*Füzesi, Raczky 2018*). In addition, by discussing both the entangled everyday and symbolic activities of the tell-like settlement, we inferred a local network of relationships (*Raczky* et al. *2018*).

In 2018, a completely new dimension could be explored in the Öcsöd-Kováshalom investigations: the start of geophysical surveys covering the entire settlement, and systematic core sampling for soil analysis. The magnetic survey by the Romano-Germanic Commission of the German Archaeological Institute (DAI-RGK), headed by Eszter Bánffy and conducted by Knut Rassmann, revealed a triple concentric ditch system around the central settlement mound and the neighbouring horizontal settlement units (Fig. 1; *Füzesi* et al. *2020a*). The newly discovered ditches thus strengthen the physical connection between the central and outer settlement units, opening a new dimension under the visual horizon. Even more surprising was the discontinuous, segmented appearance of the ditches, so far unique in the Late Neolithic of the Tisza region. However, comparable ditch systems of settlements with numerous 'entrances' are known westwards, from Sopot and early Lengyel contexts in Transdanubia, from the late 6th and early 5th milennia BC. All of these seem to predate the classic 'rondel' versions without internal settlement features (*Kreisgrabenanlagen*) (*P. Barna 2017.152–193; Kovárník 2018.440*). The relationship between the two types of ditch systems is formally illustrated by the site Ligetfalva-Gesztenyési-dűlő. Here, the two inner ditches have four symmetrically arranged 'entrances',

while the third outer ditch has nine irregularly distributed interruptions (*P. Barna* et al. *2021.Figs. 16,19*). More remote constructions similar to Öcsöd can be identified among the Central and Western European Rosheim-type 'pseudo-ditch' causewayed enclosures, from the early 5th millennium BC (*Lefranc* et al. *2017; Turek 2021.1678–1679*). Regarding the possible internal and external connections of these constructions, the late *Linearbandkeramik* culture (LBK) pit enclosure excavated in Herxheim, Germany, shows a possible and at the same time very special example (*Zeeb-Lanz 2016; 2019*).

In this regard, the association between the Öcsöd-Kováshalom ditch system, and the central tell-like and peripheral single-layered parts of the settlement are important issues and raise questions. Can the triple enclosure be considered the long-standing result of a single communal decision, or does it represent successive 'construction stages' over a prolonged period? Furthermore, what temporal dynamics and choreographies characterize the digging and filling actions of the ditch segments? These questions have already been raised and discussed in connection with several other Middle Neolithic enclosure variants in Central

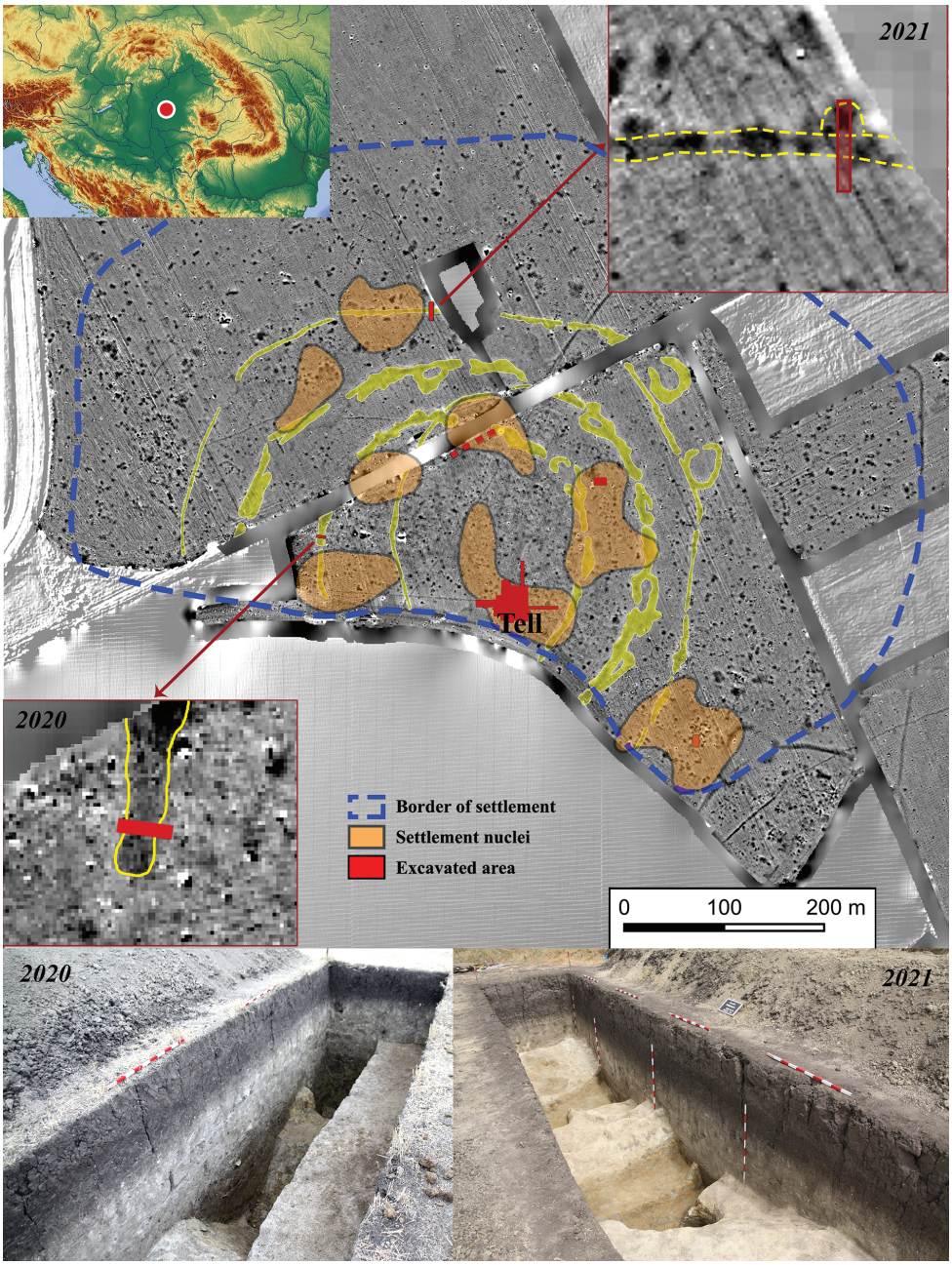


Fig. 1. The Öcsöd-Kováshalom Late Neolithic settlement complex and the 2020–2021 test excavation trenches (compiled by A. Füzesi).

Europe (among others: *Oliva 2004.516; Lisá* et al. *2013; Řidký* et al. *2014; Válek* et al. *2016; Haack 2016.37–116; 2020; Řidký 2019.67–102; Zeeb-Lanz 2019.441–466*). To address these questions, we investigated the Öcsöd-Kováshalom segmented ditch system with the help of small sondages.

We opened an 8x2m trial trench across the western part of the innermost ditch in 2020, the first excavation results and stratigraphic-statistical analyses of which were published in the same year (*Füzesi* et al. *2020b*). In 2021, again in cooperation with the ELTE Institute of Archaeological Sciences and the DAI-RGK, we cut across the northern part of the outer ditch with a 12x2m trench. By 2022, the dating of the radiocarbon samples taken from these two trenches was completed, as well as the geochemical analysis of the soil samples, carried out by Isabel Hohle. These data, put together, allow us to draw preliminary conclusions regarding segments of the Öcsöd circular ditch system.

Öcsöd-Kováshalom test excavation 2020

Archaeological features

In the summer of 2020, the southwestern section of the inner ditch was studied in a 2m wide trench. We were unable to fully excavate the area during the two weeks of fieldwork. Once we reached the subsoil and the contours of the cultural features became evident, we only continued the clearing in a 1m wide strip. The excavation was conducted in arbitrary levels of 20cm intervals. Within each level, the finds were kept separate per square meter. This way, 150 excavation units were identified, 92 of which were located in the northern, fully excavated, and studied part of the trench (Fig. 2.4–6).

The first archaeological feature, a structured deposit, has been recovered at the depth of 70cm, containing large fragments of several ceramic vessels, animal bones, and a considerable amount of mollusc shells (Fig. 2.3). This deposition may represent one of the final infilling events in the excavated ditch section, according to the post-excavation evaluation of the fill layers (Fig. 2.1). It can be interpreted as a concentrated and targeted event.

Two archaeological features have been isolated in the subsoil. One of these is a deep beehive-shaped storage pit cut in the inner, south-eastern side of the ditch. The section wall of our trench indicated that this feature was younger than the ditch, and it had two periods of accumulation, according to its fill layers. The lower part (P1) was dominated by yellow clay and charcoal pieces, while the upper part (P2) was mainly brown to light brown humus. The latter accumulation started with a massive charcoal layer containing daub fragments (Fig. 2.1–2).

The inner feature of the pseudo-ditch system showed a 315cm wide and 295cm deep, V-shaped cross-section in the excavated one-metre strip. The upper part of the ditch was probably widened several times. Its inner wall was stepped, and its outer wall was endowed with a two-meter-wide terrace, perhaps used for ditch maintenance. The structure and nature of the layers allow us to distinguish two phases in the filling of the ditch. The lower part (D1) was dominated by a maximum of 1.5m thick yellow clayey soil with several thin layers of larger daub fragments alternating in bands. Their stratification preserved the imprint of at least 10 distinct events. In contrast, the upper part (D2) was composed of massive layers of brown humus and its saline variety. The different nature and orientation of the two units suggest that the ditch had been filled after its use, from its inner side. This part of the ditch was covered by a layer strongly mixed with yellow clay, in which the structured deposit has been recognized (Fig. 2.1–2).

Archaeological material

The excavation yielded an extremely large quantity of finds, 17 430 pieces weighing 194.4kg. The detailed spatial documentation allowed the analysis of different artefact type distributions. As the data have already been published in detail (*Füzesi* et al. *2020b*), we present only three typical distribution patterns here (Fig. 2.4–6). Among the three dominant find types (pottery, daub, and animal bone), we have chosen animal bone. Their weight distribution shows the same trend as suggested by the fill layers. The lower part of the ditch (D1) was filled naturally, even if human agency is encountered. As a result, it contained limited archaeological material. In the upper part (D2) a high-intensity filling occurred in a relatively short time. Bone tools have been found only in this unit, their spatial distribution confirms the filling from the inner side, as they are scattered from the upper right part towards the lower left corner as seen in the figure (Fig. 2.4). The spatial distribution of the chipped stone artefacts further nuanced this picture. They allow us to distinguish several filling phases, with a higher number of chipped stones occurring

in both the lower and upper zones of unit D2 (Fig. 2.5). Concerning the storage pit, some artefact types dominated the lower fill unit, while others occurred more frequently in the upper part. For example, most ochre was found in the latter (Fig. 2.6), although these were occasional deposits of tool stones and animal bones.

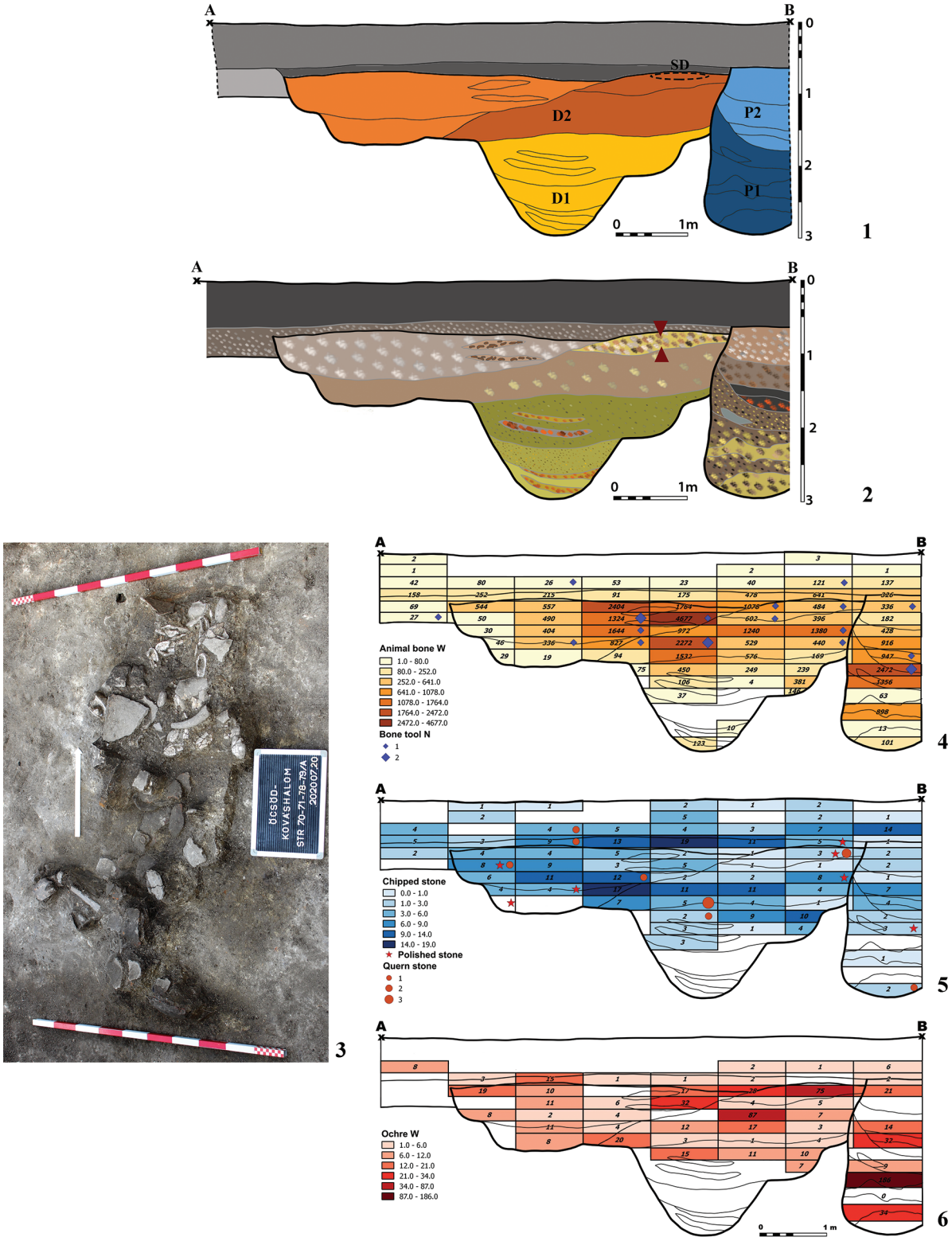


Fig. 2. The archaeological features of the 2020 trench and the distribution patterns of the find material:* 1 *identified features,* 2 *layers,* 3 *structured deposition (SD),* 4–6 *distribution patterns of bone (*4*), stone (*5*) and ochre (*6*) (compiled by A. Füzesi).

Geochemical analysis of samples from the 2020 excavations using X-ray fluorescence

Geochemical analysis using X-ray fluorescence in general

Soil is a very complex substance that consists of inorganic minerals, organic material and water (*Wilson* et al. *2008*). X-ray fluorescence (XRF) analysis is one method for investigating the multi-elemental content of the soil. Conducting XRF analyses of anthropogenic sediments will reflect the total concentration of individual elements in the sample.

The significance of phosphorus as one indicator of anthropogenic impact is long accepted and discussed in archaeology (see for example *Provan 1971; Salisbury 2012; 2016; 2020; Holliday, Gartner 2007*). Anthropogenic phosphorus can originate from human impact like waste, barns, burials, excrement ment, fertilizers, *etc*. In its natural form, the presence of phosphate is quite stable in the soil, and thus the comparison with elevated proportion caused by human activities becomes interesting for archaeological research. But a range of recent studies shows that the content of several other elements, like carbon, nitrogen, calcium, potassium, magnesium, sulphur, copper, zinc, and other metals, are also indicators of (intensive) human activity. Their analysis helps in interpreting different activity zones and understanding compound archaeological features (*Holliday, Gartner 2007.302*, quoted after *Cook, Heizer 1965.1–3; Eidt 1984.25–27; Woods 1982.1396–1399*).

A major difficulty with determining phosphorus in soil lies in the fact that it has not yet been determined how individual soil phases are responsible for phosphorus retention in different archaeological soils and features. Phosphorus is therefore a somewhat problematic indicator of human occupation (*Oonk* et al. *2009.36*, quoting *Entwistle* et al. *1998.53–68; 2000a.287–303; 2000b.171–188*). As such, using the results from analyses of total phosphorus content should be treated with considerable caution, since it can be significantly higher than anthropogenic phosphorus (*Holliday, Gartner 2007.314*). Taking advantage of geochemical, multi-element analysis, other elements presenting in the soil – like calcium, magnesium or strontium – could support the interpretation of phosphorus, separating natural phenomena from anthropogenic influences (*Oonk* et al. *2009.36*).

The use of XRF started in the DAI-RGK around 10 years ago, and the protocols developed at these times are basically still in use, although some parts have improved in the last few years, also due to better equipment. Currently, the RGK uses a handheld Niton XL3t (Thermo Scientific) in the field, which at the beginning was mostly used in the lab with a sample chamber and a helium flush for detecting light elements (see *Gauss* et al. *2013.2946–2947*).

The Öcsöd samples first underwent the RGK standard protocol of drying in a cabinet dryer (at 40°C), mortaring by hand and filling in the soil into sample cups. Later, when receiving the 2021 Öcsöd samples, the RGK possessed new technical equipment: a planetary ball mill, a press for pressing tablets and a benchtop XRF (Spectro/Ametek Xepos, ed-XRF). Indeed, the Öcsöd samples were used for testing the new sample preparation protocol, and also comparing the different preparations and XRF devices.

With the Niton we used our standard procedure (see also *Gauss* et al. *2013.2946–2947*), which means 150 seconds per sample with the mining mode. As the benchtop XRF was new, we tried to carry out a different series of measurements: powder samples in sample cups measured for 150, 300 and 600 seconds (helium), and compressed tablets measured for 150, 240 and 600 seconds, respectively (under vacuum). Unfortunately, no detailed evaluation of the tests and comparative measurements under the various parameters has been possible yet, although this is planned for the future.

After developing the customized protocol for the new mill and benchtop XRF, the 2020 and 2021 samples from Öcsöd were dried in the cabinet dryer, ground with the planetary mill (2-3 minutes max. 300rpm, 50ml cup with seven balls), filled into sample cups and measured with helium flush each 150 and 300 seconds.

During each measurements series the first, last and some in between (approximately every 10th measurement) served as measurements of certified reference materials (Nist 2709a (powder), Nist 2710a (powder and compressed tablets), NCS DC 78302 (powder and compressed tablets). These repetitive measurements were used to control the stability of both the XRF devices and to see if measurements could be reproduced over the time of the period of analyses.

Due to the differences in the results between the devices and normal variation, operating with the absolute values of element content does not seem to be practical. It seems to be more appropriate to operate with means of values and a more proportional evaluation, and to use the results for comparing higher/lower content.

The samples from 2020

From the 2020 excavation the RGK received 15 samples for analysis. The samples were taken along a continuous sediment column which offered a full series for the investigated ditch section. Additionally, two samples from the subsoil underneath the archaeological features were taken for comparison. As seen in all variants of measurement, the samples from the upper part of ditch D2 (53, 69, 85, 101, 117 and 124) have the highest phosphorus (P) content compared to the other samples (see the example in Fig. 3.2). While the amounts measured by the pXRF lie between approx. 2500 and 3200ppm, the powder samples measured with the benchtop XRF even have values from approx. 2700 and 3900ppm, while pressed pellets gave results over 4000ppm. All these values can be regarded as quite high, especially when you compare them with the values of the natural soil, where the P content is under 1000ppm.

The most striking argument for a high human impact and anthropogenic influence is the correlation of the high P values with other elements that are known as indicators of human activities and disposal, like Sr in the samples 85, 101, 117 and 124 and the K and Ca contents. But compared with the natural soil it has to be kept in mind that there are also comparably high values of Ca and K, and that is why higher levels of these elements in anthropogenic layers may also indicate admixture with the subsoils.

Interpreting geochemical data is not an easy task. It always requires context data as much as possible, as well as reference samples from the subsoils and the topsoil. Our observations coincide with the structural, stratigraphic and assemblage assessment of the ditch section. The lower part (D1) primarily displayed signs of natural refilling, while the upper part (D2) had contained indicators of a significant anthropogenic impact. Additionally, an inclusion of geochemical analyses in more comprehensive geoarchaeological studies in the future could be a step-change for a better understanding of soil formation and human impact.

Relative and absolute chronology

The finds included some impressive stone and bone tools and a zoomorphic figurine; however, decorated pottery also played a pivotal role in our analysis. The site of Öcsöd-Kováshalom, based on the old excavations in the 1980s, represented the end of the Middle Neolithic and the beginning of the Late Neolithic periods in Hungarian terminology. This is the late Szakálhát and early Tisza period, with intermingling Szakálhát and Tisza pottery style elements, the latter gradually replacing the former style. During the early excavations, which covered an area of 1243m², elements of purely Szakálhát pottery rarely appeared independently, without being mixed with other pottery styles in the archaeological features. A small number of such finds were found in the early horizon (Öcsöd A) assemblages and were absent in the Öcsöd B material. At the same time, the Tisza style developed gradually. In the early, transitional period, the Tisza I style was based on continuous and concentric main motifs, while later, in the Tisza II, meander motifs in panelled structures, the so-called textile style, became dominant (*Raczky 1992; Füzesi, Raczky 2018*).

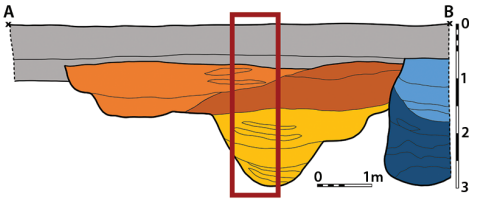
Accordingly, the ditch section excavated in 2020, yielded mainly Tisza I-style material (Fig. 5.1–5). Besides, this transitional period was also characterized by ceramic sherds decorated with grooves arranged in bands (Fig. 5.5), painted black strips (Fig. 5.4), and tar-coating (Fig. 5.3). Tisza II elements were predominant among the finds from a storage pit of a later date (Fig. 5.11–13). A fragment of a cylindrical, flowerpot-shaped vessel with textile-style decoration was found at the bottom of the feature (Fig. 5.11). The typochronology, based on the decorated pottery, thus coincided with the stratigraphical position of the features.

The absolute chronology is based on ^{14}C dating performed on eleven samples from the excavated finds. The model (Fig. 4.3) was generated by Norbert Faragó using the IntCal20 calibration curve (*Reimer* et al. *2020*) and OxCal 4.4.4 software (*Bronk Ramsey 2021*). The laboratory results and locations of the samples used for the chronological analysis and the data used for modelling are shown in Fig. 4. Hereafter, we give absolute chronological data with a 68.2% probability. The individual dates are scattered within a relatively wide temporal horizon, ranging from 5028 (68.2%) 4951 to 4889 (68.2%) 4794 cal BC (Fig. 4.3). However, the stratigraphic position of the samples

(Fig. 4.1) allowed us to construct a model with high accuracy. However, only eight of these 11 samples could be used. The results of samples 3, 4, and 6 could be excluded as outliers based on the preliminary modelling (*Bronk Ramsey 2009; 2021*), so the final model agreement index reported here is 152.3%. All three discarded samples came from the lower part of the ditch (D1), which proved to be younger than the fill above them, accurately dated with four samples (D2). There could be several reasons for the discrepancy,

ÖCSÖD 2020		Mg	P	K	Ca	Ti	Mn	Zn	Rb	Sr
Sample	*Time*	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
5	150 sek	9893	1815	23400	9835	3903	786,2	108,4	109,1	101,3
21	150 sek	10980	2010	24760	10870	4146	812,7	108,9	110,7	100
37	150 sek	10550	1843	21090	9923	3438	661,3	112,9	115,7	99,4
53	150 sek	10930	2805	19770	16420	3470	636,8	110,5	114,5	113
69	150 sek	11600	3291	18430	50180	3233	578,6	108,8	105,3	154
85	150 sek	12780	3851	18210	101800	3156	607,6	112,3	95	199,3
101	150 sek	16350	2554	20580	55430	3458	653,1	110,6	103,9	214,9
117	150 sek	17150	3101	20600	49670	3349	755,5	114	104,6	227,9
124	150 sek	17730	3140	22900	44440	3669	755,9	123,6	109,6	218,5
129	150 sek	14700	1742	20280	21790	3327	520,7	98,3	117,9	165,5
134	150 sek	17780	1116	24240	30720	4241	851	92,3	121,7	139,6
138	150 sek	15050	823,8	20350	21060	3671	590,6	84,9	111,4	114,3
142	150 sek	15250	729,3	21790	25320	3852	661,2	85,3	113	115,4
145	150 sek	15320	597,9	17920	34910	3238	670,3	80,7	113,6	132,7
148	150 sek	16970	562,2	21420	33050	3842	663,5	86,3	116	126,2
subsoil (110-120 cm)	150 sek	15480	674,2	16550	91150	3253	728	64,6	87,1	180,5
subsoil (110-120 cm)	150 sek	14030	593,4	14740	75070	2937	679,2	62,1	86,2	171,4

1



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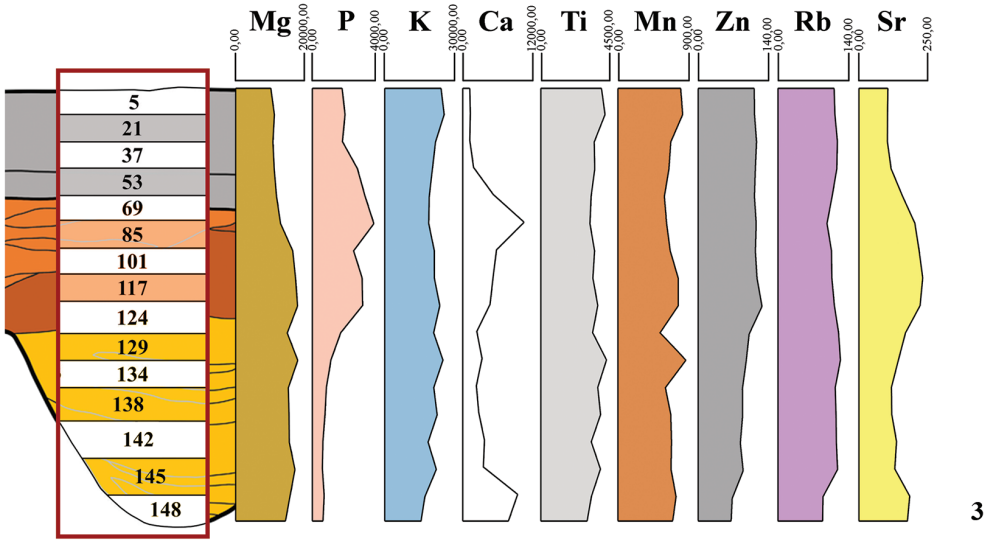

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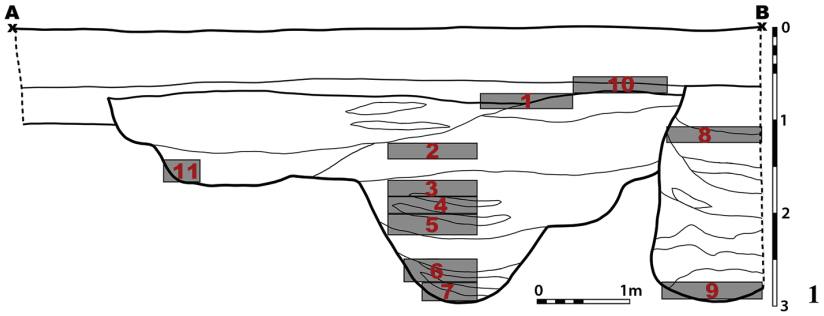
Fig. 3. Geochemical analysis of samples from the 2020 excavations using XRF.* 1 *examples measured with the ed-XRF Spectro Xepos He with a helium flush and calibration for powder samples in sample cups with 150 seconds measurement time for each sample. A samples plate with eight positions and sample rotation feature was used. Selection of elements, values in ppm;* 2 *sample locations;* 3 *results of the chemical analysis (compiled by I. Hohle and A. Füzesi).

which unfortunately cannot be identified after the event.

With our chronological model, we were able to significantly reduce the timeframe associated with each phase and event. The start of the complete sequence is estimated to be 5028 (68.2%) 4951 cal BC and the end is 4889 (68.2%) 4794 cal BC. The first accumulation phase in the lower part of the ditch (D1), according to two ^{14}C measurements, ended 4951 (68.2%) 4915 cal BC, over 40–77 years. The upper part of the ditch (D2) was filled between 4951 (68.2%) 4915 cal BC and 4935 (68.2%) 4899 cal BC, representing 16 years. The structured deposit at the top of this sequence also



Lab Nr MAMS	Sample Name	^{14}C Age [yr BP]	±	δ13C AMS [‰]	Calibrated Ages Probability 68%	Probability 95%	C:N	C [%]	Collagen [%]	Material
56015	1 - Öcsöd-Kováshalom 2020	6022	23	-17.3	cal BC 4950-4847	cal BC 4993-4843	3.3	18.6	12.7	bone
56016	2 - Öcsöd-Kováshalom 2020	6017	23	-15.0	cal BC 4945-4847	cal BC 4991-4841	3.2	32.9	4.1	bone
56017	3 - Öcsöd-Kováshalom 2020	5999	23	-17.0	cal BC 4933-4844	cal BC 4986-4797	3.2	27.9	4.3	bone
56018	4 - Öcsöd-Kováshalom 2020	5801	24	-21.1	cal BC 4708-4613	cal BC 4720-4551	3.4	8.6	1.9	bone
56019	5 - Öcsöd-Kováshalom 2020	6064	23	-20.8	cal BC 5006-4935	cal BC 5042-4851	3.2	42.5	5.3	bone
56020	6 - Öcsöd-Kováshalom 2020	5973	23	-16.7	cal BC 4899-4799	cal BC 4936-4791	3.3	20.2	2.5	bone
56021	7 - Öcsöd-Kováshalom 2020	6084	23	-20.2	cal BC 5028-4951	cal BC 5203-4907	3.2	29.0	4.3	bone
56022	8 - Öcsöd-Kováshalom 2020	5959	23	-19.0	cal BC 4884-4795	cal BC 4935-4731	3.2	26.5	3.3	bone
56023	9 - Öcsöd-Kováshalom 2020	6003	23	-20.6	cal BC 4935-4846	cal BC 4987-4799	3.2	35.9	4.1	bone
56024	10 - Öcsöd-Kováshalom 2020	6001	23	-22.1	cal BC 4934-4845	cal BC 4986-4798	3.2	31.9	7.0	bone
56025	11 - Öcsöd-Kováshalom 2020	6027	23	-19.0	cal BC 4981-4849	cal BC 4994-4844	3.2	25.1	3.7	bone

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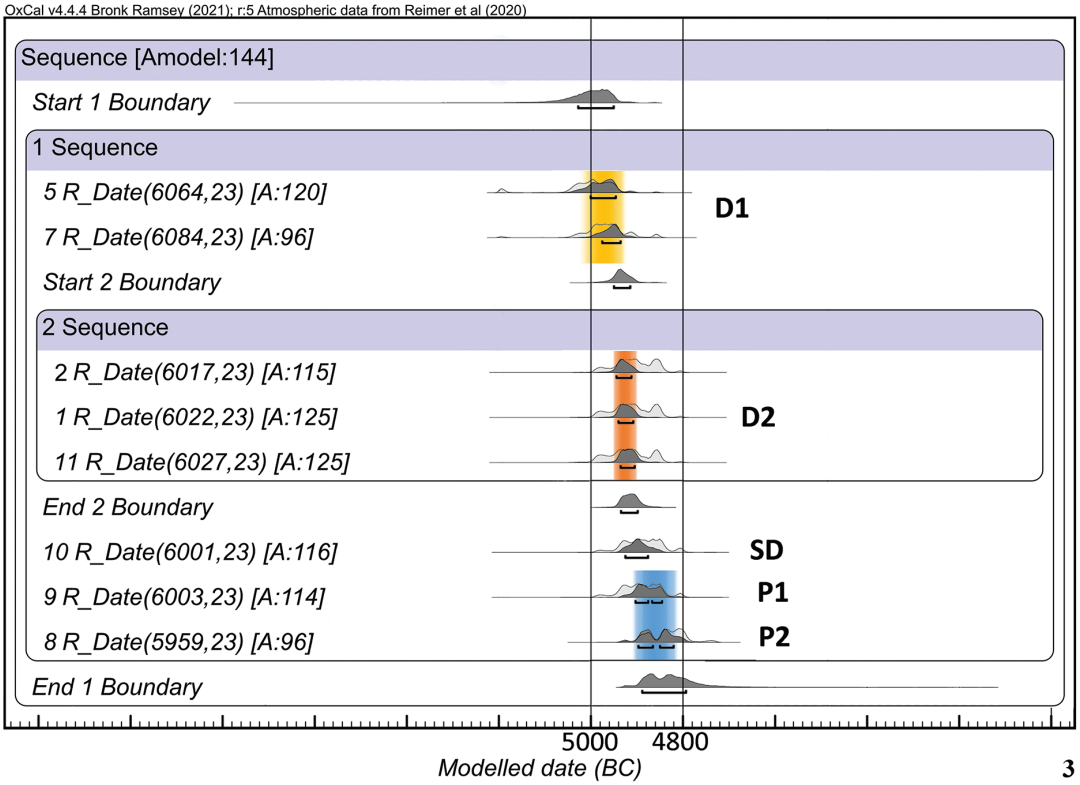


Fig. 4. The absolute chronology of the 2020 trench:* 1 *excavated units with* ^{14}*C samples;* 2 ^{14}*C data;* 3 *OxCal model of the* ^{14}*C data (compiled by N. Faragó and A. Füzesi).

dates to a similar period: 4926 (68.2%) 4877 cal BC. The two samples from the storage pit indicate that it was buried over a 0–83-year period, between 4904 (68.2%) 4846 cal BC and 4898 (68.2%) 4821 cal BC.

Comparing these results with previous ^{14}C data and the chronological model from the Öcsöd site (assembled by Zsuzsanna Siklósi), a high degree of agreement is observed in the formation dynamics of the two sampled locations. The backfilling of the ditch section excavated in 2020 directly followed a period of reorganization in the multi-layered settlement part. This activity was associated with a communal rite, recorded in a structured deposit (*Raczky* et al. *2018. 122-123*) dated between 5056 (68.2%) and 4942 cal BC. The end of the first construction horizon (Öcsöd A) thus coincided with the abandonment and filling of the inner ditch (*Füzesi, Raczky 2018*). The great quantity of artefacts in the upper layer (D2) suggests a similar landscaping process close to the ditch, along its inner side. The evidence suggests that the settlement reorganization in the first decades of the 5th millennium BC covered a large part of the site.

Fig. 5. Selection of decorated ceramic material from the 2020 trench – (1 D1, 2-10 D2, 11-13 P1) (compiled by A. Füzesi).

Öcsöd-Kováshalom test excavation 2021

Archaeological features

In August 2021, a 2x12m trench was opened in the northern part of the outer ditch surrounding the settlement, near an abandoned farmstead (Fig. 1). The geophysical survey indicated several features superimposed on the ditch, which belonged to the sparsely used periphery of the Late Neolithic settlement. Following the method of the previous excavation, the finds were collected by the square metre, in arbitrary, 20cm thick levels. We identified 275 such units, almost all of which contained find material, assigned to the identified archaeological features (Fig. 8.1–5).

Similarly to the previous season, the first excavated phenomenon in 2021 was a structured deposit at a depth of 70cm, two meters away from the inner, southern side of the ditch. It contained large fragments of a sizeable Late Neolithic storage vessel in a 50x100cm area (Fig. 7.1). The deposit cannot be associated directly with the backfilling of the ditch; however, it was situated above an intact Neolithic cultural layer (Fig. 6.1–2). Both the 2020 and 2021 structured deposits can be interpreted as targeted, closing events between accumulation processes.

In a 9m section of the 12m long trench we identified six pits (P1–6), two ditches (D1, D2), and one well (W) dug into the subsoil, creating a complex superposition that could only be inferred from the section walls. In the northern section of the trench we recovered parts of five pits, three of which were regular beehive-shaped storage pits (P2–3, P6), one medium-sized irregular-bottomed pit (P5) and one large amorphous feature (P4) identified as a clay extraction pit. Their stratigraphic relationlationship enabled us to reconstruct a sequence for the establishment and infilling of each feature: the similarity of the finds suggests that they all date to the earliest, relatively short period of habitation. The large number of features indicates intensive settlement activity, at a distance of about 350m from the riverbed. An important observation concerning settlement structure is that all of them predate the ditch system. The layers of the filling (except for P6)

demonstrate that the features were filled up during several events. Layers containing larger amounts of ash and daub did not cover the entire surface of the larger pits (P5–6), *i.e.* they testify to small-scale depositions (Fig. 6.2).

The structure of the outer part of the pseudo-ditch system in its excavated 2m section differed significantly from the inner ditch recovered in 2020. Most notably, here we could distinguish two construction phases (D1, D2) with similar shapes and sizes, although only the later one (D2) could be observed in its entire width. The recovered part of the ditch displayed a V-shaped, slightly trapezoidal cross-section, with a width of 220cm at the top, 40–50cm (D1) and 30–45cm (D2) at the bottom, and a depth of 190cm (D1) and 205cm (D2). The outer, northern side was less steep, the earlier features promoted a slightly stepped appearance there. The inner, southern side of the later ditch was steep at the bottom and less inclined at the top. Both ditches were filled in several phases resulting in a layered structure. No significant difference occurred in the filling of the early ditch, and its layers predominantly consisted of yellow clayey humus. This suggests a faster accumulation rate than in the case of the later feature, the upper and lower parts of which showed differences similar to what has been observed in the inner ditch. The lower part of the sequence was brown humus interstratified with thin layers of yellow clayey sediment, while the upper part consisted of a single darker humus layer (Fig. 6.2).

The eastern section wall (C–D) showed that the large pit P1 intersected both ditches. Two burials (G1, G2) were excavated at a relatively shallow depth in the northern part of this round bottom pit. The burials were situated close to the partial skeleton (G3) excavated in the P6 storage pit. Of all three skeletons, only the legs survived in a highly fragmented condition. Their orientation may have been similar, with the legs in a flexed position indicating a W/SW-E/NE orientation (Fig. 7.2,4). According to their stratigraphy, the burials represent a relatively long period, G3 was found inside an early feature and was probably disturbed by the digging of pit P4. G1 and G2 were located in the upper part of a late feature (P1) (Fig. 6.1–2), their incompleteness can also be explained by later disturbance. However, other traces of disturbance could not be identified, thus it was probably a modest event or two that did not reach the section walls.

An unexpected feature, an 80x100cm spot of a well, has been recognized at a depth of about 90cm. The well did not reach the section walls of our trench but cut the D2 ditch. Unfortunately, it is unclear whether the well is younger or contemporaneous with pit P1, the southwestern edge of which it was cut, and if the pit was created to facilitate digging the well. The well tapered to a diameter of 65–70cm at a depth of 1.5m and retained its cylindrical shape down to the bottom (Fig. 6.1–2; Fig. 8 right side). It was filled with greyish-brown loose humus mixed with a large quantity of charcoal. The size and quantity of charcoal fragments soared between 4 and 5m in depth. The feature was cleared by hand to this depth (Fig. 7.5–6), following its steady cylindrical shape in the local clayey subsoil. The last 1m was excavated by a core drill due to the limited space and no finds were collected from these units, only soil samples. The presumed bottom of the feature was reached at a depth of 6m from the surface. Besides its peculiar shape and size, the well itself is also a unique phenomenon because no such feature had been known from the Öcsöd site, despite a long history of archaeological investigation. No wells have been found in the 1243m² area excavated relatively close to the riverbed, so the location of this feature in the later settlement's periphery and its distance from the riverbed suggest that the water supply was provided separately and differently within each settlement unit.

Archaeological material

Although the 2021 trench was much larger, we encountered significantly fewer finds compared to the previous year. The 12725 finds represent a 27% difference, while their 94.9kg total weight displayed an even greater 51.2% drop. This difference, considering the higher number of archaeological features and the greater volume of soil removed, indicates the peripheral nature of the location and the lower intensity of the former activities. In addition, this phenomenon also points to the differences in the depositional activities around the inner and outer ditches. The distribution of different artefact types was analysed based on detailed spatial documentation, similar to the previous operation. Due to a lack of space, only a few characteristic distribution patterns are presented here (Fig. 8).

Of the three dominant find types (ceramics, daub, and animal bone), ceramics showed a relatively uniform distribution despite their concentration at three lo-

cations, in pits P1 and P4, and the structured deposition (Fig. 8.2). In the other pits and ditch D2, find frequency increased mainly in their upper parts. The spatial distribution of animal bones showed a similar pattern, but the differences between units were more pronounced for this find type: most finds occurred in six of the units. Compared to 2020, significantly fewer daub fragments were encountered, with strongly a

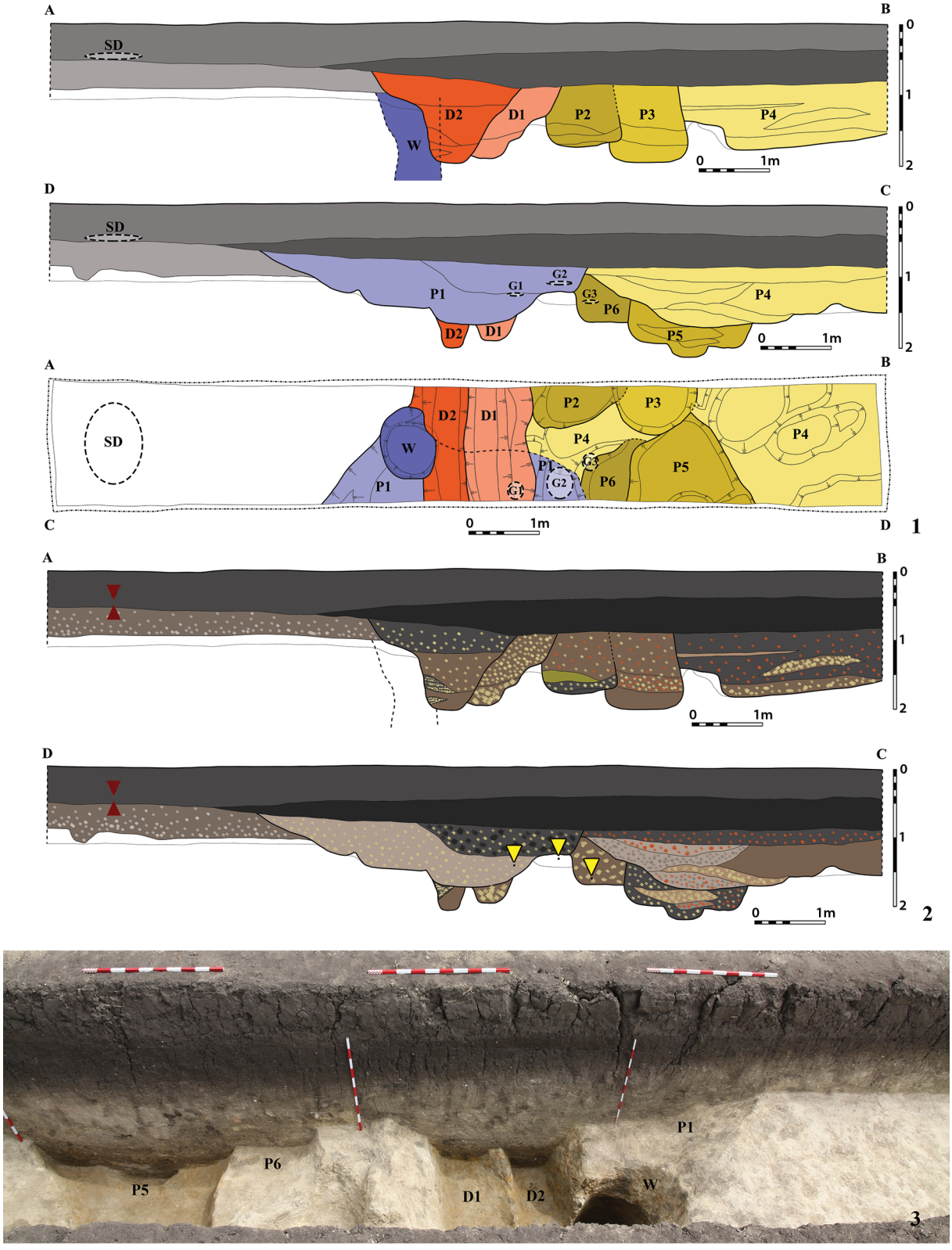


Fig. 6. The archaeological features of the 2021 trench (red double triangle – structured deposition, yellow triangle – burial) (compiled by A. Füzesi).

concentrated distribution characteristic of rare finds, mainly in the middle layers of pits P4 and P6 (Fig. 8.1). Chipped stones were concentrated primarily in the upper cultural layer. This layer, at a depth between 60 and 90 cm, partially disturbed by ploughing, can be considered the remnant of the last Neolithic occupation. A quarter of all chipped stones was recovered from the features, and these were evenly distributed among the features and layers that yielded a large number of finds (P1, P4, the upper part of D2, the upper part of the well; Fig. 8.3). Only seven grinding stones were found, most of these lay in pit P4, one came from the middle part of the well, and one from the upper part of pit P3. One of the two polished stone axes was found in the latter location as well. The other axe fragment was recovered from the upper part of ditch D2 (Fig. 8.3). Ochre was found in 18 units, which came to light only in the lower part of pit P4 and above ditch D2 in larger quantities (Fig. 8.4). Modest quantities of mollusc shells were found in almost all excavation units, with significant concentrations in the earliest storage pits (P5–6) and in feature P4 (Fig. 8.5).

Fig. 7. The archaeological features of the 2021 trench (*SD *structured deposition,* G *burial,* P *pit,* W *well,* D *ditch) (compiled by A. Füzesi).

While the total number of finds was significantly lower compared to 2020, the distribution of the different artefact types attested to greater variation. The data series was further complicated by the co-occurrence of 13 archaeological features and their associated deposition. The majority of the finds were recovered from the two large amorphous pits, early P4 and late P1. Based on layer composition, broadly similar accumulation processes could be identified, but differences in the various artefact type concentrations suggest that the successive depositions focused on a particular set of artefacts. For example, daub fragments predominated in the lower part of P4, while pottery in the middle-upper part (Fig. 8.1–2). The smaller storage pits can only be mentioned for a few find types, the high concentration of mollusc shells in the earliest features is particularly interesting in this regard (P5–6; Fig. 8.5). The mosaic distribution of finds supports intermittent small-scale filling of the pits and separately implemented events. Of the ditch sections, the later structure contained a larger number of finds, although this was still limited compared to the inner ditch section excavated in 2020. Ditch D2 was backfilled similarly to the latter, with the majority of the finds in the upper part, which was deliberately buried after the ditch had lost its function. The common find types are distributed relatively even in the well, with a slight concentration in the middle (at a depth of between 4 and 5m). We distinguished three accumulation phases in the well, based on the backfilling and find distribution. In the lower part (5–6m depth), explored by core drilling, a series of collapses documented in the form of yellow clay, which probably occurred after the well became dry. The layers and finds in the middle and upper parts are similar, except that the abundance of the charcoal component in the greyish-brown humus increases downwards, as are the finds at depths of between 4 and 5m. This pattern suggests that the feature was filled in two stages after having lost its function.

Geochemical analysis of samples from the 2021 excavations using X-ray fluorescence

The DAI-RGK received 37 samples from archaeological features of the 2021 excavation for analysis. Additionally, five samples from different areas from the subsoil were also studied (Fig. 9). The sample collection strategy focused primarily on the excavated ditch section. The series of collected samples revealed the filling of the early ditch (D1) and the cultural layers above it in two stages. A third larger sampling was completed in the tube-like well, where a more than 3m thick stratum could be investigated. Additional samples were taken from pits P4, P6 and the structured deposition, six in total (Fig. 10.1).

The results from the XRF measurements (Fig. 10.2–3), especially concerning the P values, are quite comparable to the 2020 results. The highest values of phosphorous (contents between approx. 2700 and 4200 ppm) were mainly from the samples taken from the upper of the ditch D1 (152, 170) and the well (227, 228-230). The middle section of the well (250, 257 and 262), although with a smaller absolute value, showed somewhat higher results. Samples 235 and 248, taken from the earlier pits P4, P6, have conspicuously low values (below 1000ppm).

The elements of Zn and Sr have slightly elevated values compared to the subsoil and partly correlate with high P values, and thus underline the probably intense human impact and accumulation in these layers.

The analysis of the five subsoil samples from the 2021 campaign showed extreme differences for some elements, like Ca, Mg and Sr. This variability indicates a heterogeneity in the surrounding subsoil of the Öcsöd site, which is not surprising for alluvial sediments. However, a more detailed investigation is crucial to achieve a better understanding and interpretation of the results from the XRF analysis of the anthropogenic features. Geoarchaeological and pedological reports could also be useful, as the analysis of more subsoil samples enables the classification of natural processes and influences.

A detailed comparison of the 2020 and 2021 soil sampling may yield additional results later. However, some differences can be determined between the well and ditch system in advance, based on the quantity of chemical elements (K, Ca) and the various tendencies of accumulation (Mg, P, Ca, Rb, Sr). The evaluation of distinct details can help the reconstruction of site formation processes at the Öcsöd-Kováshalom settlement complex.

Relative and absolute chronology

The 2021 fieldwork resulted in an increase in the number of features and the complexity of the stratigraphic relationships between them, but also in the quality of the finds recovered. The typochronology of decorated

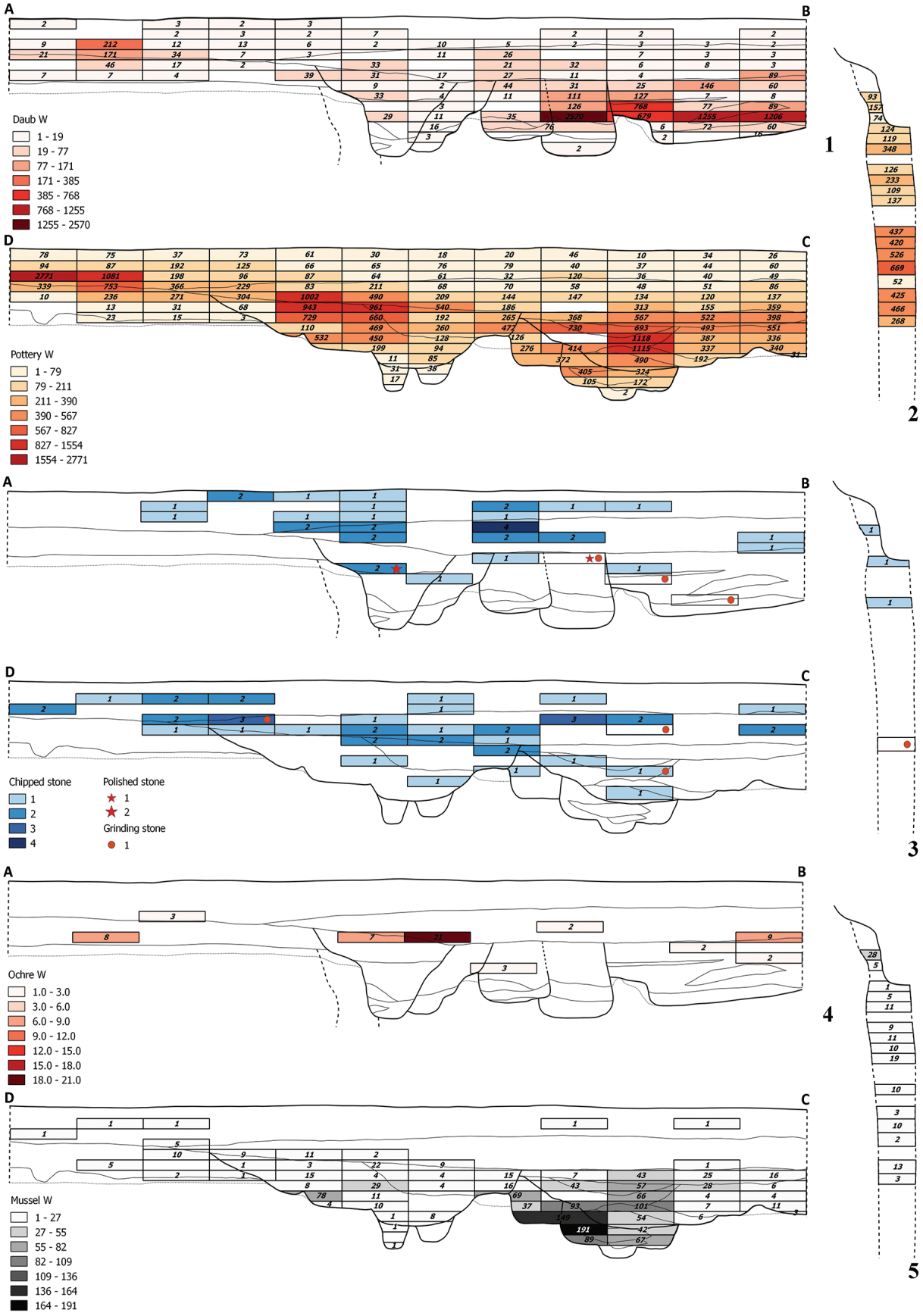


Fig. 8. The distribution patterns of archaeological material from trench 2021:* 1 *daub*, 2 *pottery*, 3–4 *stone artefacts*, 5 *ochre*, 6 *mollusc shells (compiled by A. Füzesi).

pottery covered periods of the Szakálhát and Tisza cultures (Figs. 12–13). Although the abundant find material excavated in the 1980s included several classic Szakálhát-style pottery sherds, no features dated to the classic Szakálhát period were found then (*Füzesi, Raczky 2018*).

Based on their stratigraphy, pits P2–P6 represent the earliest occupation in the northern periphery of the site. A significant amount of the pottery recovered there showed classic Szakálhát-style characteristics. Most distinctive are incised closed patterns, filled in with red pastose painting (Fig. 12.1–4,10–12). Although the red painting is rarely preserved, the curved lines suggest the running spiral and interlocking S motifs. The space between the incised lines on the coarse ware was filled in with finger and nail impressions (Fig. 12.5,9). The characteristic plastic decoration of the coarse ware can be seen by the fingertip-impressed applied ribs on the shoulder of a storage jar (Fig. 12.8). The material shows Szakálhát-style characteristics of the Middle Tisza region (Cserkeszőlő-Kisasszony-dűlő III: *Füzesi 2020.Fig. 2.1–6, Fig. 7.2*; Kunszentmárton-Bohonya: *Kalicz, Makkay 1977.Tab. 149–151*; Szentes-Ilonapart: *Horváth 1994*; Tiszaug-Railway-station: *Füzesi* et al. *2017*). Among the features, only the large P4 and the latest P2 contained some fragments with panelled ornamentation typical of late Szakálhát and early Tisza (Fig. 12.6,13).

Szakálhát painted-incised fragments occurred (Fig. 13.2) in the fill of the earlier ditch (D1), but also classic Alföld Linear Pottery culture (ALPC) pottery (Fig. 13.1), which appeared in the microregion at the same time as the classic Szakálhát. Simple geometric motifs formed by incised parallel lines also appeared in the material of the 1980s, in all cases as stray finds. The majority of the fragments were decorated with complex patterns in panelled configuration, which was typical for Tisza style ceramics, as it appeared on the pots of the later ditch (D2), executed in varied quality (Fig. 13.3,5–7).

Similar ornamentation was observed in the material of the later features (P1 and well). The rows of interlocking lozenges (Fig. 13.9,12) were typical of the late settlement horizon (*Füzesi, Raczky 2018.85, Fig. 27*). The large, rectangular vessel, several pieces of which were found in the middle section of the well at a depth of 4–5m, is a special feature. The sides of the roughly shaped vessel were decorated with rectangular applied panels. The flattened edges of these were divided by finger-impressed ribs. The panels were filled with an incised meander pattern (Fig. 13.13). Characteristic Tisza pots were amphorae with a flattened spherical body and ring-shaped, variously decorated lugs on the belly (Fig. 13.14). This vessel group exhibited a higher proportion of black resin painting, rarely survived on the eroded fragments (Fig. 13.4), but it was nevertheless a characteristic decorative technique of Tisza I and II pottery (*Raczky, Sándorné-Kovács 2009; Füzesi, Raczky 2018.80–81; Sebők 2022*).

We completed our relative chronological observations with the ^{14}C dating of 12 find samples. The sample from the well stood out among the dates. The 5757 (68.2%) 5667 cal BC date corresponds to the Early Neolithic Körös culture in the local chronology. Although a settlement of similar age existed in the south-southeastern part of the site (*Raczky, Füzesi 2016.Fig. 5; Füzesi, Raczky 2018.Fig. 1.1*, Excavation trench III), the well was much younger than that. Supposedly, multiple reasons rendered the charcoal sample unusable. The remaining 11 samples encompass a long time range between 5303 BC (68.2%) and 4799 BC (Fig. 11.2). However, nine of these samples provided stratigraphic positions (Fig. 11.1) that allowed us to create a more accurate age model. The two discarded samples were collected in the upper part of the culture-bearing layer, which was presumably disturbed several times over the intervening millennia.

Based on our chronological model, we were able to significantly reduce the time range associated with each phase and event. The model (Fig. 11.3) was generated by Norbert Faragó using the IntCal20 calibration curve (*Reimer* et al. *2020*) and OxCal 4.4.4 software (*Bronk Ramsey 2021*). The laboratory results and locations of the samples used for the chronological analysis and the data used for modelling are shown in Fig. 11. Hereafter, we give absolute chronological data with a 68.2% probability. The results of samples 1, 11, and 12 could be excluded as outliers based on the preliminary modelling (*Bronk Ramsey 2009; 1023*), so the final model agreement index reported here is 77.1%. The start of the entire sequence is estimated to be 5363 (68.2%) 5266 cal BC, and the end is 4894 (68.2%) 4771 cal BC.

The first phase is represented by the completion of the Szakálhát pits infilling. Based on samples from the upper part of the P2 and P3 storage pits, this oc-

ÖCSÖD 2021		Mg	P	K	Ca	Ti	Mn	Zn	Rb	Sr
Sample	*Time*	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
8	150 sek	9235	1314	24850	10730	4145	830,7	99,1	115,5	93
32	150 sek	8507	1175	21120	9826	3576	709,9	95,1	112,8	93,6
49	150 sek	11010	1403	22160	31530	4008	715,2	93,7	110,8	105,5
56	150 sek	8973	1191	24020	9764	4193	835,3	100,1	113,5	93,1
80	150 sek	9071	1290	20320	9407	3375	700	106,5	116	95,2
104	150 sek	9793	1679	22980	11610	4003	789,9	110,4	115,6	97,9
128	150 sek	11000	2774	21740	24890	3952	765,5	117	114	121
152	150 sek	11550	3580	19800	48960	3461	696,7	109,8	106,7	167,8
170	150 sek	12320	2446	18760	68950	3387	607,8	96,6	96	171,4
185	150 sek	13170	2418	19770	56670	3420	641,3	99,7	103,9	188,9
200	150 sek	15360	2348	23660	45750	4197	760,1	104,2	110	177,9
204	150 sek	13620	1670	21600	53070	3837	715,6	89,7	108,2	149,3
216	150 sek	13650	1771	19360	33980	3383	645,1	98,1	106,6	172,1
227	150 sek	12820	3126	20280	32520	3306	655,2	126,1	106,5	225,6
228	150 sek	13760	4197	21440	37720	3542	765,4	129,3	104,5	240
229	150 sek	13120	3646	20980	37300	3443	728,8	128,8	105,3	226,5
230	150 sek	15280	3462	24070	37170	3981	770,5	133,3	107,6	250,2
232	150 sek	16030	1675	22670	43100	3985	710,6	89,5	106,2	161,7
235/a	150 sek	16230	905,7	25490	41760	4618	744,1	88,4	117,3	134,5
235/b	150 sek	15190	837,6	23620	31760	4163	747,7	88,9	115,6	126,7
243	150 sek	13880	2978	23030	35260	3775	776,7	123,8	105,8	237,6
244	150 sek	13900	1198	21100	35640	3598	630,6	88,1	108,4	149
248/a	150 sek	13810	930	22650	30630	3897	753,9	86,3	107,9	125,7
248/b	150 sek	15050	1158	24480	40900	4222	797,4	91,2	111,4	137
250	150 sek	14010	3344	23770	33470	3717	705	132,8	112,6	255,3
251	150 sek	13630	2571	19820	28640	3337	655,4	115,6	107,7	229,8
252	150 sek	13710	1207	22680	33050	3892	692,6	91,2	108	162,7
255	150 sek	14430	2622	24120	31940	3959	753,8	113,4	109,5	221,5
256	150 sek	13870	2055	22200	29010	3697	649,1	111,3	112,7	208,3
257	150 sek	13460	2823	21790	30630	3571	704,7	124,9	110	249,4
258	150 sek	13380	2425	21580	32390	3567	779,6	108,1	106,8	233,7
259	150 sek	13820	2793	25300	31830	4123	805,4	121,9	109,6	239,6
260	150 sek	13350	2606	22800	30520	3859	704,3	120,9	110,7	227,3
261	150 sek	13740	2409	22270	30830	3773	633,2	110,6	107,4	215,2
262	150 sek	14030	2841	23760	33280	3991	834,8	117,7	106,7	204,1
263	150 sek	14570	2381	23820	31170	4020	861,8	118,4	110	198,9
264	150 sek	14860	1041	22260	40250	4016	721,9	94,6	128,8	163,8
subsoil1	150 sek	15480	674,2	16550	91150	3253	728	64,6	87,1	180,5
subsoil2	150 sek	14030	593,4	14740	75070	2937	679,2	62,1	86,2	171,4
subsoil3	150 sek	9592	249,3	16870	6374	3952	523	81,2	109,6	90,2
subsoil4	150 sek	17520	429,5	21930	76740	4113	814,7	85,1	110	185,3
subsoil5 (under well)	150 sek	8064	306,6	17660	18700	3549	520,6	86,7	101,6	107,4

Fig. 9. Geochemical analysis of samples from the 2021 excavation using XRF. The samples were measured with the ed-XRF Spectro Xepos He with helium flush and calibration for powder samples in sample cups with 150 seconds measurement time for each sample. A sample plate with eight positions and sample rotation feature was used. Selection of elements, values in ppm (compiled by I. Hohle).

curred between 5297 (68.2%) 5265 cal BC and 5275 (68.2%) 5215 cal BC. The end of the Szakálhát period could be dated to 5246 (68.2%) 5137 cal BC. Previous ^{14}C data rendered the classic Szakálhát assemblages between 5293–5068 cal BC, while the Tiszaug-Railway-station assemblage could be dated to 5023–4909 cal BC (*Füzesi* et al. *2017.33–34*). Our recent samples date the Szakálhát features excavated in the northern part of Öcsöd-Kováshalom to the previously accepted period. This confirms our conclusion on the Tiszaug assemblage that the archaistic use of different stylistic elements (based on ^{14}C dates much younger

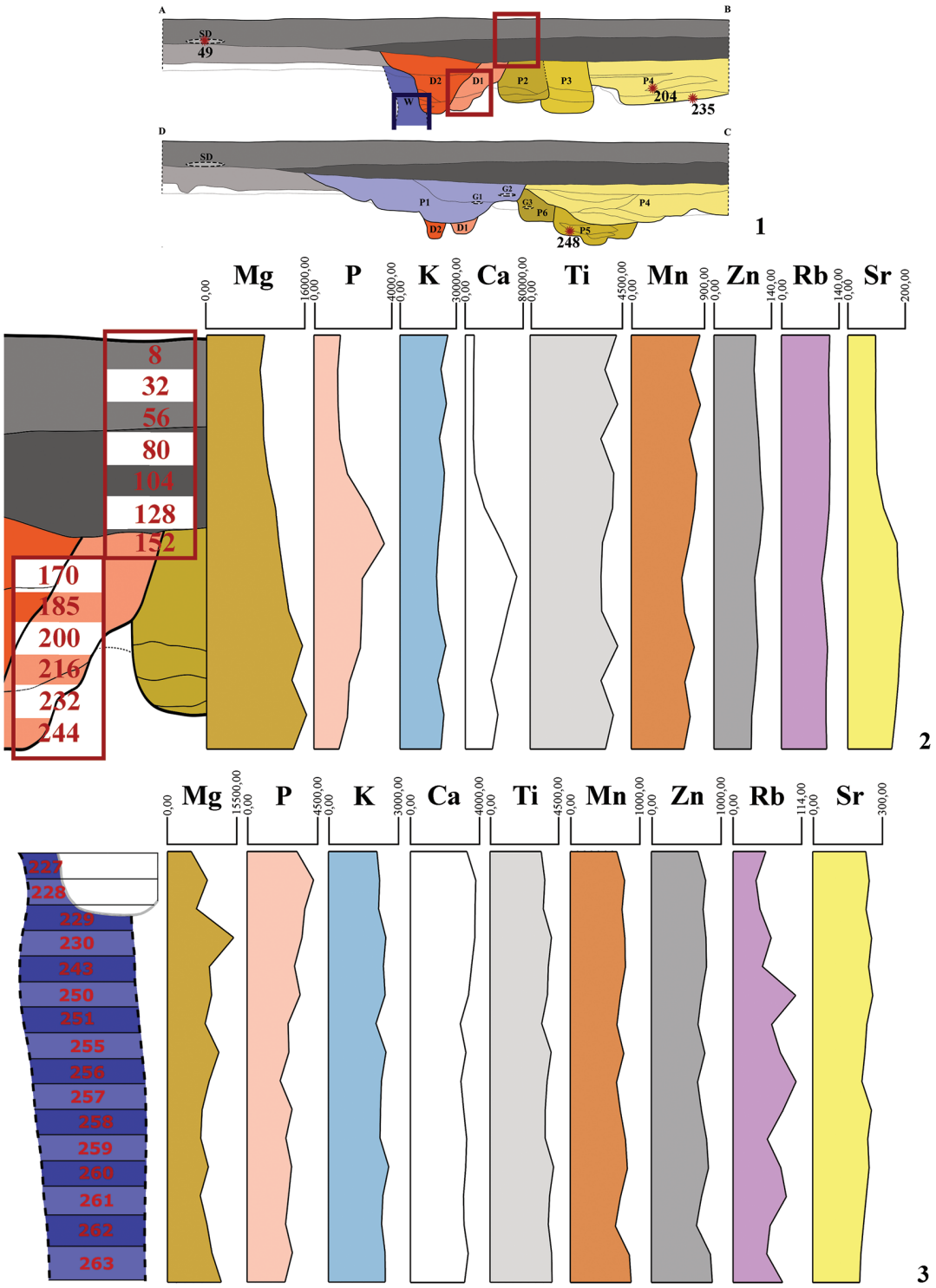


Fig. 10. Geochemical analysis of samples from the 2021 excavation using XRF.* 1 *Sample location.* 2 *Results of chemical analysis of the outer ditch section.* 3 *Results of chemical analysis from the tube-like well (compiled by I. Hohle and A. Füzesi).

than expected) was the result of different dynamics in the development of local communities and their relationship (*Füzesi* et al. *2017.34, Fig. 15*). The finds in the Tiszaug assemblage were stylistically older but absolute chronologically the same age as the Tisza pottery excavated at Öcsöd-Kováshalom. The Szakálhát assemblage, excavated in 2021, confirms that the Neolithic communities living in the Kováshalom area underwent a similar development. However, the central nature of the settlement probably accelerated this process, and eventually, this site became part of the presumed Tisza pottery style core area.

The ditch system underlines the central function of the settlement. The temporal aspect of this function in the 2021 age model has been investigated directly by one date, and indirectly by three. Based on the latter, the lower culture-bearing layer, which the later (D2) ditch was dug into, accumulated in 87–128 years, between 5246 (68.2%) 5137 and 5118 (68.2%) 5050 cal BC. Its relationship to the earlier (D2) ditch is unclear, and unfortunately no animal bone suitable for dating was recovered from this feature. The single ^{14}C date indicates that the backfilling of the D2 ditch was completed between 5118 (68.2%) 5050 cal BC, meaning that the excavated section of the outer ditch may have been in use for 68 years.

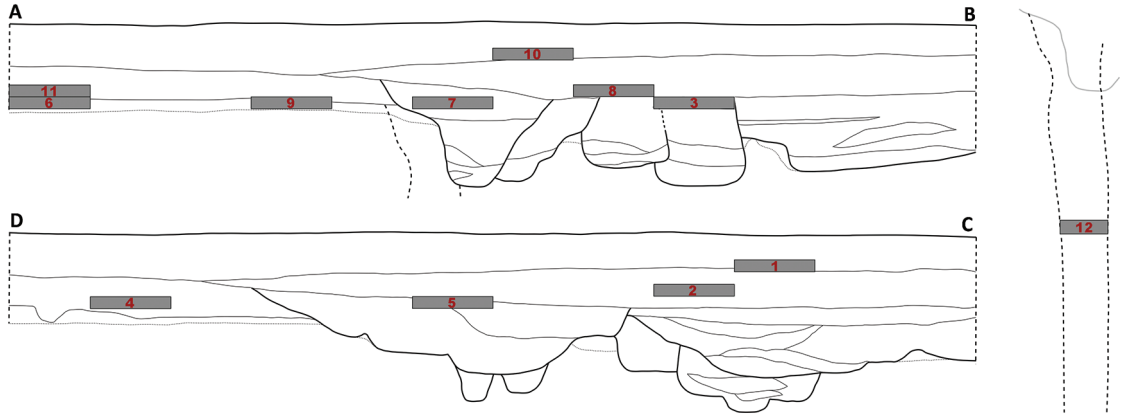
Based on the samples from the P1 feature and the upper culture-bearing layer, the later, Tisza II features date to 4991 (68.2%) 4910 cal BC and 4906 (68.2%) 4836 cal BC. They are slightly older than the storage pit excavated in 2020, nevertheless, the dates fall in the late phase of the settlement (Fig. 11: Öcsöd B; *Raczky, Füzesi 2016.34, Fig. 17,19-20*). The 2021 model also confirmed that the triple ditch system, which defined the settlement structure based on the geophysical survey, was only present during a certain period of the site's existence. After the infilling of this enclosure system, archaeological features testify to the intensive occupation in the first quarter of the 5th millennium BC, both in the interior and exterior settlement parts.

Discussion. Dynamics of the pseudo-ditch system at Öcsöd-Kováshalom

In addition to absolute chronological modelling, another crucial aspect of the investigation of the ditch systems is the interpretation of the relationship between archaeological finds and the features that contained them. According to a simplified, positivist assessment, artefacts determine the function of a feature through the activities that can be assigned to them. However, the relationship between artefacts and ditches is more complex. In some cases the finds are linked to the primary function of the ditch, to the activities carried out there. In other cases this link is missing, and so the artefacts represent the subsequent use of a broader place. Different parts of the ditches are affected by various accumulation processes, and the activities associated with them belonged to different temporal and functional horizons (*Řídký* et al. *2014.594*). Although these complex relationships are difficult to assess, their investigation is essential for research into the use and afterlife of the ditches.

The interpretation is further extended by the fact that the human *habitus* and artefact formation processes behind each artefact type are also manifold. Ceramic sherds are broken items, daub fragments are remains of constructions, and animal bones and shells are 'by-products' of consumption. However, all artefacts represent human activity, even if it varies in direction, complexity and the amount of energy invested. To aggregate the data, human activity was quantified on a ratio scale. This does not include the investment of labour needed to dig the trenches. The primary reason for this is that the dimensions of the trenches could only be deduced from trenches 1 to 2m wide, which would be incorrect even if extrapolated to individual ditch segments. Secondly, the extra investment of recutting also complicates the situation. We have thus estimated the extent and temporal dimension of the accumulation of archaeological material. The total of the finds belonging to each type was taken as 100%, and each find in a given type received a percentage value (Fig. 14.1). The following find types were encountered: pottery, animal bone, daub, chipped stone, and mollusc shell (100% each). This way, the previously presented trends in the artefact distribution patterns (Fig. 4.4–6; Fig. 8.1–5) became even more pronounced.

Using relative and absolute chronological data, we were able to assign the different filling layers and their finds to a time scale. Based on the extent of backfilling in the excavated features and activities associated with the deposited artefacts, we summed the volume of labour represented by the findings on a chronometer, and thus derived a taskscape with a temporal dimension (Fig. 14.2). Due to the differences in magnitude between each find material of the two excavations, the 2021 data were presented in two



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Lab Nr MAMS	Sample Name	^{14}C Age [yr BP]	±	δ13C AMS [‰]	Calibrated Ages Probability 68%	Calibrated Ages Probability 95%	C:N	C [%]	Collagen [%]	Material
56003	1 - Öcsöd-Kováshalom 2021	6204	26	-19.8	cal BC 5213-5073	cal BC 5291-5051	3.2	34.8	7.2	bone
56004	2 - Öcsöd-Kováshalom 2021	6036	27	-20.9	cal BC 4988-4854	cal BC 5006-4841	3.2	32.7	6.3	bone
56005	3 - Öcsöd-Kováshalom 2021	6276	27	-23.0	cal BC 5303-5216	cal BC 5317-5208	3.2	39.0	11.5	bone
56006	4 - Öcsöd-Kováshalom 2021	6209	27	-23.3	cal BC 5215-5072	cal BC 5296-5052	3.2	36.5	5.0	bone
56007	5 - Öcsöd-Kováshalom 2021	6006	24	-21.1	cal BC 4936-4847	cal BC 4988-4801	3.3	40.6	12.5	bone
56008	6 - Öcsöd-Kováshalom 2021	6264	25	-23.0	cal BC 5301-5214	cal BC 5314-5128	3.2	39.7	10.8	bone
56009	7 - Öcsöd-Kováshalom 2021	6182	25	-19.6	cal BC 5176-5070	cal BC 5215-5045	3.3	16.5	2.4	bone
56010	8 - Öcsöd-Kováshalom 2021	6247	23	-18.3	cal BC 5301-5209	cal BC 5306-5074	3.2	32.1	8.4	bone
56011	9 - Öcsöd-Kováshalom 2021	6203	24	-24.0	cal BC 5213-5073	cal BC 5289-5052	3.3	45.1	11.8	bone
56012	10 - Öcsöd-Kováshalom 2021	5984	24	-20.8	cal BC 4929-4803	cal BC 4941-4794	3.2	28.5	4.3	bone
56013	11 - Öcsöd-Kováshalom 2021	5973	24	-22.5	cal BC 4899-4799	cal BC 4937-4791	3.2	39.3	4.7	bone
56014	12 - Öcsöd-Kováshalom 2021	6845	41	-40.3	cal BC 5757-5667	cal BC 5830-5640	14.0	1.2	88.1	unknown organic matt

2

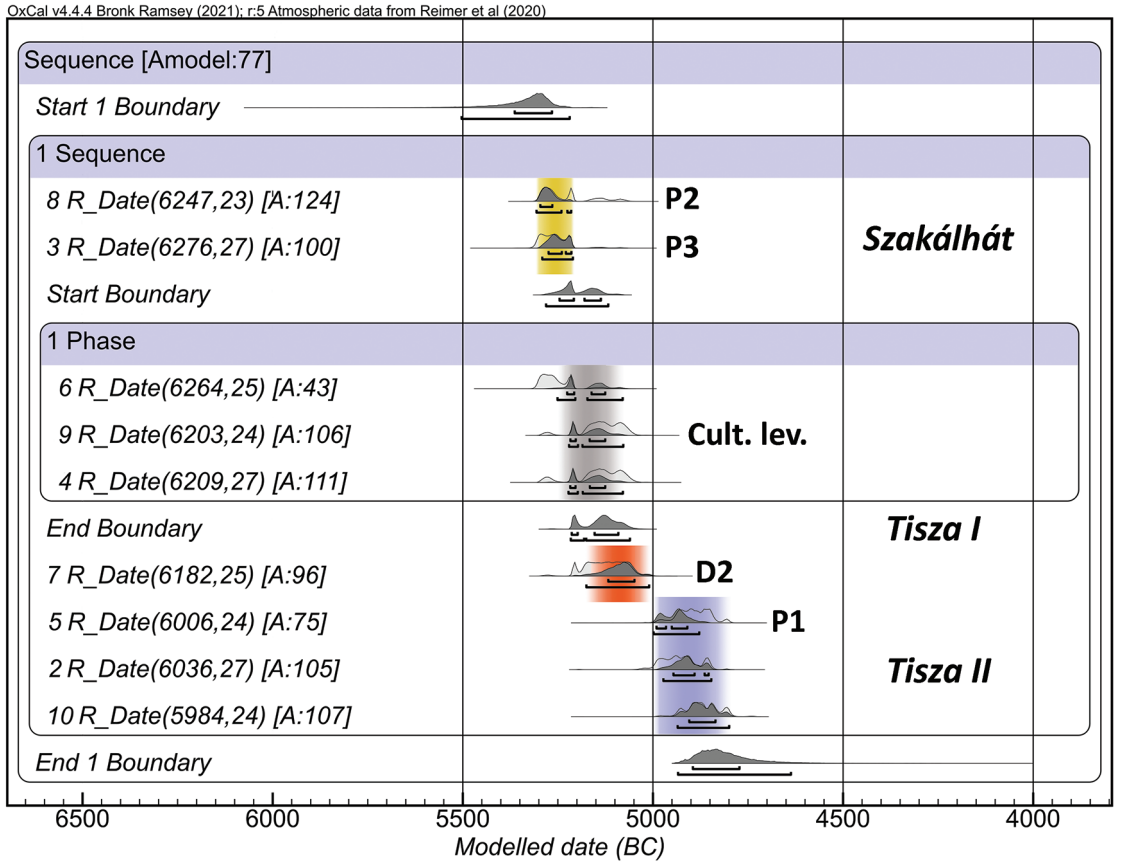

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Fig. 11. The absolute chronology of the 2021 trench: 1 *excavated units with* ^{14}*C samples,* 2 ^{14}*C data,* 3 *OxCal model of the* ^{14}*C data (compiled by N. Faragó and A. Füzesi).*

forms. One is scaled similar to the 2020 dataset, but a different logarithmic plot was also used to show the details (Fig. 14.2, left side). The model constructed highlights the cyclical intensity of human activity. In a significant proportion of the sites we identified at least two accumulation maxima, *i.e.* two intense depositional phases interrupted by less intense phases. Moreover, stratigraphic data suggest that in most cases high artefact concentrations were the result of deliberate human action (*e.g.,* in the upper fill layer of the inner ditch – D2/2020, the later version, *i.e.* the re-cutting of the outer ditch – D2/2021), while the layers with few artefacts indicate natural accumulation and deposition, which were the results of spontaneous erosion processes (*e.g.,* in the lower layer of the inner ditch – D1/2020, the earlier outer ditch – D1/2021). Intentional action was particularly prevalent in the structured deposits located in the upper part of both excavation trenches, referring to some kind of final act.

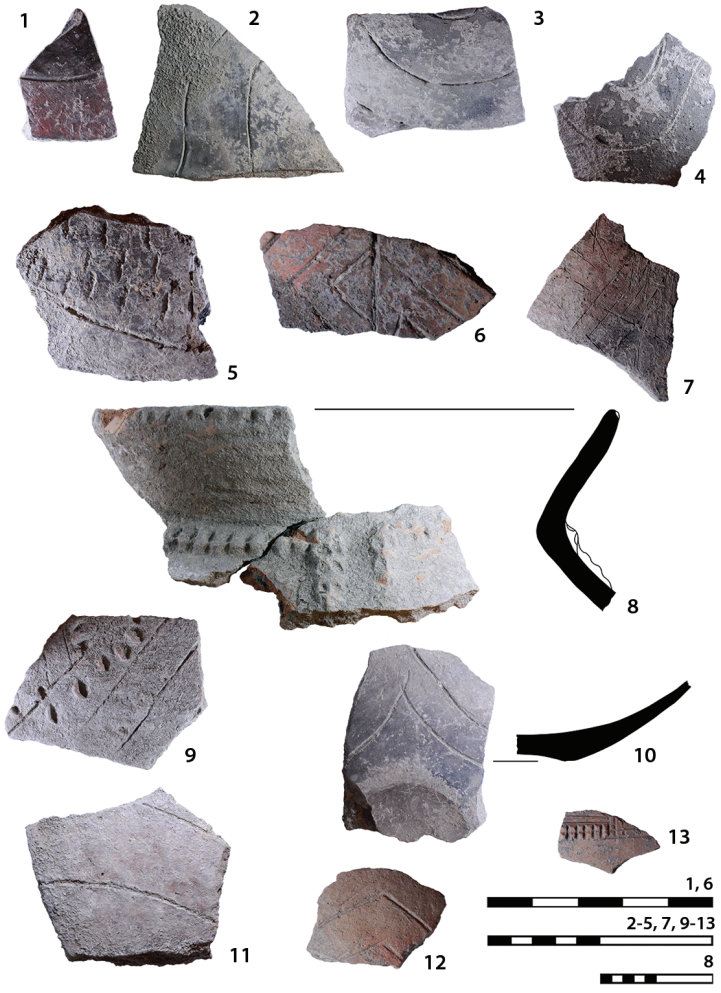

Fig. 12. Selection of decorated ceramic material from the 2021 trench – Szakálhát style (1-2: P6, 3-8: P4, 9-10: P3, 11-13: P2) (compiled by A. Füzesi).

Our detailed observations on the ditches can be integrated into the research on European enclosures in many aspects. The ditch systems constructed in large numbers during the European Neolithic show a great variety in size and form. More than 100 LBK ditch systems are known and have been studied in Western and Central Europe (*Haack 2022.69*). Late Neolithic rondels with regular structures were constructed between 4900–4500 BC (*Literski, Nebelsick 2012*). Jaroslav Řidký has reported 154 rondels for the entire distribution area (*Řidký 2019a.Tab. 4.1*), with 30 specimens currently known from 24 sites in Hungary (*Barna* et al. *2016*). Various ditch systems also occur in southeastern Europe (*Parkinson, Duffy 2007. Fig. 2; Nikolova 2022*). Local development of these structures started in the second half of the 6th millennium BC, and by the Late Neolithic mainly fortifications associated with tells became dominant (*Raczky, Anders 2012*). Extensive geophysical research in the northern Balkans and on the Great Hungarian Plain in recent decades has revealed many newly discovered constructions (*Kalafatić* et al. *2020*). Such research focuses primarily on structural features, and thus their metric data have become known, similar to the Central and Western European examples.

Contrary to the structural characteristics, backfilling processes in the ditches have been investigated only in a small proportion of constructions. In this context, the idea that the lower part of the ditches, which yielded few finds, was filled by natural agents, while the upper part, rich in finds, was filled intentionally, became a convention in the literature (*Haack 2022. 70*). The idea emphasized the mix of natural and anthropogenic effects. In addition, the temporal factor was a dominant aspect of research models concerning the European Neolithic, several of which include elements related to the Öcsöd-Kováshalom model.

Although the backfilling of the Herxheim enclosure was carried out in different events, it took place almost simultaneously in a very short time. This process of fewer than 50 years can be dated to the latest phase of the LBK (*Haack 2022.59–61; 2021.31–33*). A detailed analysis of Complexes 2 and 4 showed that the depression with the superposition of assemblages was re-excavated,

Fig. 13. Selection of decorated ceramic material from the 2021 trench – Tisza I-II style (1-3: D1, 4-7: D2, 8-11: P1, 12-14: W) (compiled by A. Füzesi).

i.e. not only was backfilling taking place, but certain ditch sections were cut again, and thus several artefacts were deliberately re-arranged (*Haack 2009. 34–35, Fig. 9*). In the short period between the construction and the backfilling of the ditch system, cleaning and recutting as well as concentrated artefact accumulation were repeated in a cyclical manner (*cf. Řídký 2019b.Fig. 6.15*). A typical example of recutting was observed in the outer section of the ditch system at Öcsöd (Fig. 6.1), and the associated absolute chronological data are also comparable to Herxheim. Although the dating of the early (D2) ditch is based on its relative chronological position due to low find frequency, the modelled chronological data resulted in a restricted time range (Fig. 11.3), indicating that the construction and filling of ditch D2 occurred quite rapidly in the decades immediately preceding 5100 BC. The suddenly buried section was replaced by a new ditch, the backfilling pattern of which already showed the double (natural-anthropogenic) pattern typical of ditches in general.

The backfilling of the inner ditch at Öcsöd-Kováshalom shows similarities with the models established in Kolín Rondel 1 (Czech Republic, Stroked Pottery Culture) and the rondel in Vychnice (Czech Republic, Stroked Pottery Culture). In the transect trench of the Kolín ditch, the finds were concentrated in the middle-upper part. The refitting of pottery fragments provided multiple connections in the upper part, indicating the contemporaneity of the fill (*Řídký* et al. *2014.582–586, Fig. 1*). At the Vychnice site, find density in the fill was analysed in six adjacent sectors. In addition to the weight data of pottery and daub, the fragmentation of the former was also investigated. The size of the fragments revealed a dispersal pattern concentrated at the entrance to the ditch system: the average size of the sherds increased towards the entrance. The daub fragments were concentrated in a single layer in the upper part of the ditch, and their detailed analysis suggested that they belonged to a single burnt construction (*Řídký* et al. *2014.589–593, Figs. 7–9*). Due to the different characteristics of the two excavations, one case (Kolín 1) confirmed the significance of the vertical, and the other (Vychnice) the horizontal patterning. In the Kolín model, the lower part of the ditch fill was almost devoid of finds, while the upper part was rich in artefacts. The infilling of the ditch, which had started naturally, was completed rapidly by human intervention, presumably after the original function of the ditch ceased. In the Vychnice model the finds concentrated at the entrance of the ditch emphasized the importance of the path as a transport route (*Řídký* et al. *2014.594*). In both cases the finds in the ditches are not related to the original function of these constructions, and the change in the original concept of the ditch, along with the end of the function, preceded the large-scale filling. In the case of the inner trench at Öcsöd, horizontal differentiation is evident in the scatter pattern of the finds (Fig. 14.1), while vertical arrangement can be interpreted by considering the spatial position of the two excavation trenches. Trench 2020, which yielded a much larger number of artefacts, was located close to the entrance of a segment of the inner ditch, while Trench 2021 was located in the middle of a longer segment of the outer ditch (Fig. 1), suggesting that similar reasons to

those at Vychnice may have been behind the higher artefact concentration in the inner ditch.

Another important aspect of the model for the Öcsöd-Kováshalom ditch system is time. The ^{14}C data from the outer and inner trenches demonstrate differences much larger than expected. In the model of the 2020 trench, natural filling of the lower part of the ditch (D1) occurred between 5028 (68.2%) 4951 cal BC and 4951 (68.2%) 4915 cal BC, while the upper part (D2) was filled between 4951 (68.2%) 4915 cal BC and 4935 (68.2%) 4899 cal BC. Unlike the outer ditch, the early version (D2) was filled before 5100 BC based on stratigraphy, and the later ditch (D1) was also filled between 5118 (68.2%) and 5050 cal BC, *i.e.* the outer ditch became buried half a century before the inner ditch began to fill up (Fig. 14.2). Of course, the ^{14}C samples are indicative of construction time only indirectly, but the large time difference between the two sections demonstrates that the ditches, which are shown as concentric circles in the geophysical survey, did not exist synchronously. The chrono-stratigraphy of the infill for Kolín Rondel 1 also showed temporal differences between the individual trench sections. Based on radiocarbon data, the four concentric ditches started to fill back in several hundred years apart. The outer ditch had begun to fill around 4871 BC, the next one around 4604 BC, the third one around 4464 BC, and finally, the construction ceased to exist around 4400 BC (*Řídký* et al. *2014.586–588, Fig. 5*). The Öcsöd case showed a similar significant temporal difference, but the two excavation trenches do not make it possible to reconstruct the temporal dynamics of the entire ditch system. Our preliminary data only confirm the complexity of the construction, operation and infilling of this monumental structure.

Pseudo-ditch systems were established in the first half of the 5th millennium BC in certain regions of Western Europe (*Lefranc* et al. *2017.Fig. 11.2*). These constructions had specific formal features different from both the asymmetrical ditch systems of the LBK and the rondels of the Lengyel cultural complex. "*Pseudo-ditches can be defined as enclosures formed of independent and discontinuous segments, oblong and morphologically varied, arranged along a predetermined path*" (*Lefranc* et al. *2017.159*). Already in our first publication we interpreted the Öcsöd ditches, consisting of independent segments, as the emergence of a pseudo-ditch system along the Tisza River (*Füzesi* et al. *2020a*). In some irregular examples of the Lengyel rondels, the ditch system was also constructed from several segments of different sizes and structures (shape and depth) (Balatonmagyaród-Hídvégpuszta: *P. Barna* et al. *2019.128–130, Figs. 9–10*), but these are mainly formal similarities to pseudo-ditch systems. The establishment and use of the pseudo-ditch systems were described by the Rosheim model (*Lefranc* et al. *2017.Fig. 11.1*), and the essential element of these is that each segment was established and buried in different phases, *i.e.* the entire enclosure, perceived today as a unit, never existed at the same time. Such temporal differences have been demonstrated by the excavations of the ditch system at Öcsöd. In the chronological model of the 2020–2021 trenches, half a century passed between the complete filling of the outer ditch and the beginning of the investigated section of the inner ditch.

The data from the two segments of Öcsöd-Kováshalom do not yet provide clear evidence for the Rosheim type of this phenomenon, although the segmented nature of the ditch system suggested this parallel already at the time of the first publication (*Füzesi* et al. *2020a*). The strong formal similarity was further confirmed by the chronological data from the two excavations. As such, the two sections explored so far can only be considered as a starting point for a detailed investigation of the Öcsöd-Kováshalom ditch system, which is known in its full structure from the geophysical survey. Based on the observations, the individual ditch segments showed differences in shape (the inner ditch had a V-shaped cross-section, and both versions of the outer ditch were trapezoidal). We reconstructed the backfilling processes of the excavated ditch segments individually and we compared them to different European models based on the backfilling/filling processes, and the intensity and duration of the artefact accumulation. The definition of the features as a pseudo-ditch system became evident from our observations, but no far-reaching conclusions can be drawn for the entire ditch system. Research on European prehistoric ditch systems uses a combination of stratigraphy, artefact distribution, ceramic typo-chronology and absolute chronology, similar to our analysis of the Öcsöd-Kováshalom ditch system (Fig. 14.2). A possible continuation of the Öcsöd research is also indicated by these studies, to investigate layers of space-and-meaning associations horizontally, similar to the ring sanctuary of Pömmelte (*Spatzier, Bertemes 2018*).

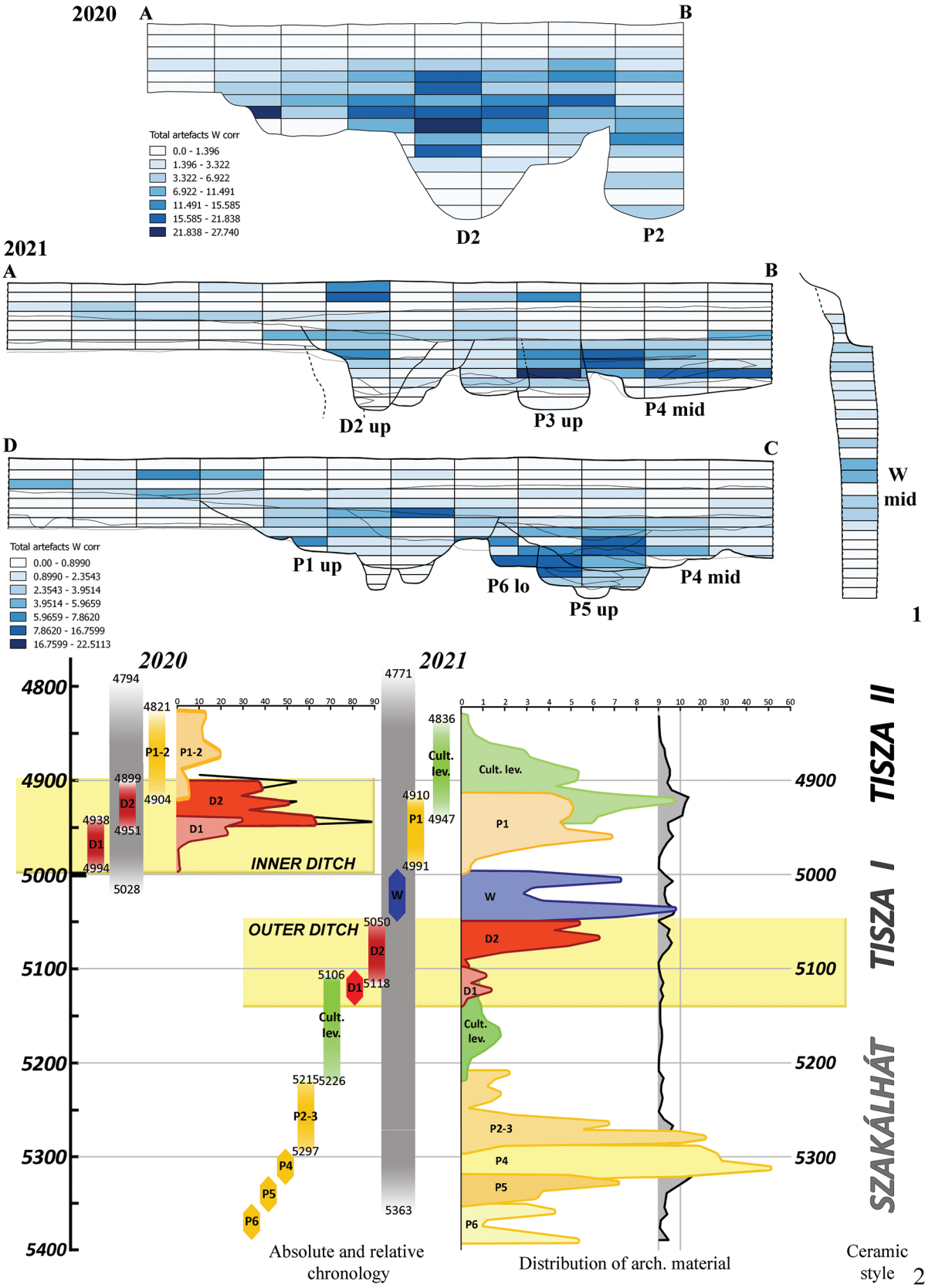

Fig. 14. The depositional practices and sedimental processes in the 2020 and 2021 trenches:* 1 *distribution pattern of archaeological material (main types summarized by per cent),* 2 *the dynamism of site formation processes (absolute and relative chronology connected with material accumulation and ceramic style development) (compiled by A. Füzesi).

Conclusion

❶ At the Öcsöd-Kováshalom settlement complex, the multi-layered central settlement part, the horizontal settlement units and the surrounding ditch system overlapped in time.

❷ Based on the excavation data, the segments of the ditch system identified by geophysical imaging had different dynamics of formation, each having their own stories.

❸ Radiocarbon data demonstrates that the outer ditch is older than the inner ditch, with 50 years' distance between the complete burial of the former and the period of use of the latter.

❹ The filling of the inner ditch happened simultaneously with the reorganization of the multi-layered central settlement part.

❺ The filling of the ditches was a combination of natural processes and anthropogenic impacts, which can be distinguished by the characteristics of the fill layers, find frequencies and the duration of the process.

❻ The geochemical XRF analyses of the 2020 and 2021 samples show indications for intense human impact through several anthropogenic layers which are comparable and consistent with other analyses of the refilling processes.

❼ The two excavation trenches at the entire Öcsöd enclosure do not allow any generalizing views on the nature of the pseudo-ditch systems. Instead they support the interpretation based on the diversity of the numerous ditch systems in Neolithic Europe, speaking for the freedom of local communities in their choices within their respective cultural frameworks.

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Purified by fire: cremation burials in the Stone Age hunter-gatherer cemetery at Dudka, Masuria, northeast Poland

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ABSTRACT - *The cemetery at Dudka was used in the Mesolithic and Para-Neolithic period. It yielded 25 graves with remains of at least 116 individuals, including 52 who were cremated. Cremation was introduced in the Para-Neolithic,* c. *4200 cal BC, and was probably a locally developed custom. Most cremations are dated to the classic Zedmar period, when the number of loose human bones also increased significantly, indicating the growing role of multi-step burial rites. Cremation could have been an alternative to temporary burial,* i.e. *bones were cleaned of soft tissue using fire, instead of waiting for their natural decomposition. Burned remains were selected and divided like bones taken from temporary burial places, then stored for a time before final disposal in the cemetery.*

KEY WORDS – *Mesolithic; Para-Neolithic; hunter-gatherers; burials; cremation; Poland*

Očiščeno v ognju: žgani pokopi na kamenodobnem grobišču lovcev in nabiralcev v Dudki, Mazurija, severovzhodna Poljska

IZVLEČEK – *Grobišče v Dudki je obstajalo v mezolitiku in para-neolitiku. Na njem je bilo 25 grobov z ostanki najmanj 116 posameznikov, 52 je bilo kremiranih. Kremiranje je bilo vpeljano v para-neolitiku, ok. 4200 pr. n. št. in se verjetno razvilo kot lokalni običaj. Večina kremacij je datiranih v klasično obdobje Zedmar, ko se je bistveno povečalo število manjkajočih človeških kosti, kar kaže na naraščajoč pomen pogrebnih običajev v več fazah. Kremiranje bi lahko predstavljalo alternativo začasnemu pokopu, tj. čiščenje mehkega tkiva na kosteh z ognjem, namesto da bi čakali na njegovo naravno razgradnjo. Sežgane posmrtne ostanke so tako razporedili kot kosti, odbrane iz začasnih grobov in jih shranili pred končnim pokopom na grobišču.*

KLJUČNE BESEDE – *mezolitik in para-neolitik; lovci in nabiralci; grobišče; kremiranje; Poljska*

Introduction

The Dudka site is located on an island in the former lake Staświn in Masuria in northeastern Poland (Fig. 1). Staświn was a large lake with an area of about 25km^2, but it was very shallow, so it began to be overgrown quite early and had turned into a swamp by the beginning of the Bronze Age (*Gumiński 2008*). Apart from Dudka two other Stone Age sites have been recorded from Staświn Lake. One of them is Szczepanki 8, located on the island at the mouth of the Pamer River to the lake. There were two settlement areas – one larger at the southern shore and the second smaller at the eastern promontory (*Gumińs-ki 2004; 2012*). Between Dudka and Szczepanki 8, there was a very small island (site Szczepanki 6) with

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a megalithic structure which belongs to the Globular Amphora culture (Fig. 1) (*Gumiński 2001*).

The first traces of settlement at the Dudka site are dated to the Late Palaeolithic, during the Allerød period, and the island was continuously occupied till the end of the Late Neolithic, like the neighbouring site of Szczepanki 8. Both islands – Dudka and Szczepanki – were occupied seasonally during the Mesolithic.

Occupation of the islands continued into the Para-Neolithic period, which is associated with the Zedmar culture that existed in Masuria and the Prussian Lowland and was a continuation of the regional Mesolithic of the Maglemosian tradition, similar to the Ertebølle culture. The Para-Neolithic period in the microregion of Lake Staświn starts with the appearance of the oldest Zedmar pottery *c.* 5600 conv BP (4500 cal BC), but hunting and gathering remained the basis of the economy till the end of the Late Neolithic. The residence during the year was then prolonged at both sites, and they could have eventually even been settled year-round (*Gumiński 1995; 1999; 2004; 2012; 2020; Gumiński, Michniewicz 2003*).

In the Bronze Age, the islands were abandoned, because the overgrown lake became unattractive for settlement purposes (*Gumiński 2008*).

The cemetery at Dudka was located between two main encampment areas – the southern promontory and the eastern bay (Fig. 2). There were at least 25 graves in the cemetery containing the remains of 116 individuals. Most graves were collective and contained different kinds of burials. Secondary burials (at least 39 individuals) and cremations (52 individuals) prevailed over primary inhumations (12 individuals) (Fig. 3). Primary burials were usually placed in sitting-squatting positions with crouched legs. Only three individuals were buried in other positions, on one side (individual VI-3-A) or on the back (individuals VI-17A and VI-18A) (*Gumiński, Bugajska 2016*). Three sitting burials from two graves (VI-6 and VI-13) were disturbed in the Stone Age to collect particular bones of the dead (*Bugajska 2021b; Bugajska, Gumiński 2016.526–527*). Apart from formal graves, there are numerous pits at the cemetery. Some of them can be interpreted as disturbed and emptied graves from which almost the whole skeleton was removed and only small elements or possible grave goods remained inside or around the pit (*Bugajska 2021b*). Bones of at least six individuals may come from such disturbed and emptied graves (Fig. 3).

Large assemblages of loose human bones come from different layers of the settlement zones at Dudka and Szczepanki (*Bugajska, Gumiński 2016*). Most such remains can be interpreted as the remnants of temporary burials, which means that after soft tissue decomposition the bones of the dead were collected and taken to the destination grave at the main cemetery. Some bones could have been overlooked and lost, or perhaps even left purposely at the place of temporary interment. Selected bones, especially skulls, could

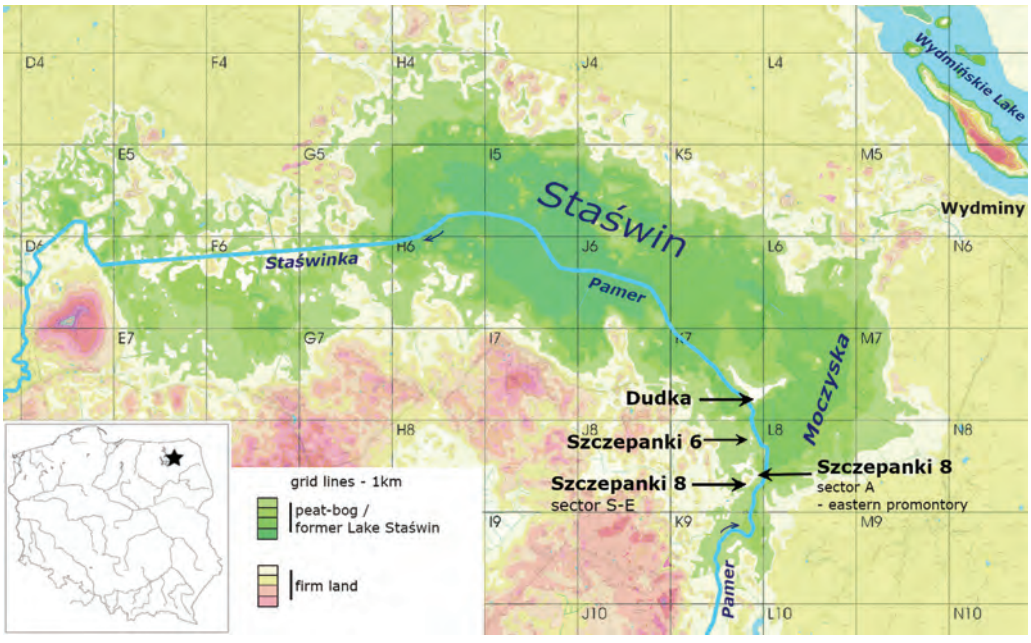

Fig. 1. The former Staświn Lake. Location of the Dudka site (compiled by W. Gumiński).

have been kept at the settlements as memorabilia of the dead ancestors. Most loose bones come from the eastern bay at Dudka – trench III (Fig. 2). The sloping shore of the island was probably one of the main zones where temporary burials were deposited, from the Early Mesolithic until the post-Zedmar period (*Bugajska, Gumiński 2016*).

Cremation burials at Dudka cemetery

Burned remains are rare among the loose human bones found outside the cemetery area. This is especially true for these remains that could be regarded as resulting from the burning of the body (Tab. 2). There are only seven fragments of heavily incinerated bones and 14 bones burned unevenly to white-blue-grey, which may result from combustion of the body. The burning of the body at the site should be excluded, however, because single charred bones appeared in different layers and at different places on both sites (*Bugajska, Gumiński 2016.529–537*). There is no clear evidence suggesting the presence of funeral pyres at either Dudka or Szczepanki. The presence of single, heavily cremated remains in the occupied zones could be interpreted as an indication of the storage of cremated remains at the settlement.

Loose human bones that are only partially blackened occurred at the sites more often than heavily burned bones (Tab. 2). In such cases there are traces of exposure to the fire, but as dry bone. The more so since these were mostly random small pieces of generally unburned skulls or long bones (*Bugajska, Gumiński 2016.533–537*). It is most probable that such skulls or long bones were broken into pieces first and then some of the bone fragments were accidentally singed and mixed with refuse material. It can be excluded that these bones were put into fire intentionally.

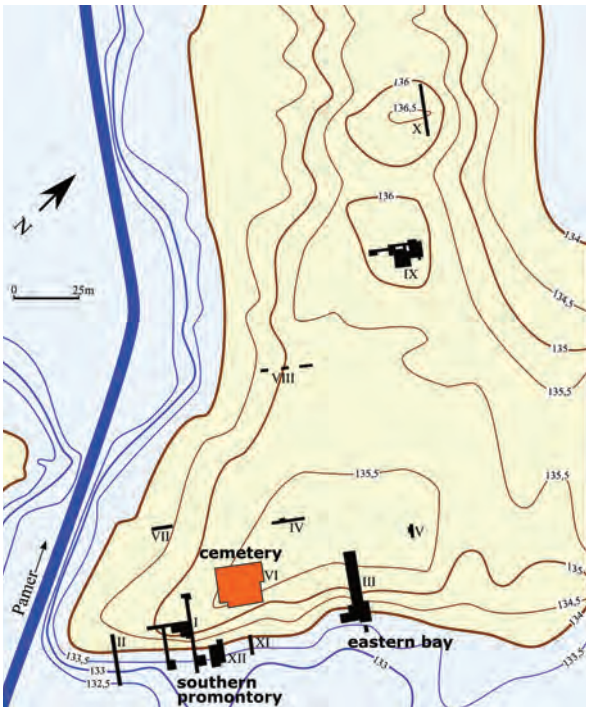

Fig. 2. Dudka site, location of the cemetery (Trench VI) (compiled by W. Gumiński, K. Bugajska).

The majority of the cremated remains from the Dudka cemetery come from formal graves, pits or from deposits recorded over graves. They comprise at least 43 individuals (Tab. 3, see below). Apart from them, burned human bones were found in the highest layers of Trench VI as loose bones, comprising 1663 bone fragments (1360g). Some of them could be assigned to graves or pits that were destroyed by ploughing. Apart from that, at least nine individuals (C1–C9) were identified based only on loose cremated bones (Tab. 3). Altogether, at least 52 burned skeletons were recorded from the cemetery, comprising 45% of all individuals. The minimum number of cremated individuals was revised after radiocarbon dating and re-analysis of bone material, and two more individu-

Archaeological period		Climatic Period	^{14}C years BP	cal BC
Late Palaeolithic		Allerød–Younger Dryas	11 200–9800	11 200–9250
Early Mesolithic		Preboreal–Boreal	9800–8000	9250–7000
Late Mesolithic		early–middle Atlantic	8000–5600	7000–4500
Para-Neolithic (pottery appearance)	Early Zedmar	late Atlantic	5600–5100	4500–4000
	Classic Zedmar	Atlantic/Subboreal	5100–4700	4000–3500
	Post–Zedmar	early Subboreal	4700–4200	3500–2800
Late Neolithic		early/middle Subboreal	4200–3700	2800–2200

*Tab. 1. Chronology of the Stone Age occupation at the Dudka and Szczepanki sites. The chronology is based on stratigraphy and relevant radiocarbon dates (44 from Dudka and 16 from Szczepanki) obtained mostly from charcoal (***Gumiński 1995; 1999; 2008; 2012; Gumiński, Michniewicz 2003***), excluding newly obtained AMS measurements for cremations, which are presented for the first time in this paper.*

als were added to those published previously (*Bugajska 2021a.32–41, Tab. 2*).

All the cremation burials are secondary deposits of bones collected from the funeral pyre. There are no traces of body burning at the cemetery or directly in the grave pit. Moreover, there was no charcoal among the burned remains. This suggests that bones were very carefully collected from the pyre. Bones could have been kept and carried for some time before final interment at the cemetery, which could also have resulted in the loss of charcoal.

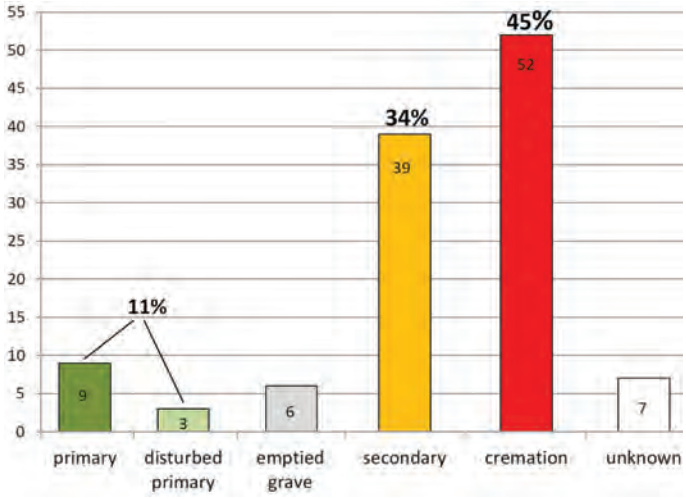

Fig. 3. Burial types at Dudka cemetery.

Cremated remains were deposited in the cemetery in two main ways. The first was depositing the remains in a pit, which involved at least 23 individuals and seven graves (Fig. 4 and Tab. 3). This group is made up of pits containing only a small number of burned human bones (VI-n-1, VI-n-2, VI-g-1, VI-e-4), one grave with a complete burned skeleton (VI-15) and two collective graves with very large

Site	**Trench**	**Individual**	**Number of heavy burned bones** (white)	**Bones cremated unevenly** (white/grey/blue)	**Number of charred or singed bones** exposure to fire as dry bone	**Period** According to stratigraphy **Radiocarbon dated**
Dudka	I	I-D, +?			**16** (cranium, femur)	classic Zedmar
Dudka	I	I-H	**4** (cranium, vertebra, phalanx)			classic Zedmar
Dudka	III	III-AK	**1** (fibula)			**5150 ±29 BP (GrM-30005) – early Zedmar**
Dudka	III	III-J		**4** (cranium; phalanx)	**4** (cranium)	early Zedmar
Dudka	III	III-T, +?			**4** (cranium)	classic Zedmar
Dudka	III	III-AA, +?		**8** (cranium; phalanx)	**3** (cranium)	post-Zedmar/Late-Neolithic
Dudka	III	III-AC, +?			**5** (cranium)	post-Zedmar/Late-Neolithic
Dudka	III	III-AD			**2** (fibula)	post-Zedmar/Late-Neolithic
Dudka	XI	XI-D, +?	**1** (long bone)	**2** (cranium)		early Zedmar
Dudka	XII	XII-A?			**3** (cranium)	classic Zedmar
Szczepanki	S	S-VII	**1** (cranium)			Mesolithic/Zedmar?
Szczepanki	E	E-VI			**1** (cranium)	Late Mesolithic
TOTAL - settlements			**7** (12%)	**14** (24%)	**38** (64%)	
Dudka	IV	IV-F			**9** (cranium)	Zedmar/Late Neolithic?
Dudka	IV	IV-H			**4** (long bones)	Zedmar/Late Neolithic?
Dudka	IV	IV-J *+Human?*	***8** (long bones) **+ 27** (postcranial)*			Zedmar/Late Neolithic?
TOTAL -Trench IV	**48**		**35** (73%)	-	**13** (27%)	

Tab. 2. Burned and singed loose human bones from Dudka and Szczepanki (except the cemetery – Trench VI). Trench IV at Dudka is probably a periphery of the cemetery area destroyed by later post-Zedmar and Late Neolithic settlement activity.

quantity of bones and a large number of individuals (VI-4 and VI-16). Bones were usually spread loosely inside the grave pit, but exceptionally in the case of grave VI-15 they were interred in a container. The second type of cremation burial is small concentrations of burned remains deposited directly on the cemetery ground surface (Fig. 4). These comprised at least 21 concentrations containing the remains of at least 27 individuals. Usually, these were found just above a grave or pit (Tab. 3).

Two cremated individuals are represented by single bones only. One bone is probably connected with pit VI-e-3, whereas two fragments of a child skull (ind. C6) were found in the southwestern part of the cemetery but their exact provenance is uncertain (Fig. 4 and Tab. 3).

Pits with scarce cremated human remains

Four pits in the cemetery, VI-n-1, VI-n-2, VI-e-4 and VI-g-1, contained very few burned human bones and were only defined as graves after osteological analyses (Fig. 4 and Tab. 3). All these pits comprise some items such as animal teeth, lumps of ochre, turtle carapaces or bird bones which could be interpreted as grave goods, but none of them contained charcoal (*Bugajska 2021a; Gumiński 2014*).

Pit VI-e-4 yielded a small quantity of cremated remains of at least two individuals (Tab. 3). One skeleton (VI-g-1C) was heavily burned to white whereas the remains of the second individual (B) were grey-blue-white, which indicates burning at a lower temperature of *c.* 600°C (*McKinley 2004; Walker* et al. *2008*). This suggests that the deceased were not cre-

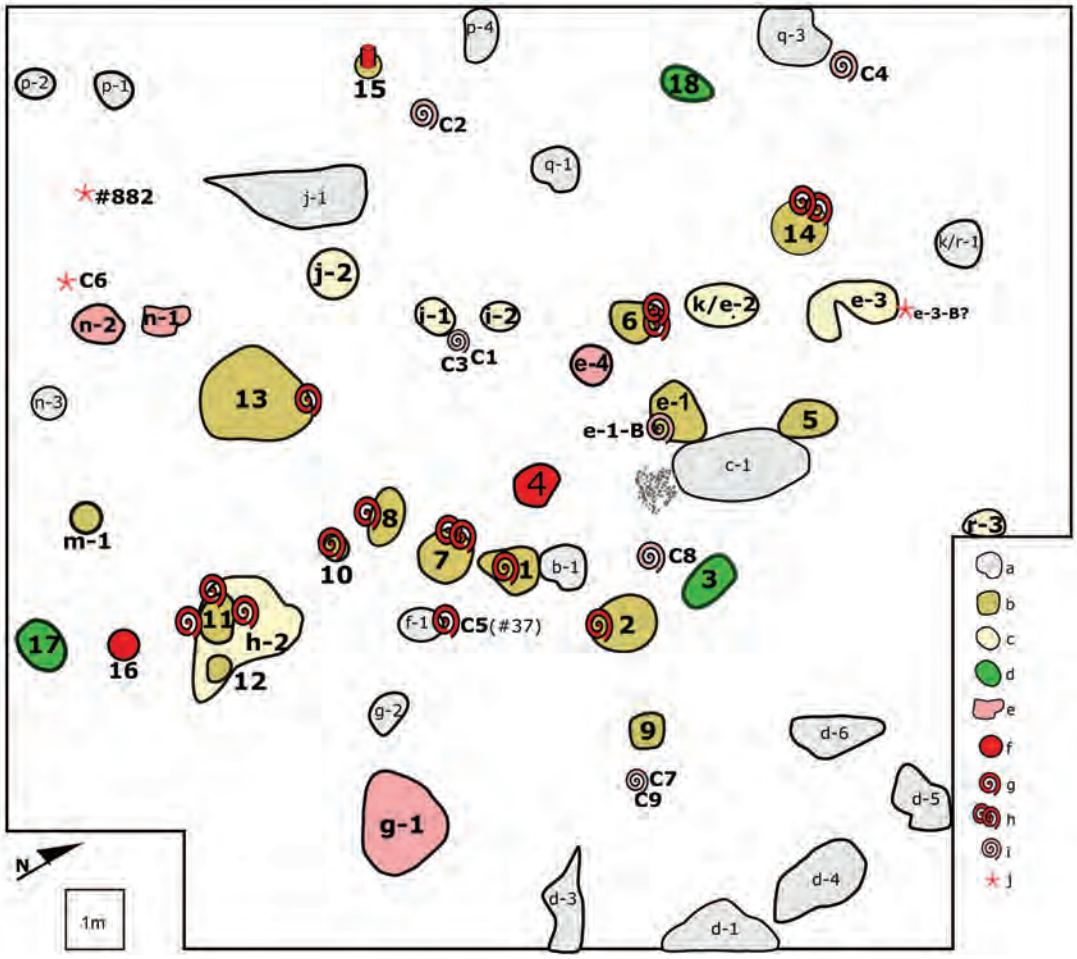

Fig. 4. Dudka cemetery. Deposition mode of cremated remains. **a** ***pit;*** **b** ***graves with secondary or sitting primary burials;*** **c** ***possible emptied grave, pit affiliated with human remains;*** **d** ***graves with single primary interments placed on one side or on the back;*** **e** ***grave with a small amount of burned human bones;*** **f** ***grave with a large number of cremated remains;*** **g** ***concentrations of cremated remains, separate deposits above the graves;*** **h** ***two small clusters put next to each other and containing bones of the same individuals;*** **i** ***possible concentration of cremated remains based on loosely spread human bones;*** **j** ***single burned bones not affiliated to a particular deposit/grave (compiled by K. Bugajska).***

mated together. Moreover, the remains were mixed with single disarticulated unburned human bones, mostly ribs and vertebrae, of a third individual (VI-e-4-A). One fragment of burned long bone gave a date of 5039±29 BP (3951–3714 cal BC; GrM-29999) which can be assigned to the classic Zedmar period (Tab. 4, see below).

Pit VI-g-1 contained exclusively heavily cremated remains belonging to at least one individual (Tab. 3). The upper part of the pit was destroyed by modern ploughing, so it is difficult to estimate the exact quantity of burned remains belonging to this grave. It is not excluded that some unburned remains could have been present in the pit since several loose human bones were found close to the grave (*Bugajska, Gumiński 2016; Bugajska 2021b*). Some possible grave goods were found in the pit: a lump of ochre, one belemnite, a piece of turtle carapace and 43 fish bones (Fig. 5) (*Bugajska 2021a.Tab. 2*). One burned bone from the pit bottom was radiocarbon dated as 5107±26 BP (3973–3802 cal BC; GrM-29998) which corresponds with the transition from the early to the classic Zedmar period (Tab. 4).

Pits VI-n-1 and VI-n-2 were located very close to each other (Fig. 6). Pit VI-n-2 contained heavily cremated remains of at least one individual (Tab. 3) which were accompanied by grave goods such as an otter fang, pieces of turtle carapace and ochre lumps. In turn, neighbouring pit VI-n-1 contained burned antlers of roe deer mixed with several flints and unburned animal bones including a bird bone and a hedgehog jaw. Both structures included around 30 fish bones, which is typical for graves located in this part of the cemetery (*Bugajska 2021a; Gumiński 2014*). No human remains were found inside pit VI-n-1, but several burned human bones, of individual VI-n-1A, were placed around it (Fig. 6). The precise location is known for one large fragment of a femur and six cranial fragments including part of the occipital bone and almost the whole left half of the maxilla (Fig. 6.a–d). Bones are burned to black suggesting a very low temperature of burning – *c.* 300°C (*Walker et al. 2008*).

Human individuals from pits VI-n-1 and VI-n-2 were cremated in different circumstances. Both skeletons are represented by a small number of bones (Tab. 3), which suggests the division and intentional selection of remains. Taking into account the close location of the pits it seems probable that both structures were created at the same time and were somehow connected. A radiocarbon date of 5300±27 BP (4240–4045 cal BC; GrM-29995) was obtained for individual VI-n-2A. Thus grave VI-n-2 turned out to be the oldest

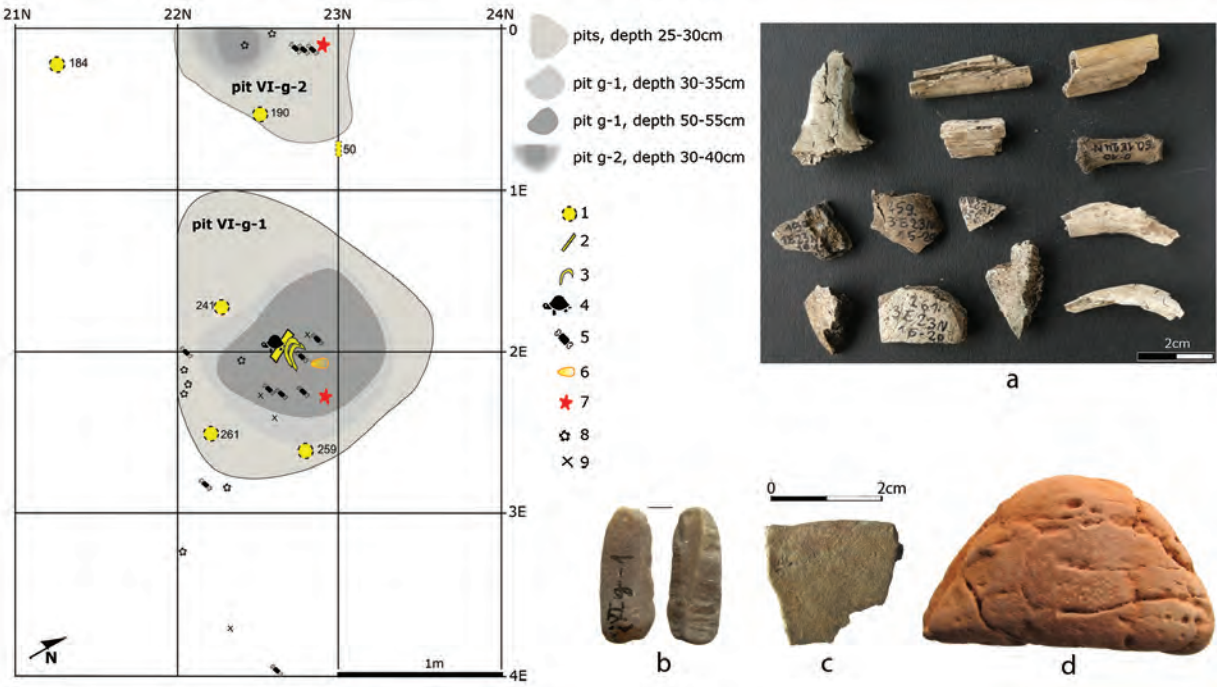

Fig. 5. Grave VI-g-1 with heavily cremated remains.* a *heavily burned human remains from the pit VI-g-1 and its close surrounding;* b *belemnite;* c *turtle carapace;* d *ochre lump.* 1-3 *bones of individual VI-g-1;* 1 *cranial pieces;* 2 *fragments of long bones shafts;* 3 *ribs;* 4 *pieces of turtle carapace;* 5 *animal bones;* 6 *belemnites;* 7 *ochre lump;* 8 *small pieces of pottery sherds,* 9 *flints (compiled by K. Bugajska).

cremation at the Dudka site, belonging to the early Zedmar period (Tab. 4).

Grave VI-15 – cremation burial in a container

Grave VI-15 contained a complete cremated skeleton of a 20–25-year-old male individual (Tab. 3). There was also a complete unburned skeleton of a dog and additionally several unburned human bones, which probably belong to one male individual (B) of similar age (27–30 years) to the cremated male. A whole hedgehog skull and one flint were added as grave goods (*Bugajska 2021a; Gumiński, Bugajska 2016*).

The cremated male and dog were probably interred together in a container (*Bugajska 2015*) since the bones make such a tight cluster that there was almost no sediment between them (Fig. 7.A). The unburned bones of the second male (ind. B) were probably placed directly in the pit rather than in the presumed basket. Two forearm bones were stacked between the container and the pit wall (Fig. 7.A,B), while two proximal parts of femurs along with fragments of the pelvis, sacrum and a lumbar vertebra were found at the bottom of the pit and likely were placed just below the container with cremated remains (Fig. 7.C).

The skeleton of individual A was heavily burned to white, indicating the high temperature of combustion of *c.* 1000°C (*McKinley 2004; Walker* et al. *2008*). The bones are very hard and preserved in large fragments, though strongly deformed and cracked. Taking into account the exceptional completeness of the skeleton and the low bone fragmentation, it seems likely that the bones were collected from the pyre and immediately packed into the container in which they were then deposited in the cemetery (*Bugajska 2021.33–34, Fig. 14*).

Both femurs of individual B bear traces of exposure to fire as dry bones. They could have been broken

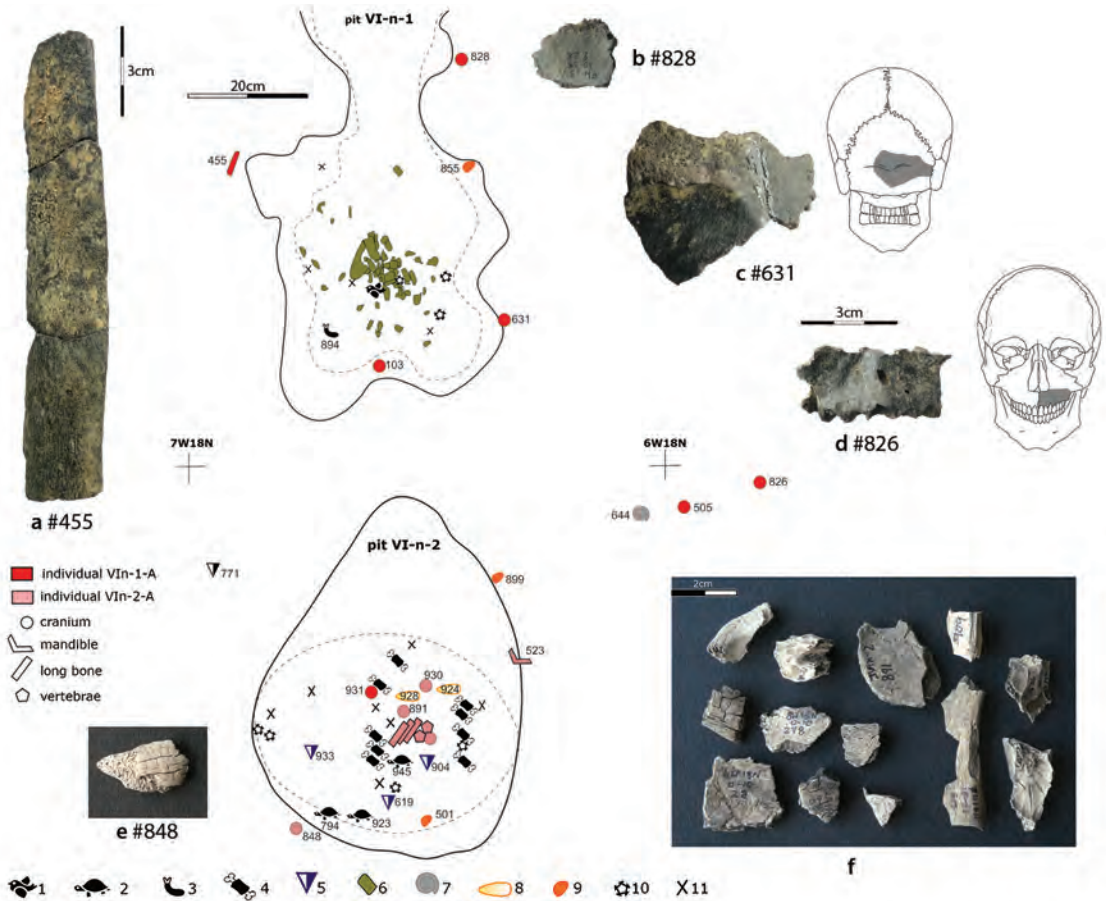

Fig. 6. Graves VI-n-1, VI-n-2. The oldest cremation burial in the cemetery. **a** ***piece of tibia shaft, middle part;*** **b** ***cranial fragment;*** **c** ***occipital bone;*** **d** ***left half of maxilla;*** **e** ***piece of skull #848, radiocarbon dated to 5300 ±27 BP (4240-4045 cal BC; GrM-29995);*** **f** ***heavily burned bones from pit VI-n-1 and its close surrounding, bones of individual VI-n-2A.*** **1** ***bird bone;*** **2** ***piece of turtle carapace;*** **3** ***hedgehog jaw;*** **4** ***animal bone;*** **5** ***animal tooth, red deer and other;*** **6** ***burned antler of roe deer;*** **7** ***fossil;*** **8** ***belemnite;*** **9** ***ochre lump;*** **10** ***small pieces of pottery;*** **11** ***flints (compiled by K. Bugajska).***

into large pieces before they were singed. Only the proximal ends of both femurs are present in the grave and both are more or less blackened on the breaks (Fig. 8). This is more evident in the case of the right femur which is more intensely blackened and a little shiny (Fig. 8.a). Additionally, the high temperature caused fractures of the bone and the loss of small fragments of the shaft. It should be noted that superficial burning appeared only on femur shafts, not on the rest of the unburned human remains of individual B.

The presence of purposely singed bones in the grave is intriguing. Such manipulation of human bones is exceptional at the Dudka and Szczepanki sites. The traces of superficial burning and blackening among loose human bones, including femurs, occur only on several small bone fragments and the exposure to fire was probably not intentional (*Bugajska, Gumiński 2016.533–537*). It seems likely that femurs of individual B were somehow used in the cremation ritual. Possibly, they were intentionally selected and put into the fire, perhaps during the combustion of the body of the second male (ind. A) and then the femurs could have been taken to the cemetery and put into the grave along with the container of burned remains.

The grave was dated by a single ^{14}C measurement of 5079±27 BP (3959–3797 cal BC; GrM-29993) made for burned bone of individual A, placing it within the classic Zedmar period (Tab. 4).

Graves with a large quantity of cremated remains

Two graves – VI-4 and VI-16 – contained remarkably large amounts of cremated remains and both are very similar, taking into account different aspects of the burial rite (*Bugajska 2021.35–37, Tab. 2; Gumiński, Bugajska 2016.485–488, Figs. 34–35*).

In grave VI-16 at least 11 individuals were interred and eight of them were cremated (Tab. 3). Three others, one female and two children, are represented by unburned bones. Interestingly, only the unburned remains of a female (ind. B) were mixed with the cremated remains and appeared in the middle and lower part of the pit (Fig. 9.a,b). In turn, the unburned bones of one child (ind. A) were placed on the bottom of the pit below the cremated remains (Fig. 9.c), whereas the skull of the second child (ind. K) was placed at the top of the grave.

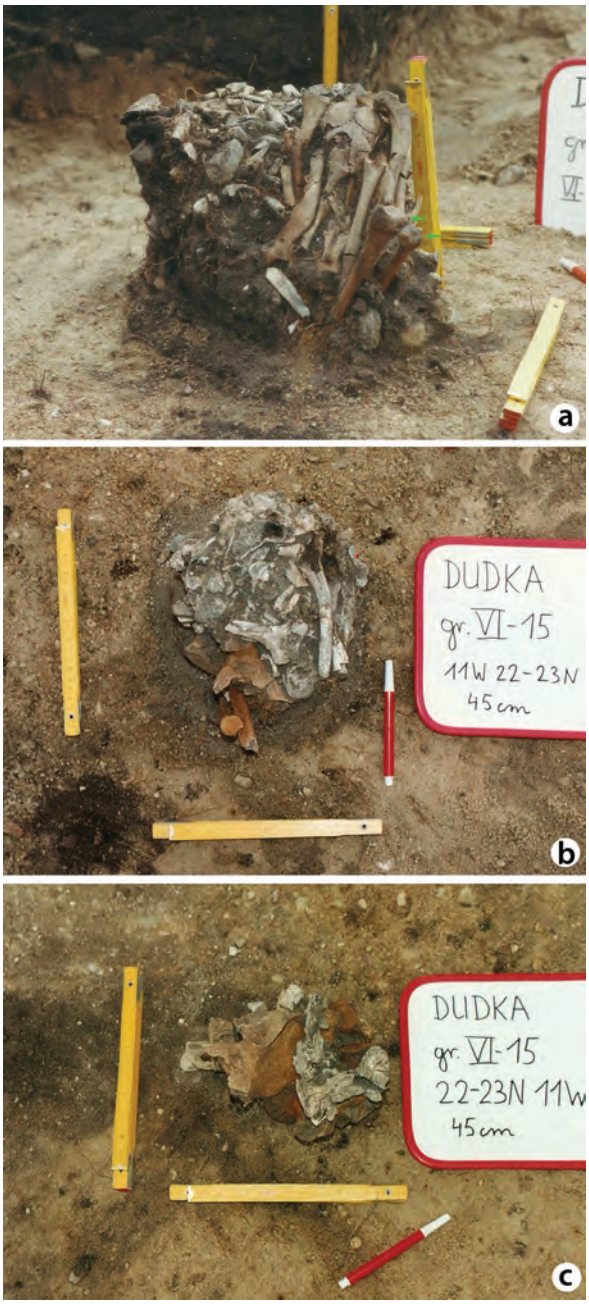

Fig. 7. Grave VI-15.* a *The view from the western side of white burned bones of a male and unburned bones of a dog deposited in a presumed container; two forearm bones of individual B put next to the supposed container are marked with green arrows;* b *view if the lower part of the grave, unburned forearm set of individual B put vertically and pieces of pelvis placed on the bottom and covered by cremated remains;* c *bottom of the grave pit with the unburned bones of individual B: pelvis, proximal ends of both femurs and lumbar vertebrae (photo by W. Gumiński).

The cremated remains in grave VI-16 represent a very diversified pattern of burning (Fig. 10 and Tab. 3). At least two individuals – one adult male (D) and one ju-

Fig. 8. Grave VI-15, individual B. Femurs with traces of exposure to the fire. **a** ***right femur with blackened and shiny end of the broken shaft;*** **b** ***left femur with slight evidence of exposure to the fire on the shaft breakthrough (photo by K. Bugajska).***

venile (G) were burned at a low temperature. Bones are black-brown with white-blue spots in the parts most affected by the fire (Fig. 10.a,b). The more intensive burning appeared on those bone parts that are less protected by the soft tissue, like the frontal bone in the case of the skull or the knee and elbow regions in the case of long bones (*Symes* et al. *2008*). This suggests incineration of the whole body, not dry bones. Four other skeletons (E, F, I, J) were unevenly burned to white-blue-grey (Fig. 10.a,c) indicating combustion temperatures up to *c.* 600°C (*Walker* et al. *2008*). The last group are porcelain-like bones heavily burned to white, which are preserved in large, but strongly deformed fragments with numerous transverse and irregular fractures (Fig. 10.a,d). Such a manner of burning concerns at least two adult individuals (C and H). Bones of different individuals were mixed within the grave, so they were deposited at the same time (*Bugajska 2021a.Fig. 18*). The diversified manner of burning indicates at least three cremation events which were conducted in different circumstances. Bones were collected from different pyres, and they were probably stored for some time before their final deposition in the grave.

Grave VI-4 contained the burned remains of at least nine individuals (Tab. 3) as well as two unburned hu-

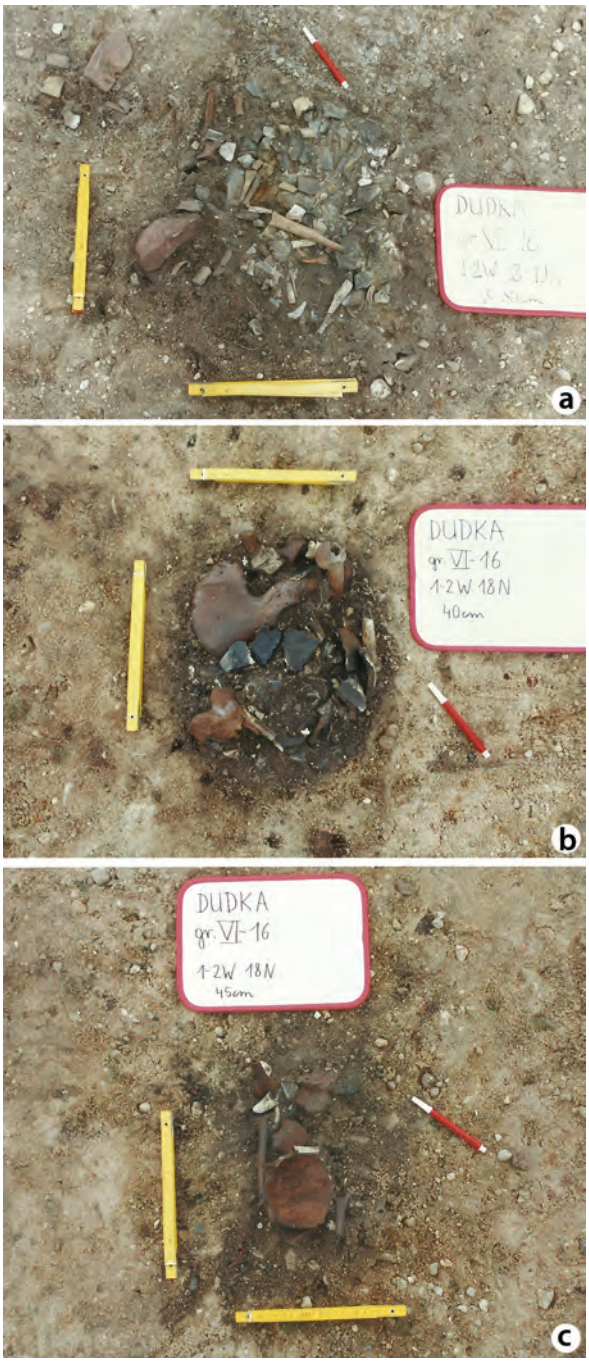

Fig. 9. Grave VI-16. **a** ***Middle part of the pit, mixed cremated remains and unburned bones of a female (humerus and foot bones);*** **b** ***lower part of the pit with mixed cremated remains and next unburned bones of a female (pelvis, proximal end of humerus and tibia shaft);*** **c** ***the bottom of the grave with bones of a child – individual A (photo by W. Gumiński).***

man bones – one fragment of the tibia of an adult and one child phalanx. There was also one slightly burned metapodium of a dog. As with grave VI-16, bone burning was very diversified. At least one skeleton (ind. VI-4A) was burned unevenly at low temperature to brown-black with white-blue spots (Fig. 11.1). Two in-

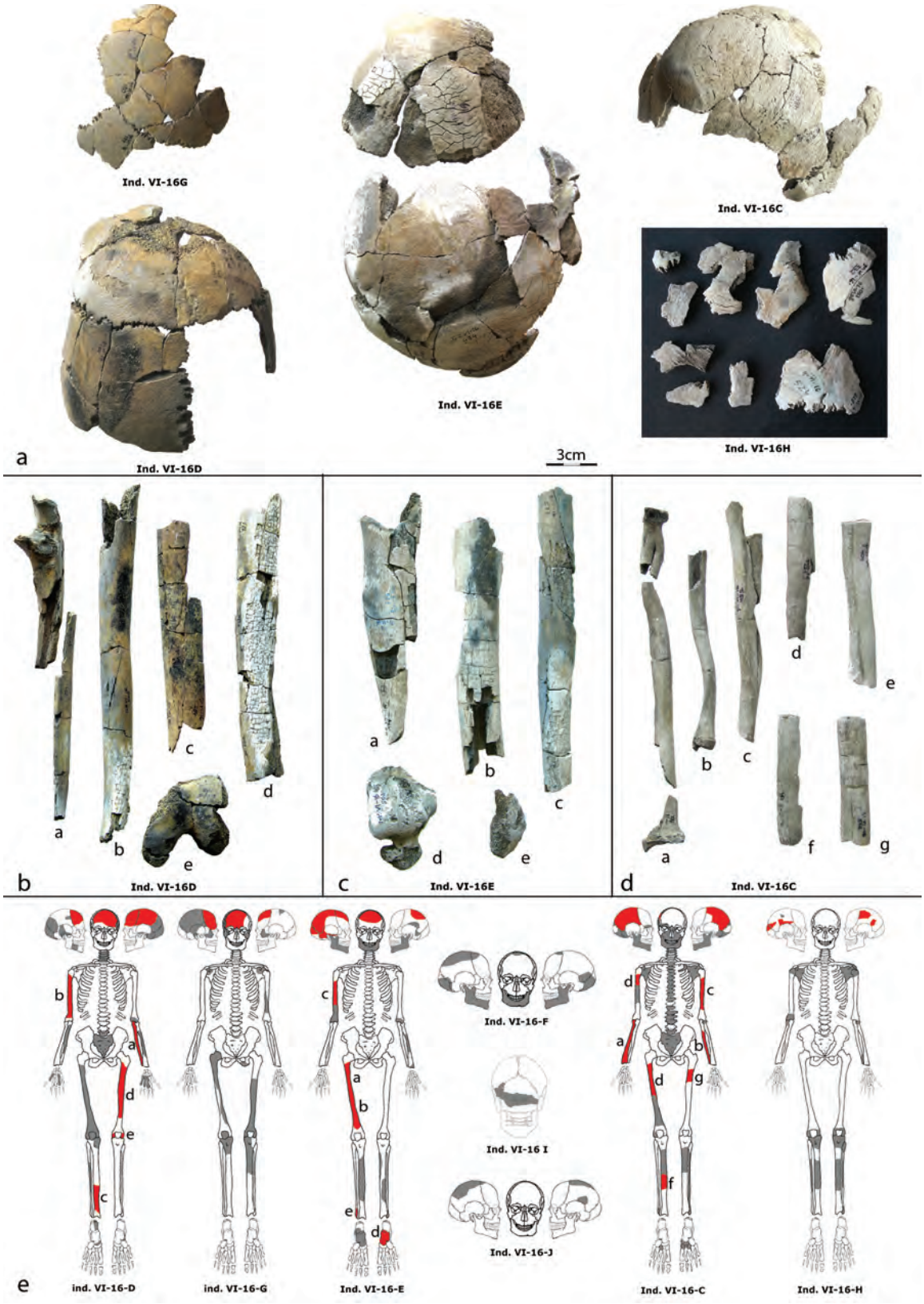

Fig. 10. Grave VI-16, examples of bones burned in different ways and completeness of reconstructed skeletons. **a** ***Skulls representing different degrees of burning;*** **b** ***long bones of individual VI-16D (male, Adultus) burned to black-brown;*** **c** ***individual VI-16E (male?), bones burned to blue-white;*** **d** ***individual VI-16C (female, Maturus), heavily burned porcelain-like bones;*** **e** ***reconstructed skull and postcranial skeletons completeness: grey – identified bone fragments; red – bone fragments presented at photos (marked with the same letters) (compiled by K. Bugajska).***

dividuals (B–C) were burned slightly more intensively to blue-grey-white (Fig. 11.2,3). In turn, the next six individuals were burned at higher temperatures to white, but two groups of remains could be distinguished. The first is represented by porcelain-like bones, which were heavily deformed, shrunken and transversely fractured, but they were still preserved in large fragments. At least three individuals (D, E, I) were burned in this way (Fig. 11.5). The second group are chalky white bones, heavily fragmented, with a soft powdery bone surface (Fig. 11.4). In this case, transverse fractures dominate, which indicates that the bones were burned while still fleshed (*Ubelaker 2009*); however, the burning process seems to have been less rapid than with the first group. The fragmented white bones belong to at least three individuals (F, G, H): one adult and two children aged 1.5–2 years and 7–8 years (Tab. 3). Considering the differences in the patterns of burning, at least four cremation events can be suggested for these remains. As in grave VI-16, the bones of different individuals were mixed in the grave pit, suggesting they were all deposited in grave VI-4 simultaneously (*Bugajska 2021a.Fig. 16*).

The burned skeletons from both graves represent different degrees of completeness. This suggests that a kind of bone selection and division of remains was practised. In both cases, there are more skulls than postcranial skeletons. In grave VI-16 there were at least eight skulls, but only five had mandibles, and there were bones from at least six postcranial skeletons from which five were reasonably complete (Figs. 11.5, 12.b). In the case of grave VI-4, the disparity between skulls and postcranial skeletons is more evident. There were at least nine skulls and six postcranial skeletons, but only two skeletons (A and E) were mostly complete and capable of reconstruction (Figs. 11.1,5, 12.a). A third more or less complete skeleton could belong to individual VI-F, but the bones are heavily fragmented, so the number of pieces that could be precisely anatomically identified is small, and reconstruction of the skeleton is not possible. All other postcranial skeletons distinguished for grave VI-4 are represented only by a single anatomically-determined bone fragment.

Both graves contained mixed assemblages of unburned and burned grave goods (*Bugajska 2021a. Tab. 2*), which indicates that some grave goods were cremated with the dead while others were added to the grave at the cemetery. The unburned inventory includes mostly animal teeth and bones. Two unburned tusks of a wild boar were added to grave VI-4, while four elk teeth and one roe deer incisor were placed in grave VI-16. In both graves, there were bird and fish bones. Additionally, in grave VI-4 there was a piece of turtle carapace. In both graves burned belemnites were found which could have been attached to the clothing of the dead. Flints were also present, but they bear traces of exposure to fire only in grave VI-4. Grave VI-16 also comprises pieces of burned bone implements, including a dagger, which could have been the personal belongings of the deceased that were burned with them on the pyre. It should be noted that bone implements were rarely added to the graves in the Dudka cemetery (*Gumiński 2014; Gumiński, Bugajska 2016*).

Radiocarbon dates were obtained for both graves. Grave VI-16 is older and dated to 5181±26 BP (4045–3955 cal BC; GrM-29994) which falls in the early Zedmar period. Grave VI-4 is much younger and dated to 4699±26 BP (3619–3372 cal BC; GrM-29983), corresponding to the transition from the classic Zedmar to the post-Zedmar period. Moreover, Grave VI-4 is the youngest cremation burial in the cemetery (Tab. 4).

Concentrations of cremated remains – separate deposits on the cemetery ground surface

There were at least 21 separate cremation deposits that occurred as small concentrations directly on the ground surface of the cemetery (Fig. 4). They yielded at least 27 individuals (Tab. 3). Most concentrations (15) were recorded during the excavation of graves, so their exact location is known. Additionally, at least six more concentrations could be estimated according to the dispersion of loose burned human bones (Figs. 4, 13). One possible concentration with the remains of two individuals (C7, C9) was located in the eastern part of the cemetery (Fig. 4), where many burned bones had been scattered by modern ploughing (Fig. 13). This deposit may have been placed over grave VI-9 or one of the pits present in this area. Three supposed concentrations of cremated remains come from the central part of the cemetery (Fig. 4, 13). One was probably located above pit VI-e-1 (ind. VIe-1-B), the second – individual C8 – was located somewhere between pit VI-c-1 and graves VI-2 and VI-3, whereas the third concentration with remains of two individuals (C1, C3) was located above pits VI-i-1 and VI-i-2. In the northernmost part of the trench, heavily cremated remains were found (ind. C4) which may have come from a deposit located near pit q-3 (Fig. 13). The

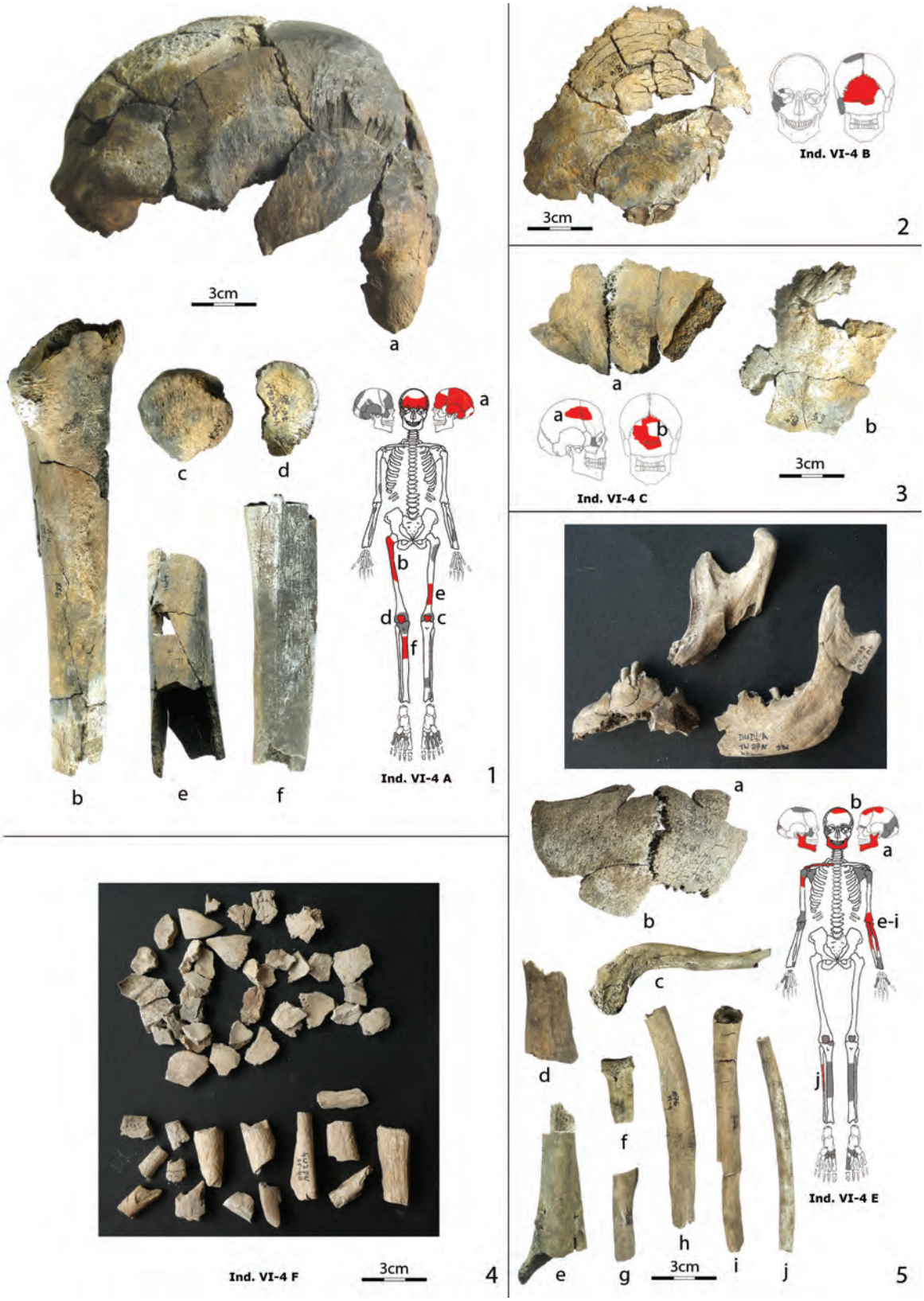

Fig. 11. Grave VI-4, examples of bones burned in different ways and completeness of reconstructed skeletons. **a** ***Bones of individual VI-4A (male, Maturus) burned to black-brown;*** **b** ***occipital bone of individual VI-4B (adult male?);*** **c** ***individual VI-4C (female, Maturus),*** **a** ***frontal and parietal bone,*** **b** ***occipital bone;*** **d** ***heavily fragmented pieces of skull and long bone shafts, individual VI-4F (an adult);*** **e** ***heavily burned bones preserved in large fragments, individual VI-4E (an adult). Grey in the drawings – identified bone fragments; red – bones presented in photos marked with the same letters (compiled by K. Bugajska).***

last possible concentration with unevenly burned bones of one individual (C2) was located in the western part of the cemetery, probably in the same area as grave VI-15 (Fig. 4, 13).

Concentrations of burned bones were uncovered just above graves that contained other burials, such as: single sitting primary burials – VI-6, VI-11; sitting primary and secondary: VI-2, VI-7, VI-13, VI-14; only secondary human burials – VI-10, VI-1, VI-e-1(?), VI-9(?) or the secondary burial of a dog – VI-8. Interestingly, cremated remains were not placed above graves containing single primary burials with the body lying on the back or on one side, i.e. above graves VI-3, VI-17 and VI-18. This suggests that the placement of these cremated remains was purposeful, and the locations of particular graves were still known.

Usually, single concentrations were placed over a given grave (Fig. 4). Two very small concentrations placed next to one another occurred above three graves only – VI-6, VI-7 and VI-14 (*Bugajska 2021a. Fig. 20*). In all these cases, the concentrations can be treated as one deposit because they contained remains from the same individuals. There is only one grave – VI-11 – where three larger clusters of cremated remains were uncovered and each one contained bones of another individual (*Bugajska 2021a.Fig. 19.b*). Concentration #735 appeared first and included remains of an adult. The next two concentrations (#790, #791) were located about 5cm deeper next to the skull of the sitting child. Interestingly, all three individuals were cremated in the same way. Bones are white and very fragmented with a soft powdery external surface (Tab. 3). Possibly, the deceased were burned together. Despite the intensive burning of the bones, it was impossible to obtain radiocarbon dates for these concentrations, so the chronological relation between them is unknown.

Each concentration of bones includes the remains of one or two individuals. Distinctive bone elements that could be identified anatomically are rare in concentrations. If two individuals are identified, usually one is an adult and the second is a child or juvenile, or there are bones burned in a completely different manner suggesting the presence of at least two skeletons – one heavily burned and the other slightly and unevenly burned (Tab. 3).

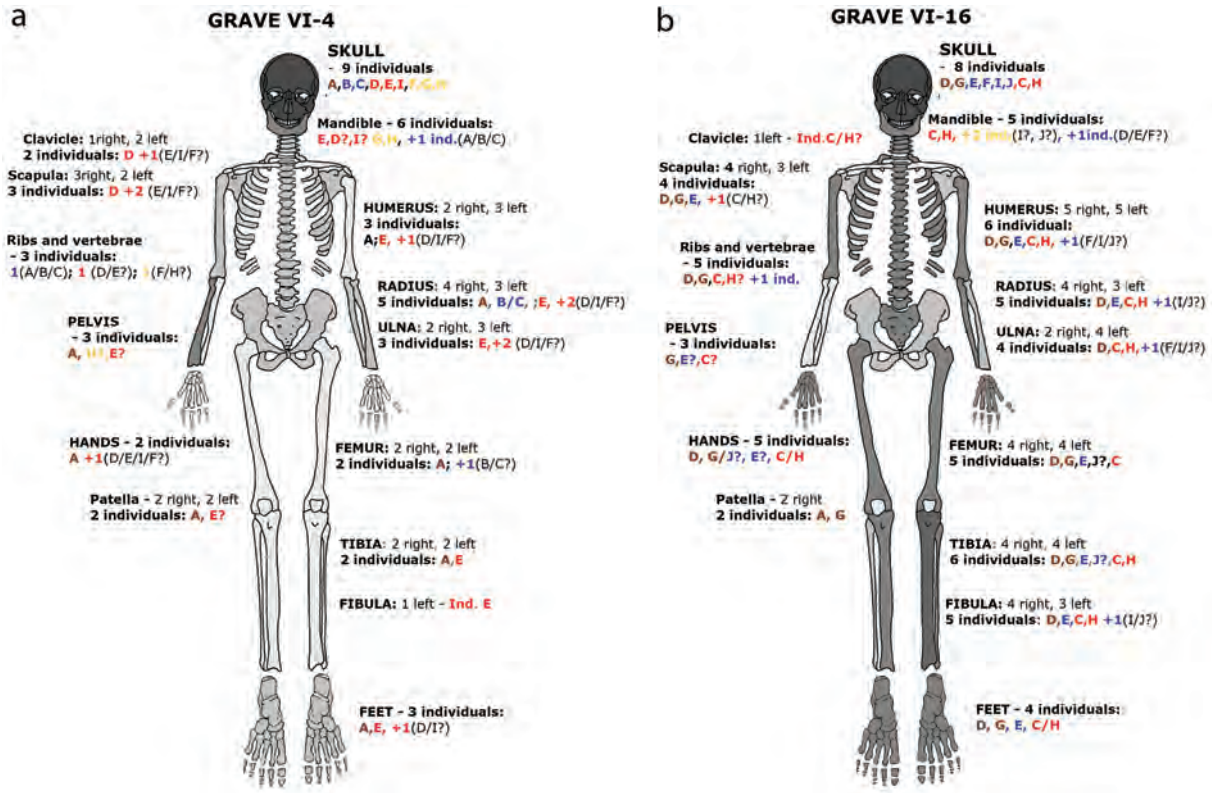

Fig. 12. Grave VI-4 and VI-16 – number of individuals determined based on different bones/parts of skeleton. Shades of grey – the darker the more identified bones, colours of letters: brown – bones burned to black-brown; blue – bones burned to white-blue; red – white porcelain-like bones, yellow – chalky white bones, very fragmented (compiled by K. Bugajska).

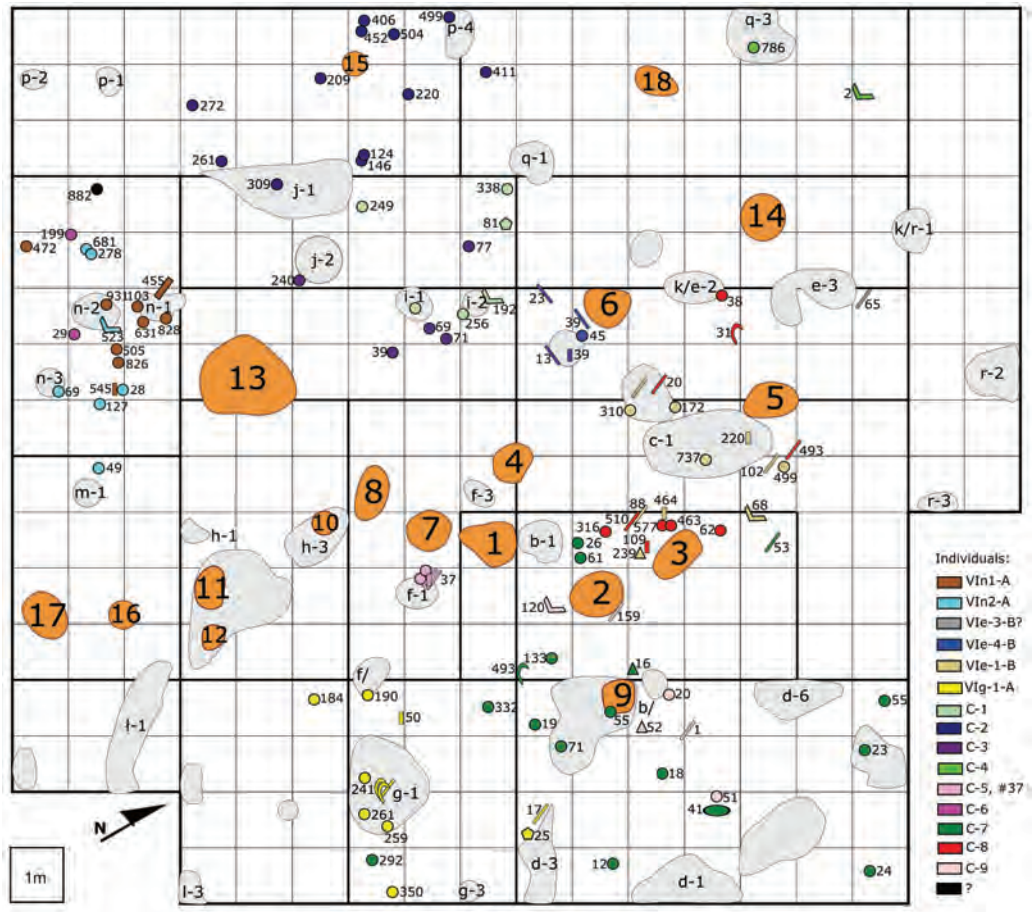

Fig. 13. Dudka cemetery. Distribution of loose burned bones. Bones of distinguished individuals are marked with different colours (compiled by K. Bugajska).

The deposit recorded above grave VI-10 is the only one containing the remains of three individuals – a dog and two humans, juvenile and adult. Bones were placed in multiple small clusters just above a secondary burial of a female. An adult individual is represented by only a slightly burned skull (Tab. 3), while a juvenile and a dog were burned in similar ways and until the bones were white (Fig. 14). Some of the juvenile and dog bones had visible green discolouration on the external surface which comes from ochre that was altered in the combustion process (*Gumiński 2014.129*). It thus seems probable that the dog and young human were cremated together on the pyre.

It should be emphasized that there is no correlation between the number of individuals and the number of bones in a given concentration. The majority of deposits contain a small quantity of burned remains, up to 400g, so just a handful of bones (Fig. 15). The number of bone fragments is usually less than 500 pieces. Larger quantities of bones were found only in three concentrations. The first is from grave VI-11 (#735) and includes only one adult skeleton. The second, comprising the bones of two individuals, was located near grave VI-13. And the third one is the concentration above grave VI-14 with the bones of two individuals, an adult and a juvenile. However, the remains of an adult prevailed and this skeleton may be almost complete (Tab. 3).

It can be assumed that in most cases only some of the bones of a given individual were deposited in one concentration, although bones from different parts of the skeleton are usually present (Tab. 3). The lack of distinctive bone elements and the extensive fragmentation make it impossible to accurately reconstruct the completeness of skeletons. In general, bones could only be assigned to particular anatomical groups – cranium, ribs-vertebrae and extremities (Fig. 16 and Tab. 3). For most long bone fragments it is impossible to distinguish if they come from the lower or upper extremities. Consequently, the proportion of bone pieces classified as 'both extremities' is much higher in concentrations than in the case of individual VI-15A (Fig. 16). The undetermined bone pieces are also frequent in the concentrations, usually

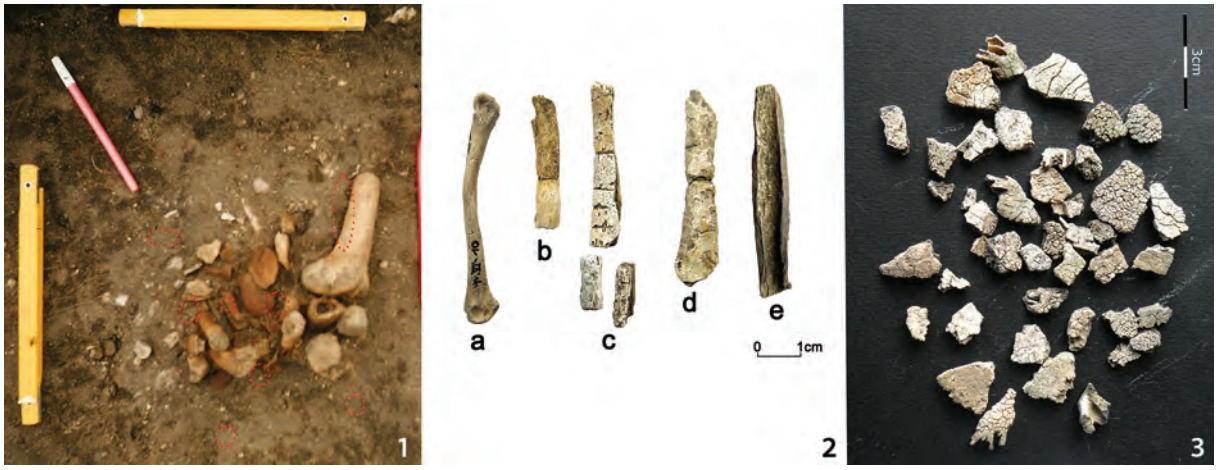

Fig. 14. Grave VI-10.* 1 *The view from above with marked places where clusters of cremated remains were noted;* 2 *burned bones of a dog,* a *metacarpal III,* b *metapodium;* c *radius?,* d *humerus with green stains;* f *long bone, humerus?;* 3 *burned pieces of skull of juvenile individual, some with green stains (photo by W. Gumiński, K. Bugajska).

comprising *c.* 20–30% of the total weight (Fig. 16 and Tab. 3).

Bones from concentrations are in most cases heavily burned to white, representing at least 15 individuals including one dog (Fig. 17). Nevertheless, there are some concentrations in which bones burned unevenly to brown-black or blue-grey occurred (Fig. 17 and Tab. 3). The degree of fragmentation is, in general, higher in concentrations than in graves VI-4, VI-15, VI-16, even comparing those skeletons burned in a similar way (Fig. 18.a,b). The least fragmentation of bones was noted for the heavily burned skeleton from grave VI-15, which was deposited in the container (Fig. 18.b). In turn, the most fragmented group is the heavily burned white bones from concentrations. In these cases, the maximum length of the bone fragments does not exceed 4cm and there are 2–3.5 bone fragments per gram (Fig. 18.b).

Differences in the degree of fragmentation result not only from the manner of burning but also from other factors such as particular ritual behaviours, the deliberate breakage of bones or various post-depositional factors (*McKinley 2004.11; Symes* et al. *2008; Walker* et al. *2008*). In the case of Dudka, it can be supposed that the more fragmented remains could have been stored and carried along for a long time before their deposition in the cemetery. This explains why there is a difference in fragmentation between the skeleton from grave VI-15, thought to have been interred in a container immediately after cremation, and the remains from graves VI-4 and VI-16 as well as from deposits placed on the cemetery ground surface (Fig. 18). This is supported by the incompleteness of the skeletons, resulting from possible selection and division of collected remains. Moreover, the lack of charcoal among the cremated bones could also be a result of the lengthy storage and transportation of

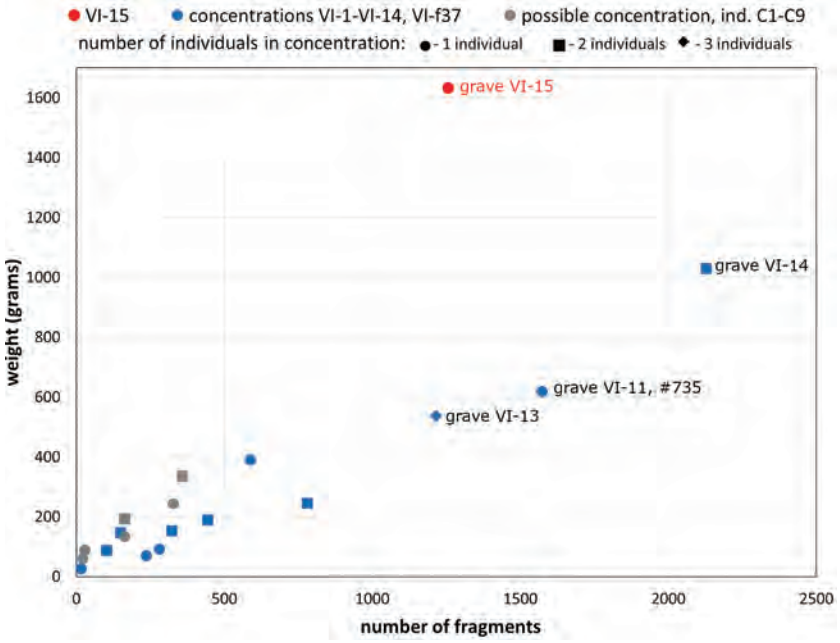

Fig. 15. The weight and number of bone fragments in concentrations compared with the almost complete skeleton from grave VI-15.

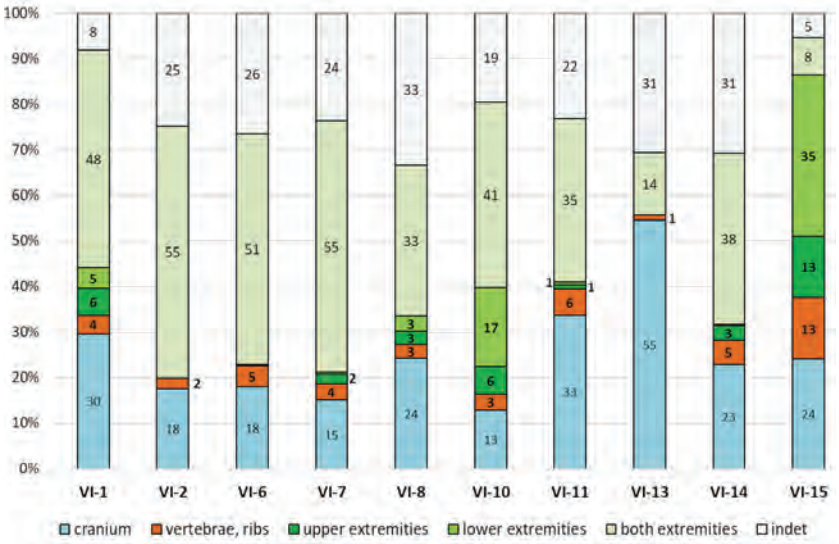

Fig. 16. Anatomical structure of human remains from concentrations* versus *skeleton from grave VI-15. Concentrations distinguished based on loose human bones are not included. For grave VI-11 all three concentrations as well as bones from pit filling were counted together.

bones. In addition, those remains that were deposited in the concentrations located beyond the pits were more affected by post-depositional factors, such as later settlement activity and modern ploughing. As such, the fragmentation of these remains is consequently greater than for the bones from graves VI-4 and VI-16.

The chronology of the cremation burials in Dudka cemetery

Twenty radiocarbon dates were obtained for cremation burials (Tab. 4). White heavily cremated bones were subjected to measurements, taking into account that reliable results can be obtained only for bones which undergone full re-crystallisation of bio-apatite (*Olsen* et al. *2008; 2012; Van Strydonck* et al. *2009*).

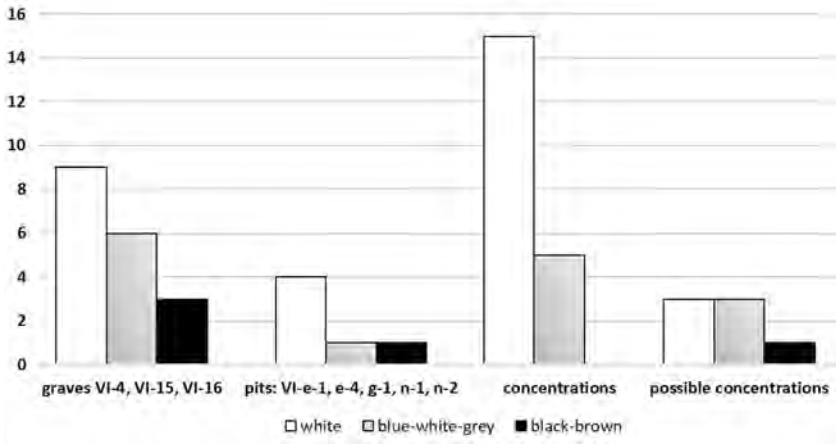

Fig. 17. The manner of burning. Comparison between the concentrations and the graves with cremated remains inside the pit.

Dates were made for all burials, *i.e.* graves, pits and concentrations that yielded suitable material for dating. Loose, burned bones from the cemetery area were also included, but only those for which the exact locations within the cemetery were known. Three such bones were selected (Tab. 4); one from individual C1 (#256), another (#51) from the eastern part of the cemetery probably associated with grave VI-9, and the third one (#882) from the western part of the cemetery. It was also possible to obtain a radiocarbon date for a fragment of fibula from trench III at Dudka, which was found in the Late Neolithic layer.

All dates fall into a limited timeframe between 4200–3400 cal BC and can be associated exclusively with the Para-Neolithic period (Fig. 19 and Tab. 4). This also applies to the fragment of fibula from the Late Neolithic layer in trench III, which was assumed to be the youngest cremation. This bone was found in two pieces scattered about four meters apart and located just below the surface (up to 10cm). It indicates that burned fibula was found in a secondary location due to post-depositional disturbance.

Cremation was introduced to the burial customs of the local hunter-gatherers in the early Zedmar period *c.* 4200 cal BC (Fig. 19). The oldest date was obtained for grave VI-n-2, 5300±27 BP (4240–4045 cal BC). However, the majority of dates fall into the classic Zedmar period, between 4000–3500 cal BC (Tab. 1 and Fig. 19). The youngest cremation burial comes from grave VI-4 which was dated to the turn of the classic and post-Zedmar period, 4699±26 BP (3619–3372 cal BC). It shows that in the post-Zedmar period as well as in the Late Neolithic cremation was no longer practised.

There is no difference in the chronology between the pits containing cremated remains

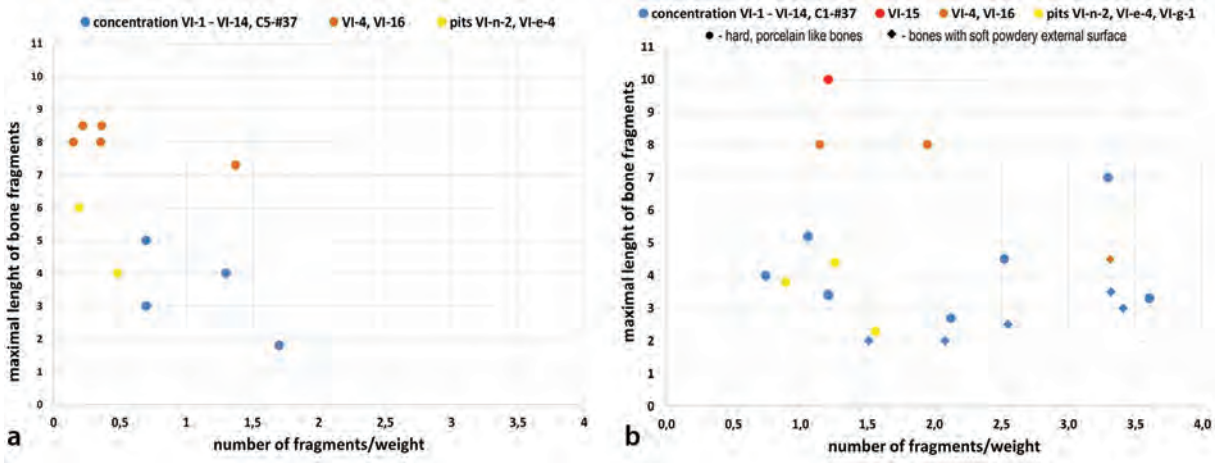

Fig. 18. Degree of bone fragmentation. **A** ***bones burned unevenly to blue-white-grey or black-brown;*** **B** ***bones cremated evenly to white.***

and the concentrations deposited on the cemetery ground surface (Fig. 19). Both customs were practised from the early Zedmar period to the end of the classic Zedmar. In both cases, the oldest burials are dated to *c.* 4200–4000 cal BC. It is indicated by ^{14}C measurement for grave VI-n-2 mentioned above. A similar result was obtained for loose bone #51 from trench VI-d, 5271±26 BP (4231–3990 cal BC, GrM-30003), which could come from a destroyed concentration placed near grave VI-9 (Figs. 13 and 20). This bone was previously thought to have been ploughed up from pit VI-g-1 (*Bugajska 2021a*), but remains from the pit gave a younger date, so a new individual was recognized (Tabs. 3–4).

Concentrations were deposited in the cemetery continually in the early and classic Zedmar periods. However, two main phases of deposition could be distinguished (Fig. 19). One is dated to 4000–3700 cal BC and the second is to *c.* 3600 cal BC, *i.e.* to the end of the classic Zedmar period. In turn, most pits with cremated remains, including collective grave VI-16, are dated to *c.* 4000–3800 cal BC. Only grave VI-4 is distinctly younger than other pits with cremations, and it is even younger than the youngest concentrations of cremated remains (Tab. 4 and Fig. 19).

The distribution of cremations within the cemetery shows some patterning. Cremation burials with similar dates, especially the concentrations, are concentrated in particular sectors of the cemetery (Fig. 20). This suggests the deposits of cremated remains were made in a particular area of the cemetery at a given time, so the concentrations are connected with a particular sector of the burial ground rather than with particular graves.

In the southern and southeastern parts of the cemetery, there are two graves and two concentrations dated to the early Zedmar period. In turn, in the central part of the cemetery are the youngest dates which fall at the end of the classic Zedmar period – including the youngest grave VI-4 and two concentrations – one placed above grave VI-1 and the second next to the pit VI-f-1 (ind. C5). In the northwestern part of the cemetery is a group of burials dated to *c.* 5100–5000 BP to which belong grave VI-e-4 and at least three concentrations: one represented by individual C1 and two located above graves (VI-6 and VI-e-1). Grave VI-15, dated to 5079±27 BP (3959–3797 cal BC), can be also included into this group.

Loose bone #882, which was found in the western part of the cemetery, gave a radiocarbon date of 5078 ±26 (3958–3797 cal BC, GrM-30004). The original provenance of this single bone (#882) is not clear. It was found comparatively deep, 40–45cm below the surface, in a layer which yielded almost no other finds. It was previously assigned to pit VI-n-2, which was located *c.* 2m away (*Bugajska 2021a*), but the loose bone proved to be younger (Tab. 4), so it belonged to another individual. Bone gave almost the same dating result as measurements obtained for two other samples: one taken from grave VI-15 and the second from individual C1 (Tab. 4 and Fig. 20). However, grave VI-15 is remote from bone #882 and shows no signs of being destroyed by ploughing, so it should be excluded. It seems probable that the bone belongs to individual C1, as represented exclusively by loose bones (Figs. 19–20). On the other hand, bone #882 was found close to the edge of the excavated area, which may indicate the presence of cremations in the unexcavated area (Fig. 20).

In previous papers, the connection between particular graves and the concentrations of burned remains was highlighted (*Bugajska 2021; Bugajska, Gumiński 2016*), because most of the deposits occurred just above particular graves and pits, and thus seem to be purposely arranged. This suggests that the location of the graves was known when cremated bones were deposited above them. However, following radiocarbon dating of cremated remains, the close chronological relationship between graves and concentrations is less certain than previously supposed. The study of chronological relations between cremations and other types of burials at Dudka cemetery requires more data and new AMS measurements of unburned bones. A few attempts at radiocarbon dating were made about 20 year ago, but they encountered serious problems with regard to proper collagen extraction and getting reliable measurements, since most results were much too young. This probably resulted from too low collagen content and its possible contamination. Only two of the obtained dates – for grave VI-8 and VI-17 – can be assumed as generally acceptable, *i.e.* falling into the Mesolithic (Tab. 4), but they may still be affected by soil contaminants and should be taken with some caution.

According to the available data, some preliminary conclusions can be made. It seems that at least some of the concentrations could be younger than the graves, as younger-than-expected dates were obtained for deposits located above graves VI-2 and VI-14. The graves probably correspond to the Mesolithic period based on stratigraphy and could be the oldest graves in the cemetery. Moreover, the cremated remains that were deposited there have produced almost the youngest results in the whole cemetery. They are 4792±26 BP (3638–3527 cal BC) for the concentration above grave VI-14 and 4968±26 BP

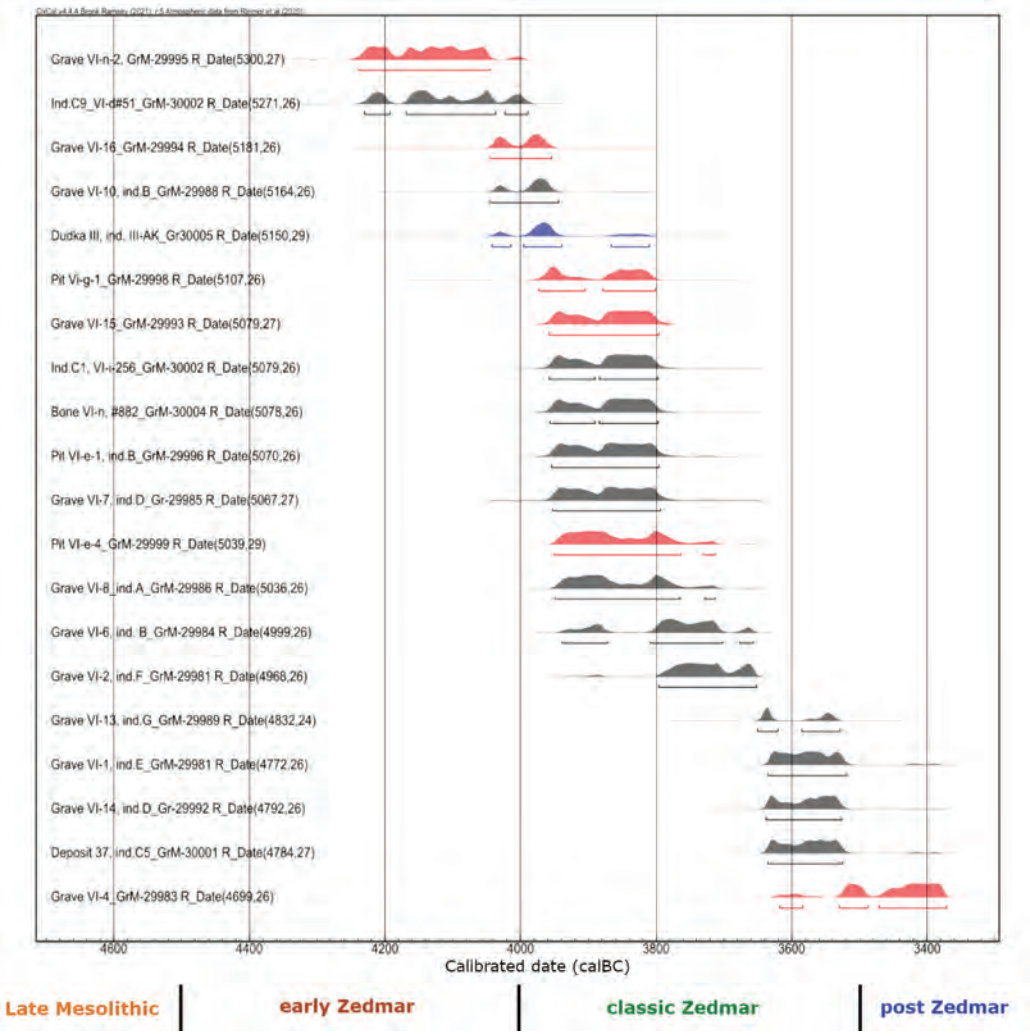

Fig. 19. Radiocarbon dates for burials at Dudka. Red – pits with cremated remains; grey – concentrations including these based on loose bones from cemetery; blue – loose burned bone (fibula) from trench III at Dudka.

(3796–3652 cal BC) for that above grave VI-2 (Fig. 20 and Tab. 4). Another example of a similar time difference comes from grave VI-8. A secondary dog burial from the grave was dated to 5690±25 BP (4584–4458 cal BC, KIA-19171), *i.e.* to the transition from the Late Mesolithic to the early Zedmar period, whereas the concentration of burned human remains is dated to 5036±26 BP (3950–3714 cal BC) which corresponds to the classic Zedmar period (Tab. 4).

Discussion. The role of cremation in the burial rites of hunter-gatherers from Lake Staświn

Cremation was introduced in the Staświn Lake microregion during the Para-Neolithic *c.* 5300 conv BP (*c.* 4200 cal BC), but it appeared *c.* 300 years later than pottery. The oldest Zedmar pottery is dated to *c.* 5600 conv BP (c. 4500 cal BC). It is one of the Western Para-Neolithic regional styles of pottery with some specific and outstanding features. The idea of producing pottery came to the Zedmar culture from the west or south (not from the east), as with other Western Para-Neolithic Cultures *i.e.* Swifterbant and Ertebølle. Certain similarities between Zedmar and the Danubian Neolithic ceramics can be distinguished, and some pottery imports from Brześć Kujawski culture were also found at the Szczepanki site (*Gumiński 2020*). The time difference between the appearance of pottery and the introduction of cremation suggests, however, that cremation was not a new idea that came with pottery from the Neolithic societies, *e.g.,* from Danubian Neolithic, but it was probably a local invention. It can be a response to the changes in settlement strategy and population growth that happened in the Para-Neolithic period (*Gumiński 1999; 2004; 2012; 2020; Gumiński, Michniewicz 2003*).

It should be emphasized that the appearance of cremation was accompanied by a rapid increase in the

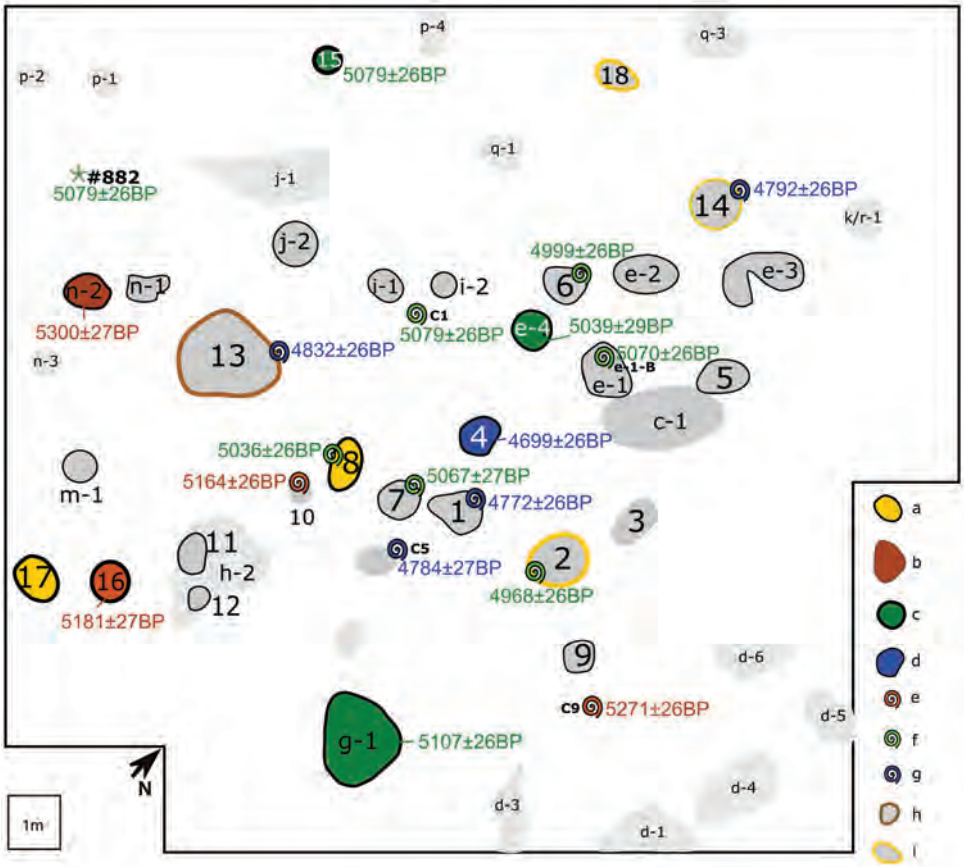

Fig. 20. Dudka cemetery with added ^{14}C dates for different cremations. **a** ***Graves dated to the Middle or Late Mesolithic based on unburned bones;*** **b** ***graves with cremations dated to the early Zedmar period;*** **c** ***grave with cremation dated to classic Zedmar period;*** **d** ***grave with cremation dated to the turn of classic and post-Zedmar;*** **e** ***concentration of cremated remains dated to early Zedmar;*** **f** ***concentration dated to classic Zedmar;*** **g** ***the youngest concentrations dated to the end of classic Zedmar;*** **h** ***grave affiliated with early Zedmar based on grave inventory;*** **i** ***grave affiliated stratigraphically to Mesolithic (compiled by K. Bugajska).***

occurrence of loose human bones in settlement areas, especially those that can be interpreted as remnants of temporary burials. At the Dudka site, loose human bones were found mostly in Trench III (*Bugajska, Gumiński 2016*). The oldest remains in this area belong to the Early Mesolithic (Boreal period) and are constantly present in all layers until the end of the Stone Age. The numbers of bones and teeth that can be associated with the Mesolithic are small; while a few more bones were found in the early Zedmar layers (Fig. 21). However, a large increase occurred in the classic Zedmar layers which yielded at least 65 bones from 30 individuals. Most of these remains may be interpreted as temporary burial remnants located on the lakeshore. Some bones remained in anatomical position and were accompanied by single-tooth pendants (*Bugajska, Gumiński 2016*). These data correspond generally with the chronology of the cremation burials (Fig. 19), which were much more numerous in the classic Zedmar period than in the early Zedmar.

The role of multi-step burial rites increased in the Para-Neolithic, reaching its apogee in the classic Zedmar period. It may have been influenced by a growth in population and changes in the settlement strategy, *i.e.* prolongation of residence on the islands. All places used in the Mesolithic for seasonal camps were then occupied throughout the year (*Gumiński 1999; 2004; 2012; Gumiński, Michniewicz 2003*). The cemetery at Dudka probably remained the main burial ground for the whole micro-region of Staświn Lake (*Bugajska, Gumiński 2016; Bugajska 2021a*). Possibly, it was important for the local hunter-gatherers to demonstrate their claims to occupy land and hunting territories based on their affiliation to the ancestors buried at the cemetery. Consequently, some graves were reopened, and certain bones were taken. On the other hand, the remains of the dead were carried to the cemetery for final burial. The appearance of cremation at this time suggests it could have played an important role in the complex multistep burial rites of the local hunter-gatherers. It may have been an alternative to the temporary burial mode. Cremation could have been used in those cases when the bones had to be cleaned of soft tissue immediately without a prolonged wait for natural decomposition. Cremated and fragmented remains are also much easier to store and transport, so it seems possible that cremation was used by hunter-gatherers who occupied settlements further from the main cemetery. Burned bones could be collected, selected and stored at encampments, before being brought to the main cemetery.

It can be stated with confidence that cremation was no longer used in the post-Zedmar and Late Neolithic periods. The youngest dates for burned remains fall at the very end of the classic Zedmar period (Tabs. 1 and 4). It is not known how long the multistep burial rite was practised and whether it was abandoned in the post-Zedmar period or the Late Neolithic. Unburned loose human bones are still numerous in the post-Zedmar and Late Neolithic layers, especially in Trench III at Dudka. It should be noted, however, that bones from these layers are much more fragmented and pieces of skulls predominate to a significant extent. Bones come mostly from the area used for settlement purposes and they were probably stored as memorabilia rather than being a remnants of temporary burials (*Bugajska, Gumiński 2016*). Moreover, radiocarbon dates are needed to determine whether these bones date to the post-Zedmar period or the Late Neolithic, because they may be older than the layer in which they occur. Some cranial fragments could come from skulls kept previously in the settlement, but they could have been already broken, mixed with refuse material and trampled in the Late Neolithic period. Bone pieces could also occur in the top layer due to other post-depositional disturbances, as in the case of the burned fibula from the Late Neolithic layer which was radiocarbon dated to the early Zedmar period (Tab. 4).

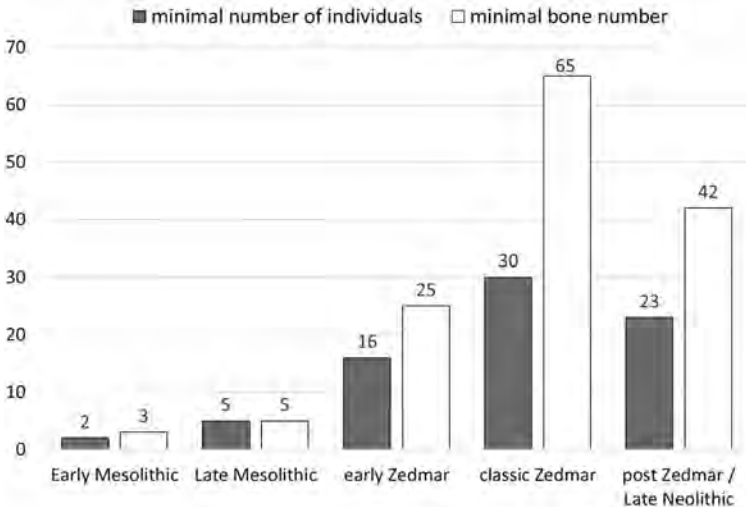

Fig. 21. Loose human bones at Dudka and Szczepanki belonging to different periods.

It could be argued that the youngest dates for cremations mark the end of

the use of the Dudka cemetery, which was probably abandoned in the post-Zedmar period, and the burial rites were transformed during that time. The change in burial customs in the post-Zedmar period possibly reflects increased influences from Neolithic societies, which are indicated by changes in pottery style and the presence of domesticated animals (*Gumiński 1999; 2004; 2012; 2020*) as well as by the presence of a megalithic structure which was constructed on the small island between the Szczepanki and Dudka site (*Gumiński 2001*). In the Late Neolithic, the cemetery area was even used for settlement purposes, and the burial ground was moved to another location, such as the interior of the island at Dudka. This is suggested by a primary child burial (grave IX-1) that was uncovered in Trench IX at Dudka. This is dated to 3775±40 BP (2341–2038 cal BC, Ki-5717) and associated with the Corded Ware or Bell Beaker culture (Tab. 4). Another Late Neolithic grave was probably located in the north part of Dudka island, but was destroyed by modern ploughing, and only a stone axe typical of the Corded Ware culture was found (*Gumiński, Kowalski 2011*).

Intriguingly, there are no Mesolithic cremations at Dudka, although the cemetery was already used in the Mesolithic period (Tab. 4). Moreover, cremation is noted from the Early Mesolithic on the European Plain (*Bugajska 2021a*), and this custom also appeared in the Early Mesolithic in northeastern Poland. The oldest cremation in the region comes from the Mszano site (Fig. 22). In this case, however, combustion of the body took place directly in the grave pit, so it was a primary cremation burial, not a secondary deposit of burned bones collected from the pyre (*Marcinak 2001*). The next evidence of Late Mesolithic cremation comes from the Wieliszew site in Masovia. There were pieces of a burned skull scattered within the settlement layer, but without a formal grave context (*Bugajska 2021a.31; Tomczyk* et al. *2019; Więckowska 1985.73–74; Wiercińska, Szlachetko 1977*). Numerous burned human bones in settlement areas were also reported from two other sites in northeastern Poland: Leśna Góra in northern Masovia and Grądy-Woniecko in Podlasie (*Bugajska 2021a; Piasecki, Kapla 2003; Więckowski 2017. 201*). In both cases, concentrations of cremated remains were uncovered, reminiscent of those found at the Dudka cemetery. Leśna Góra was occupied in the Late Mesolithic and probably also in the Para-Neolithic period (Neman culture?), *i.e.* till the transition between the late Atlantic and early Subboreal

Fig. 22. Map of northeastern Poland. Sites with cremation burials or loose burned human bones (compiled by K. Bugajska).

period (*Kawalkowa 2003.45–46; Piasecki, Kapla 2003*), whereas the Grądy-Woniecko site belongs to the Para-Neolithic Neman culture (*Wawrusiewicz* et al. *2017*).

Taking this into account, it seems possible that cremation was practised more broadly in the Para-Neolithic of northeastern Poland and its role in the region may have been greater then than in the Mesolithic. This is in contrast to southern Scandinavia and the Low Countries, where cremation burials were frequent in the Early and Middle Mesolithic, whereas in the Late Mesolithic and Para-Neolithic (*i.e.* in Swifterbant and Ertebølle cultures) cremation played probably a marginal role (*Bugajska 2021a*).

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Tab. 3. Cremation burials at Dudka. Brown font - dog bones; grey italic font - loose human bones, affiliation to the individual/grave is uncertain. Way of bone deposition: pit – bones deposited loosely in the pit; 👜 bones in container; ● separate concentration, deposit at the cemetery ground; # – single loose bone; PF – bones in pit filling, but previously in the concentration above grave. Colour: Bl *black,* B *blue,* W *white,* G *grey,* Br *brown,* l *light,* d *dark. Age:* I2 *infans 2;* J *juvenis,* A *adultus;* M *maturus;* S *senilis.*

GRAVE/DEPOSIT /TRENCH INDIVIDUAL (number of deposit)	WAY OF BONE DEPOSITION	NUMBER OF INDIVIDUALS BURNED IN THE SAME WAY	MIXED BONES OF INDIVIDUALS	AGE AND SEX	SKULL	RIBS AND VERTEBRAE	UPPER EXTREMITIES	LOWER EXTREMITIES	BOTH EXTREMITIES	UNDETERMIND	TOTAL WEIGHT (g)	BONE FRAGMENTS - TOTAL	MAXIMAL LENGTH OF BONE FRAGMENTS	NUMBER OF FRAGMENTS / WEIGHT	COLOUR	TRANSVERSE FRACTURES	SHRINKAGE/ DEFORMATION	HARD, PORCELAIN LIKE	SOFT POWDERY SURFACE
VI-1, inds. D+E	●	**2**	+	adult, child	25,5	3,5	5	4	41	7	86	104	34	1,2	W	+	+	+	-
VI-2, ind. F	●	1	+	I2/J	15	2			47	21	85	282	35	3,3	W	+	+	-	+
VI-4, inds. F, G, H	pit	**3**	+	adult, I1, I2,	138,5	23,3		2,8	185,5	670	1020	3380	45	3,3	W	+	-	+	+
VI-4, inds. D, E, I	pit	**3**	+	♀; 2 adults	527	258	242	187	412,5	1546	3172,5	6182	80	1,9	W	+	+	+	-
VI-4, inds. A, B, C +dog	pit	**3**	+	M♂, ♂, M♀	1169	73	71	753	427 +1	200,5	2693,5 +1	959 +1	80	0,3	B-G-W	+/-	-	-	-
VI-6, ind. B	●	1	+	child	21,5	8,5		91,5	47	47	172	434	45	2,5	W	+	+	+	-
VI-6, ind. C		1	+	adult	11,5		0,5	1,5	1,5	1,5	15	11	50	0,7	Br-G	+	-	-	
VI-7, ind. D	●	1?	-	adult	21,5	5	3	0,5	78,5	33,5	142	150	52	1	W	+	+	+	-
VI-7, ind. E?	Pit?	1	-	adult				8		-	3	1	-	-	Bl	-	-	-	-
VI-8, inds. A-B	●	**2**	+	adult, child	37	4,5	4,5	5	50,5	51	152,5	323	27	2,1	W+B-G	+	+	+	+/-
VI-10, ind. B	●	1	+	I2/J	22	8	14	39,5	93,5	44,5	221,5	762	70	3,4	W	+	-	+	+
VI-10, dog				adult?			10,2	3,7	1		14,9	17	46	1,1	W	+	+	+	+/-
VI-10, ind. C		1	+	adult	7,5					-	7,5	5	30	0,7	Bl	+	-	-	-
VI-11, ind. C (#735)	●	**1**	-	adult	172	37,5	3	1,5	226	177	617	1574	25	2,6	W	+	+	+	+
VI-11, ind. B (#790)	●	**1**	-	adult	23	4	0,5		15	27	69,5	237	30	3,4	W	+	+	+	+
VI-11, ind. D (#791)	●	**1**	-	I1?	110	27	8	5	157	82	389	588	20	1,5	W	+	+	+	+
VI-11; inds. B-D	PF	**3**	+	-	132,5	9,5	2,5	2	89,1	26,2	232,1	326	25	1,2	W	+	+	+	
VI-11 - total	3 ●	3	-	-	437,5	78	14	8,5	487,1	312,2	1307,6	2725	25	2	W	+	+	+/-	+
VI-13, ind. G	●	1	+	child	48	5			73	100	226	815	33	3,6	W.	+	+	+	-
VI-13, ind. H		1	+	adult	245	1,5				64,5	311	401	40	1,3	G	+	-	-	-

Tab. 3 continued

VI-14, ind. D	●	**2**	+	Adult; +J?	237,5	54	34	1,5	373	314,5	1014,5	2111	53	2,1	W.	+	+	+	+
VI-14, ind. E?				J?					12,5		12,5	21	21	1,7	N-W	+	-	-	+
VI-15, ind. A	👜	**1**	-	♂, 20-25y	379	211	212	557	127	86	1572	1257	100	0,8	W	+	+	+	-
VI-16, inds. D + G	pit	**2**	+	A♂, In2	715	177,5	296	712,5	293,5	62	2256,5	820	85	0,4	Br-Bl.	+	-	-	-
VI-16, inds. C, H	pit	**2**	+	M♀, A♀	562	444	169,5	263,5	462	304	2205	2529	80	1,1	W	+	+	+	-
VI-16, inds. E, F, I, J	pit	**4**	+	A♀, S, J, a	844	129	81,5	314,5	508	714	2591	3562	73	1,4	B-G-W	+	+	-	+/-
VI-e-1 (ind. B)	pit	1	+	adult	15	1	2	28	3,1	1,3	50,4	22	45	0,9	W	+	+	+	-
VI-e-1/ VI-4?	*?*	*1?*		*adult*	*29,2*	*18*	*15*	*10,5*	*53,8*	*51,5*	*178*	*306*	*31*	*1,7*	*W-light G*	*+*	*+*	*+*	*-*
VI-e-3 (ind. B)?	#	1	?	adult				6		-	6	1	-	-	G	+	-	-	-
VI-e-4 (ind. B)	pit	1	+	adult?	5		3	36		-	44	17	40	0,2	W-B-dG	+	-	-	+
VI-e (ind. VI-e4B?)	?			adult?		0,4			6,4	1	7,8	8	31	1	W-B-dG	+	-	-	+
VI-e-4 (ind. C)	pit	1	+	adult?	1,2	0,5			6,5	2,7	10,9	17	23	1,6	W	+	+	+	-
VI-g-1 (ind. A)	pit	1	+	adult	12,4	4,5	11,6		15,2	10,1	53,8	48	38	0,9	W	+	+	+	-
VI-n-1 (ind. A)	pit	1	-	adult	48	3,4		46	-	-	97,4	19	60	0,2	Black	+/-	-	-	-
VI-n-2 (ind. A)	pit	1	-	adult	23	5,5	0,9	13	-	2,2	44,6	32	44	0,5	W	+	+	+	-
VI-n (ind. VIn-2A)	?	1	-	-					41,2	11	52,2	90	30	1,7	W	+	+	+	+
Deposit #37, Ind. C5	●	1	-	adult	11			5	5,8	2,4	24,2	18	40	0,7	W	+	+	+	-
VI-7/VI=8/ #37	*?*	*1*	*-*	*-*	*14,5*	*4*	*2*	*8*	*38,8*	*19,1*	*86,4*	*112*	*42*	*1,3*	*W*	*+*	*+*	*+*	*-*
Ind. C1	●?	1	+?	adult	13	1,2	0,5	15,7	47,3	22,6	100,3	110	38	1,1	W	+	+	+	-
Ind. C3		1		adult	34,7	0,7		20,2	35,9	-	91,5	54	41	0,6	dG-N	+	-	-	+/-
Ind. C2	●?	1	-	adult	42		4	15	13	-	74	23	32	0,3	Br-Bl-dG	+	-	-	+/-
Ind. C4	●?	1	-	adult	17,7	6,2	0,5	32	43,4	34,3	134,1	164	37	1,2	W-W/l.G	+	+	+	-
Ind. C6	#	1	-	Child	0,5					-	0,5	2	17	4	W		+	+	-
Ind. C7; g.VI-9?	●?	1	+?	adult	57	3,5		33,8	55,4	33,5	183,2	168	50	0,5	G-N-W	+	-	-	+/-
Ind. C9, g.VI-9?		1		adult	14,6	4,1	2,1	8,9	89,6	31,8	151	191	39	1,3	W	+	+	+	+/-
Ind. C8	●?	1	-	adult	19,7	1,5	2,3	51,3	14,2	-	89	29	75	0,3	Br-Bl-dG	+/-	-	-	+/-
VI-a//b/c	*?*	*-*		*-*	*7*			*14,2*	*17,5*	*13,2*	*51,9*	*44*	*27*	*0,8*	*Bl +W/B*	*+*	*-*	*-*	*+/-*
VI-a//b/c	*?*	*-*		*-*					*38,3*	*19,5*	*57,8*	*69*	*33*	*1,2*	*W-G-N*	*+*	*-*	*-*	*+/-*
VI-a; g.VI-1/VI-4	*?*	*-*		*-*					*6,5*	*11,1*	*17,6*	*54*	*27*	*3*	*W*	*+*	*+*	*+*	*-*
VI-m; VI-l/ł,Vi-h	*?*	*-*		*-*	*2,1*	*6,6*	*4,7*	*7,8*	*42,8*	*13,6*	*74,6*	*128*	*31*	*1,7*	*W*	*+*	*+*	*+*	*-*
VI-p; VI-n	*?*	*-*		*-*		*2,4*				*5,8*	*11,4*	*9*	*30*	*0,8*	*W*	*+*	*+*	*+*	*-*
(VI-r)	*?*	*-*		*-*	*0,5*	*0,2*	*3*	*0,5*	*8,7*	*4,8*	*17,7*	*20*	*31*	*1,1*	*W + l.G*	*+*	*+*	*+*	*+/-*
VI-r	*?*	*-*		*-*	*1*				*26,6*	*3*	*30,6*	*21*	*26*	*0,7*	*W-G-N*	*+*	*-*	*-*	*-*

Tab. 4. Radiocarbon dates of burials at the Dudka site. AMS measurements of cremated bones (no 1–20) were made at the Centre for Isotope Research of University of Groningen. The applied methods of sample pretreatment and measurement are described in Dee *et al.* 2020. *Three dates (no 21–24) on unburned bones from graves at Dudka are included and are marked with *. Measurement of $\delta^{13}C$(‰): –17.31±0.06 is reported only for sample KIA-19171. Calibrated BC dates (95% confidence intervals) are based on: OxCal v.4.4.4 (*Bronk Ramsey 2021*), IntCal20 curve (*Reimer *et al.* 2020*).*

No	Site/ Trench	Grave/pit/ trench	Ind.	Bone number	Depth	Bone determination	Type of burial / way of bones deposition		^{14}C years BP	cal BC (2σ)	Lab.No.
1	Dudka	Grave VI-1	VI-1E	88	30-35	long bone shaft	Cremation burial or loose burned bones	concentration above grave	**4772** ±26	3636-3519	GrM-29981
2	Dudka	Grave VI-2	VI-2F	-	35-40	long bone shaft		concentration next to the top of grave	**4968** ±26	3796-3652	GrM-29982
3	Dudka	Grave VI-4	VI-4F	896	25-30	long bone shaft		grave pit – upper part	**4699** ±26	3619-3585; 3530-3487; 3471-3372	GrM-29983
4	Dudka	Grave VI-6	VI-6B	94	40-45	long bone shaft		concentration above grave	**4999** ±26	3940-3872; 3809-3702; 3677-3657	GrM-29984
5	Dudka	Grave VI-7	VI-7D	93/94	35-40	long bone shaft		concentration above grave	**5067** ±27	3954-3794	GrM-29985
6	Dudka	Grave VI-8	VI-8A	89	35-40	long bone shaft		concertation next to grave	**5036** ±26	3950-3765; 3729-3714	GrM-29986
7	Dudka	Grave VI-10	VI-10B	-	30-35	tibia shaft		concentration above grave	**5164** ±26	4046-3945	GrM-29988
8	Dudka	Grave VI-13	VI-13G	-	35-40	long bone shaft (femur?)		concertation next to the top of grave	**4832** ±24	3651-3620; 3586-3529	GrM-29989
9	Dudka	Grave VI-14	VI-14D	-	40-45	long bone shaft		concentration above grave	**4792** ±26	3638-3527	GrM-29992
10	Dudka	Grave VI-15	VI-15A	473	25	long bone shaft (humerus/tibia)		grave pit – container	**5079** ±27	3959-3797	GrM-29993
11	Dudka	Grave VI-16	VI-16C/H	566	40-45	femur shaft		grave pit	**5181** ±26	4045-3955	GrM-29994
12	Dudka	VI-n-2	VI-n-2A	848	35-40	cranial fragment		grave pit	**5300** ±27	4240-4045	GrM-29995
13	Dudka	VI-g-1	VI-g-1A	-	25-30	long bone shaft		grave pit	**5170** ±26	3973-3906; 3879-3802	GrM-29998
14	Dudka	VI-e-1	VI-e-1B	747	30-40	cranial fragment		single bone from pit filling	**5070** ±26	3954-3796	GrM-29996
15	Dudka	VI-e-4	VI-e-4C	-	40-65	long bone shaft		grave pit – from bottom	**5039** ±29	3951-3764; 3731-3714	GrM-29999
16	Dudka	Deposit VIf-37	C5	37 (2W24N)	25-30	long bone shaft		separate concentration	**4784** ±27	3636-3526	GrM-30001
17	Dudka	VI-i-1/VI-i-2?	C1	256 (7W25N)	20-25	frontal bone		loose human bone – possible concentration	**5079** ±26	3958-3891; 3884-3797	GrM-30002
18	Dudka	Grave VI-9?	C9	51 (30N3E)	20-25	temporal bone		loose human bone – possible concentration	**5271** ±26	4231-4194; 4170-4038; 4023-3990	GrM-30003
19	Dudka	Trench VI-n	?	VI-n 882	40-45	fibula shaft		loose human bone, cemetery area	**5078** ±26	3958-3890; 3884-3797	GrM-30004
20	Dudka	Trench III	III-AK	1 (2E68N) + 12 (6E67N)	0-10	fibula shaft		loose human bone, settlement area	**5150** ±29	4043-4015; 3996-3940; 3866-3810	GrM-30005
21	Dudka*	Grave VI-8	dog	-	-	dog bone (unburned)	secondary dog burial		**5690** ±25	4603-4453	KIA-19171
22	*Dudka**	*Grave VI-17*	*VI-17A*	-	-	adult bone (unburned)	primary female burial		***6645*** ±30	*5628-5521; 5496-5484*	*Poz-3913*
23	*Dudka**	*Grave IX-1*	*IX-1A*	-	-	child bone (unburned)	primary child burial, outside the cemetery (Corded Ware Culture)		***3775*** ±40	*2341-2316; 2310-2118; 2098-2038*	*Ki-5717*

The significance of Early Neolithic settlement burials: a case study from Central Germany

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ABSTRACT - *Early Neolithic Settlement burials in Central Europe have long been treated as an irregularity and thus sparked discussions about perceptions of social deviancy. In recent years, the highly increased number of documented settlement burials suggests that they constituted an integral part of a more complex system of burial practices, which precludes a dichotomous division into 'regular' and 'irregular' burials. Based on the characteristics of a series of interments in the Central German settlement Niederröblingen, this study aims to determine the probabilities of individual agency within a framework of collective rules in the early Neolithic* Linearbandkeramik *culture.*

KEY WORDS – *Linear pottery culture; burial customs; settlement burials; settlement archaeology; Neolithic; irregularity*

Pomen zgodnjeneolitskih grobov v naselbinah: študija primera iz Srednje Nemčije

IZVLEČEK – *Zgodnjeneolitski pokopi v naselbinah v srednji Evropi so bili dolgo obravnavani kot anomalije in so zato sprožali razprave o percepcijah družbene deviantnosti. Povečano število dokumentiranih pokopov v naselbinah v zadnjih letih kaže, da predstavljajo sestavni del kompleksnega sistema pogrebnih običajev, ki preprečuje dihotomno delitev na 'prave' in 'neprave' pokope. S pomočjo niza značilnih pokopov v osrednjenemški naselbini Niederröblingen želimo v študiji določiti verjetnost individualnega delovanja v okviru pravil skupnosti kulture Linearno trakaste keramike v zgodnjem neolitiku.*

KLJUČNE BESEDE – *kultura Linearno trakaste keramike; pokopne prakse; pokopi v naselbini; naselbinska arheologija; neolitik; nepravilnosti*

Aim of this study

Hardly any aspect of human existence seems to transcend both the private and the collective spheres of a society as much as the death of one of its members. From the perspective of most modern cultures, few acts are more personal than dealing with grief and loss, and yet a multitude of social requirements and taboos determines the adequate actions connected to burial practices. This is by no means a recent development, but can instead be traced back through the customs of many archaeological cultures. Burials within settlements as a phenomenon of early sedentary cultures are especially intriguing from a modern point of view, due to the seemingly fluent transition of the domains of the living and the dead, which are usually kept distinctly separate in modern societies.

This study aims to determine the probabilities of individual agency within a framework of collective rules

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regulating the burial customs in the early Neolithic *Linearbandkeramik* culture in Central Europe. Taking the characteristics of a series of interments deposited within the settlement of Niederröblingen in Central Germany as a starting point, a broader examination of the differences between this type of burial and the graves in contemporary cemeteries in conducted. A central aim of the paper is to ascertain why certain individuals were interred apart from cemeteries in general, and specifically why they were deposited within the settlements, a domain one would assume to be reserved for everyday life. By analysing rites, grave goods and anthropological data, the question is examined as to whether certain subsets of people were treated differently as a rule or if the choice concerning the location of burial was based on uniquely individual decisions. In this context, the oft-applied dichotomous division into 'regular' and 'irregular' burials is assessed anew.

The *Linearbandkeramik* culture (LBK)

As the first Neolithic culture in many parts of Europe, the. *Linearbandkeramik* (translating to Linear pottery culture) has been extensively studied since the late 19th century. Approximately dating from 5600 to 4900 BC (*Coudart 2015.309; Jakucs* et al. *2016.323*), it has been named for the eponymous decorations on its characteristic pottery vessels. The culture occupies a key position within the research into early Neolithic life-ways in Europe, as it saw a dramatic change in many areas of daily life, including the transition from a mobile to a sedentary lifestyle, as well as a shift within the strategies of subsistence from a foraging to an agricultural society. At the height of its distribution, settlements containing the characteristic longhouses could be found from the Paris Basin in the west to Western Ukraine in the east, and from the Northern German Plain in the north to the Carpathian Basin in the south (*Bickle 2013.151; Coudart 2015.310f; Stäuble 2010.25*). While occasionally showing signs of regional variation, the majority of architectural features as well as objects of daily use display a surprising uniformity over the vast area of distribution, allowing for the designation as a single archaeological culture.

The Niederröblingen site

The Niederröblingen site is located within the eponymous incorporated community belonging to the city of Allstedt in the district of Mansfeld-Südharz

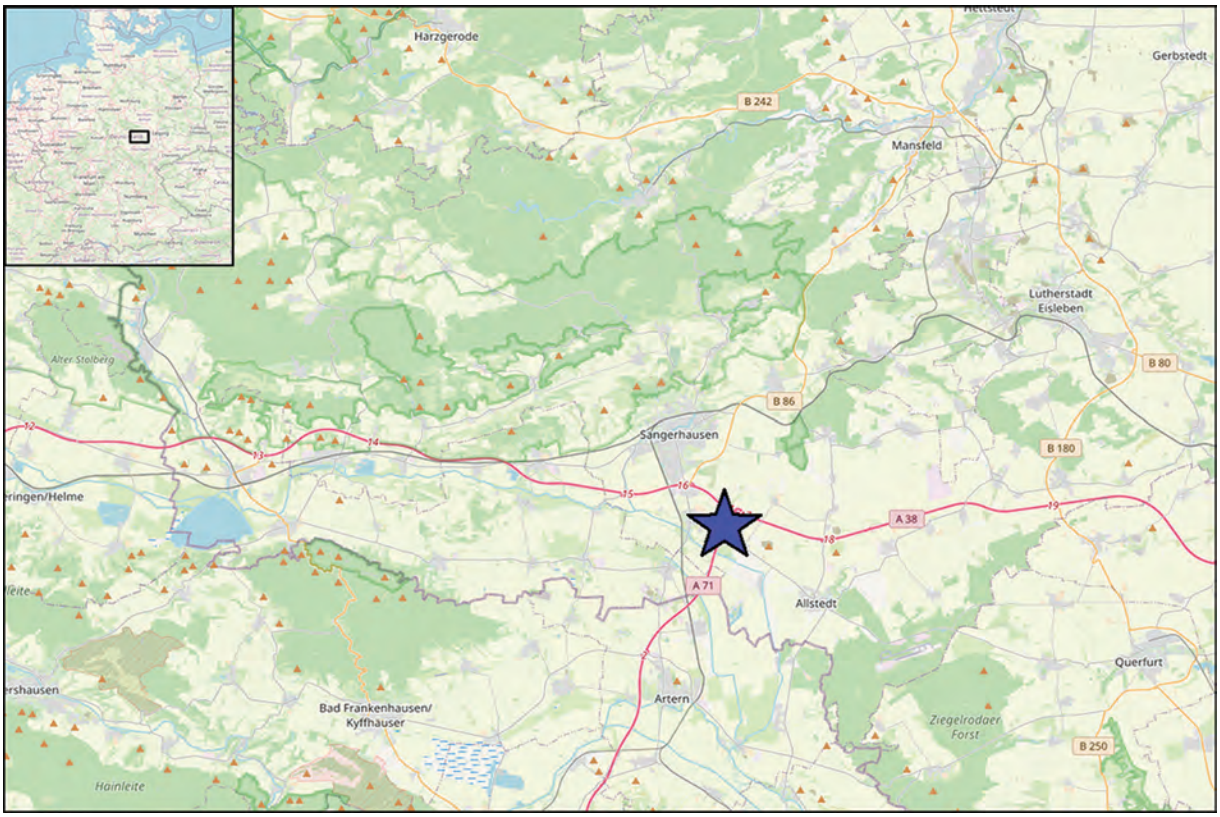

Fig. 1. The location of the Niederröblingen site within its natural environment (source: www.openstreetmaps.com; edited by the author).

in the southern part of the German federal state of Sachsen-Anhalt (Fig. 1). The surrounding natural area is formed by the *Goldene Aue*[1] valley, which, thanks to its outstanding natural conditions, offered an ideal location for an extensive *Linearbandkeramik* settlement and also saw frequent use by subsequent cultures. The site apparently experienced the most intensive settlement activity in the regional phases LBK II to LBK IV, which approximately date from 5300 to 4850 BC (*Schwarz 2021.54*). In between the houses and other settlement structures, a total of 29 contemporaneous inhumations could be identified (Fig. 2; Tab. 1) (*Stolle 2021.7*).

The exceptionally high number of settlement burials allows for systematic comparisons concerning the burial rites of that time. In the vast majority of contemporaneous sites, interments were only documented in small numbers, if at all. Furthermore, the level of preservation of the majority of features was extremely favourable. In most settlements, it was impossible to ascertain the temporal relation between houses and human remains, due to the absence of clear stratigraphical relations. Although, due to the high density of local features, most of the skeletons in Niederröblingen were inevitably situated spatially close to the houses, the site lacked clear evidence of temporal relations between buildings and interments[2]. However, the proven continuous and long-term usage of the settlement helps to clarify the concurrency of houses and burials. The earliest features at the site could be radiocarbon-dated to around 5300 BC, relating to the regional Phase LBK II, while a complex stratigraphic sequence in the southern section of the excavated area implies continuous settlement activity ending concurrently with the final phase of the *Stichbandkeramik* culture (Eng. Stroke-ornamented ware culture), which regionally followed the *Linearbandkeramik*. Afterwards, usage of the site seems to have been discontinued until the late Neolithic (*Lubos* et al. *2011.51–52*).

The majority of the investigated burials, none of which was dated earlier than 5300 BC, were found in the southern section of the site as well, implying the simultaneity of houses and burials in this area. Even in the other parts of the site, the buildings can be dated to the whole array of locally represented phases of the culture, as is evidenced by radiocarbon dating as well as characteristic architectural features and a con-

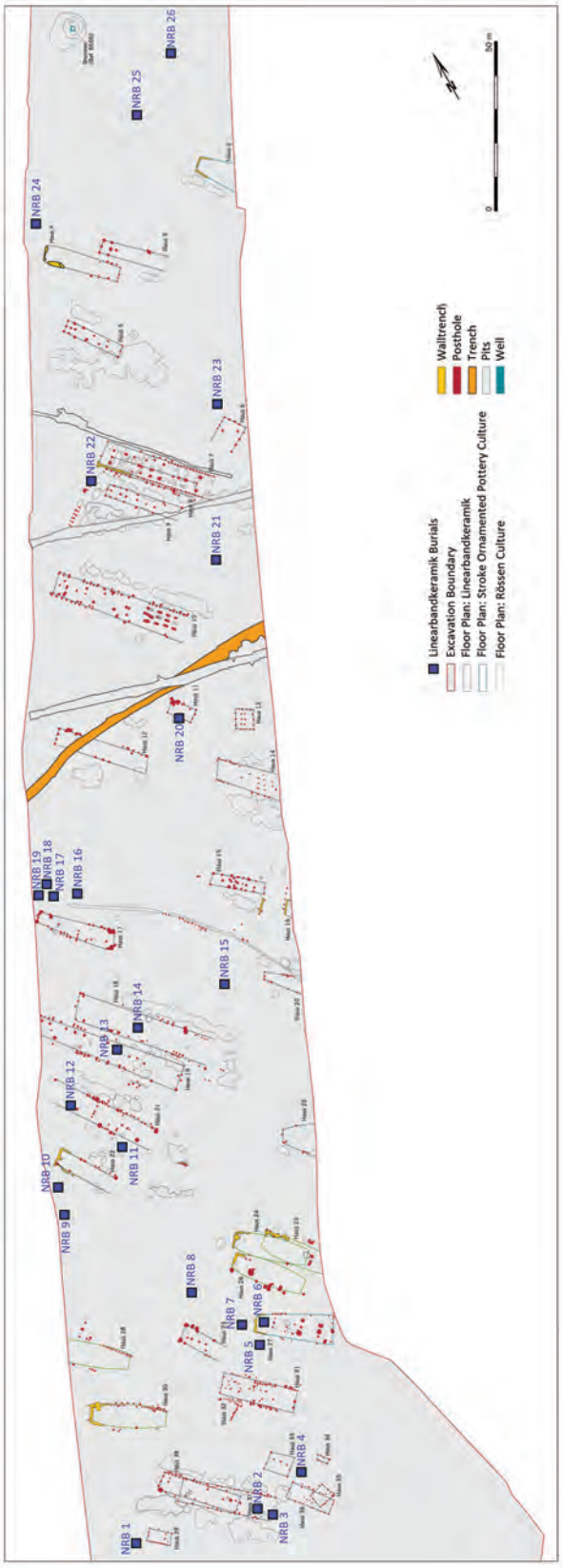

Fig. 2. Settlement plan Niederröblingen. © Landesamt für Denkmalpflege und Archäologie Sachsen-Anhalt, M. Scholz, edited by R. Stolle.

1 This roughly translates to 'golden meadow', referring to the favourable natural conditions of the environs.

2 Two burials (NRB 2 and 3) that seemed to be located within the floor plan of a house are most likely the product of unintentional subsequent overlays.

Burial	Age	Sex	Location	Position	Orientation	Dir. of View	Burial Goods	^{14}C-Date (2σ)
NRB 1	infans II		grave pit?	crouched, left side	NE-SW	SE	CRJ, R, SGJ	
NRB 2	adult or older		refuse pit		E-W	N	FT, P, R	
NRB 3	juvenil or older		refuse pit	stretched, prone	SW-NE	S	P	calBC 5207–4940
NRB 4	adult or older		grave pit?	stretched, prone	NW-SE	NE	-	calBC 5284–5046
NRB 5	juvenil	male?	grave pit?	crouched, left side	E-W	S	-	calBC 5225–5000
NRB 6	juvenil	male?	grave pit?	stretched, prone	NE-SW		-	calBC 5319–5080
NRB 7	infans (II?)		grave pit?		SE-NW		ABJ, P	calBC 5218–5020
NRB 8	infans I		grave pit?	crouched, left side	NW-SE	E	P (2x)	
NRB 9	adult		refuse pit	crouched, left side	NE-SW	SE		
NRB 10	infans II		refuse pit	crouched, supine	NE-SW	SE		
NRB 11	infans		grave pit?				P	calBC 4934–4745
NRB 12			?	crouched, right side	NW-SE	SW		calBC 5207–4858
NRB 13a	adult or older	female?	refuse pit	crouched, right side	SW-NE	SE?		
NRB 13b	infans I		refuse pit	crouched, left side?	SE-NW?	SW?		
NRB 14			?		S-N		S, R	
NRB 15	adult or matur	female?	grave pit?	crouched, left side	NE-SW	SE	CRJ, SGJ (2x)	
NRB 16a	adult?		refuse pit	stretched, prone	E-W	downwards		calBC 5211–4987
NRB 16b	infans I		refuse pit	crouched, right side	E-W	N		calBC 5219–4997
NRB 16c	infans I		refuse pit					
NRB 17	infans I		grave pit?	crouched, right side	SE-NW	N	P	calBC 5217–5007
NRB 18	juvenil		grave pit?				AB, P	calBC 5215–5018
NRB 19	juvenil	female?	grave pit?	crouched, supine	NE-SW		AB, HT, P, S, SGJ	
NRB 20	infans I		grave pit?	crouched, right side	W-E	S	AB, ATJ, FT, SGJ	
NRB 21			?					
NRB 22	infans II		grave pit?	crouched, left side	NW-SE	NE	-	calBC 5291–5053
NRB 23	infans I		grave pit?	crouched, left side	NW-SE	NE		
NRB 24	adult	female?	grave pit?	crouched, prone	W-E	downwards	QS	
NRB 25	adult?		grave pit?	crouched, left side	NW-SE	NE?	AB	calBC 5298–5062
NRB 26	adult or older		refuse pit	crouched, right side	NE-SW	SW		calBC 4999–4841

Tab. 1. Overview of settlement burials from Niederröblingen (abbreviations for grave goods:* AB *animal bone;* ABJ *animal bone jewellery;* ATJ *animal tooth jewellery;* CRJ Columbella rustica *jewellery;* FT *flint tool;* HT *horn tool;* P *pottery vessels;* QS *quernstone;* R *red ochre fragment;* S *shell;* SGJ Spondylus Gaederopus *jewellery).

tinuous stylistic development of the chronologically highly variable pottery decoration. Furthermore, no evidence of a spatial shift of the settled area over time was discernible, which could have led to the accidental construction of houses in the plot of an earlier cemetery. Lastly, the dispersal of the burials is too random and not at all like to the usually structured appearance of contemporaneous graveyards. It is thus highly likely that the burials in Niederröblingen were deliberately placed within the context of a continuously inhabited settlement.

Settlement burials in Niederröblingen in the context of contemporaneous burial rites

Hereinafter, the attributes of the burials documented in Niederröblingen will be discussed and subsequently contextualized within the framework of contemporaneous burial rites, both in other settlements and on graveyards. Apart from general observations of differences relating to the burial location, the two cemeteries of Sondershausen and Bruchstedt, which are located about 30km and 45km southwest of Niederröblingen, respectively, were used for a more case-specific comparison, due to their relative proximity to Niederröblingen.

Burial location and grave construction

Niederröblingen

Approximately one third of the documented inhumations were deposited in refuse pits, while the remaining features might very well have been deliberately constructed as grave pits, since they were devoid of waste and their dimensions roughly corresponded to those of the skeletons. While no indications of wooden or lithic constructions within the graves could be documented, a young child's burial (NRB 20) was surrounded by a narrow circular ditch with an outside diameter of almost three metres and an opening in the northwestern section (Fig. 3). While the exact function of this structure could not be determined, its uniqueness sets the grave construction apart from the remainder of local burials.

Comparison

The vast majority of documented *Linearbandkeramik* burials consisted of individuals deposited in simple flat graves (*Veit 2008.45*). Among those found within the settlements, inhumations in refuse pits, trenches, or other pre-existing structures were clearly predominant (*Trautmann 2006.63*). Niederröblingen seems to be an exception as far as the relatively

low proportion of interments in settlement pits is concerned. As a rule, grave pits within settlements seem to have been constructed more shallowly than those in the cemeteries, a fact which could be observed in the Lower Bavarian site of Stephansposching, where both settlement burials and an extensive contemporaneous cemetery were documented (*Pechtl*, *Hofmann 2013.12*). Usually, there are no clear indications of additional receptacles serving as sarcophagi within the pits, neither on the cemeteries nor within the settlements (*Siemoneit 1997.146; Veit 1996.94*). The burial NRB 20 documented in Niederröblingen seems to be an exception in this respect, which is all the more unusual as the appearance of the circular ditch seems to suggest the former existence of a mound atop the grave, which is almost unheard of in the context of the early Central European Neolithic. A comparison can be drawn to the Ukrainian site of Nezvis'ko, where a richly furnished inhumation within a settlement showed traces of a grave architecture that was significantly more complex than usually is the case in *Linearbandkeramik* burials (*Dębiec 2016*). The Nezvis'ko grave is interpreted as the burial of a person with a high social status (*Dębiec 2016.243*).

Fig. 3. Niederröblingen infans I Burial NRB 20. © Landesamt für Denkmalpflege und Archäologie Sachsen-Anhalt.

In total, about a tenth of all *Linearbandkeramik* settlement burials were discovered in the longitudinal pits accompanying the houses, which can be found in the majority of contemporaneous sites (*Trautmann 2006.63*). These characteristic features were likely dug to obtain clay for the construction of the exterior walls of the houses and subsequently used as refuse pits. In Niederröblingen the situation was quite different and only dislocated human remains could be documented within these structures. Furthermore, the circumstances in these cases seem to suggest a mere disposal rather than a proper secondary burial. Interments with a recognizable spatial relationship to contemporaneous buildings are exceedingly rare (*Trautmann 2006.63*). In particular, individuals that have been found within houses seemed to either be victims of accidents, (*e.g.,* in case of a fire during which the surrounding structure was destroyed) or more often than not the result of subsequent superpositions of features.

Anthropological data

Niederröblingen

The anthropological data from Niederröblingen did not allow for a single certain determination of the sex of any of the skeletons. Instead, a clear assessment of the age group was possible in most cases, and 25 of the individuals could roughly be classified as adults, adolescents, or children (Fig. 4).[3] It is notable that non-adults (*i.e. infans* and *juvenis*) were featured in relatively high numbers, as their relation to adults was almost 2:1 (*Stolle 2021.8*).

Comparison

The age of the skeletons in Niederröblingen largely reflects the conditions within other *Linearbandkeramik* settlements, as both children and adolescents were usually represented in significantly higher numbers when compared to adults (*Hedges* et al. *2013.373; Pechtl*, *Hofmann 2013.129; Peter-Röcher 1997.62; Scott 1999.98; Siemoneit 1997.105*). Conversely, on contemporaneous burial grounds chil-

3 Age groups: *neonatus:* up to 0.5 years, *infans* I: 0.5–6 years, *infans* II: 7–14, *juvenis*: 15–20, adult: 21–40, *matur*: 41–60, *senil:* older than 60.

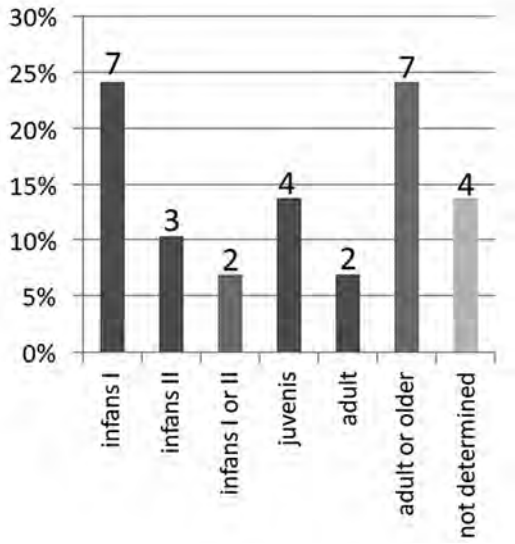

Fig. 4. Age distribution of burials in Niederröblingen: black – certain determination; grey – uncertain determination.

dren only made up around 20 to 30% of interments, with younger children up to the age of seven generally occurring significantly more rarely than older ones (*Bickle*, *Fibiger 2014.216; Orschiedt 1998.69; Siemoneit 1997.17*). The varying age distributions are evident in the Central German cemeteries of Sondershausen and Bruchstedt (*Kahlke 2004.49, 105*) (Fig. 5). Differing opinions exist as to whether the children's burials from settlements compensate for the shortage in cemeteries to the extent that the actual mortality rates are reflected (*Pechtl*, *Hofmann 2013.133; Peter-Röcher 1997.65*), but there is a consensus that newborns and children under the age of one were generally strongly underrepresented (*Pechtl*, *Hofmann 2013.131; Kahlke 2004.106; Peter-Röcher 1997.63*). This observation could be confirmed in Niederröblingen, where no infants were documented at all. It would be conceivable, for example, that a completely different treatment took place for members of this age group, the traces of which are simply no longer tangible by archaeological means (*Wilhelm-Schramm 2009.134*).

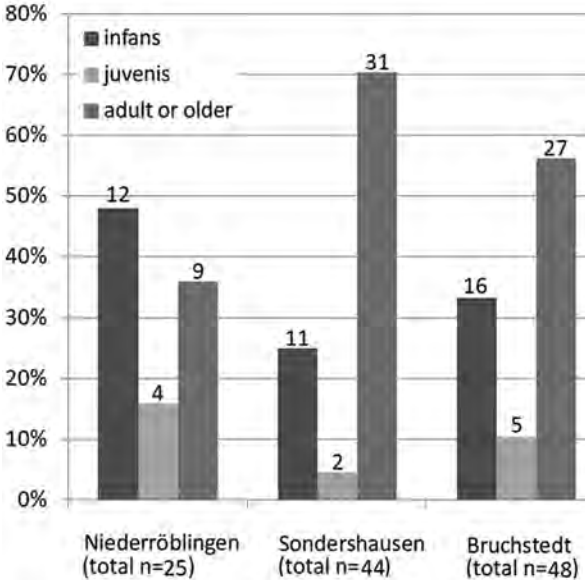

Fig. 5. Age groups in Niederröblingen compared to the cemeteries of Sondershausen and Bruchstedt – only clearly determinable age groups are considered.

Information on the sex of the skeletons tends to be scarcer as a rule. However, current data indicate that there was a roughly balanced relationship between the burials of men and women in both settlements and graveyards [4] (*Hedges* et al. *2013.373*).

Form of burial, skeletal position and orientation

Niederröblingen

With 24 of the 29 individuals, more than 80% were deposited as single inhumations, while two cases of multiple inhumations of adults and children within a single pit were documented. NRB 16 contained one adult and two small children, all of indeterminate sex, while NRB 13 contained one adult skeleton, likely female, and one small child. Nearly all the skeletons in Niederröblingen were deposited as primary burials, as can be determined by the fact that their bones were mostly still positioned within their anatomical context. However, the presence of isolated and dislocated human skeletal remains in at least ten contemporaneous refuse pits could possibly indicate the parallel existence of multi-stage burial rituals (*Stolle 2021.8–9*). In at least two cases the skeletons were found in almost their entirety, if completely dislocated, which could very well be the result of secondary burial processes. The determination of the other isolated remains is less straightforward. Due to their placement in refuse pits and the lack of any objects that could positively be identified as grave goods, these could very well be the result of an incidental disposal of bone remains, for example in the case of an accidental destruction of earlier graves during a subsequent construction process.

4 This new data contradicts earlier studies suggesting a predominance of female skeletons within the settlements (*cf. Peter Röcher 1997.62; Scott 1999.98; Siemoneit 1997.109*).

Among the 21 interments for which the arrangement of the body could be determined, crouched skeletons on their left side slightly dominated the picture, directly followed by those crouched on the right side and skeletons in a stretched prone position (Fig. 6). Two individuals were buried in a crouched supine position with their legs to the left. A single skeleton was interred in an unusual crouched prone position. Altogether, the variations were rather pronounced, with no clear preference for a single skeletal position (*Stolle 2021.9*).

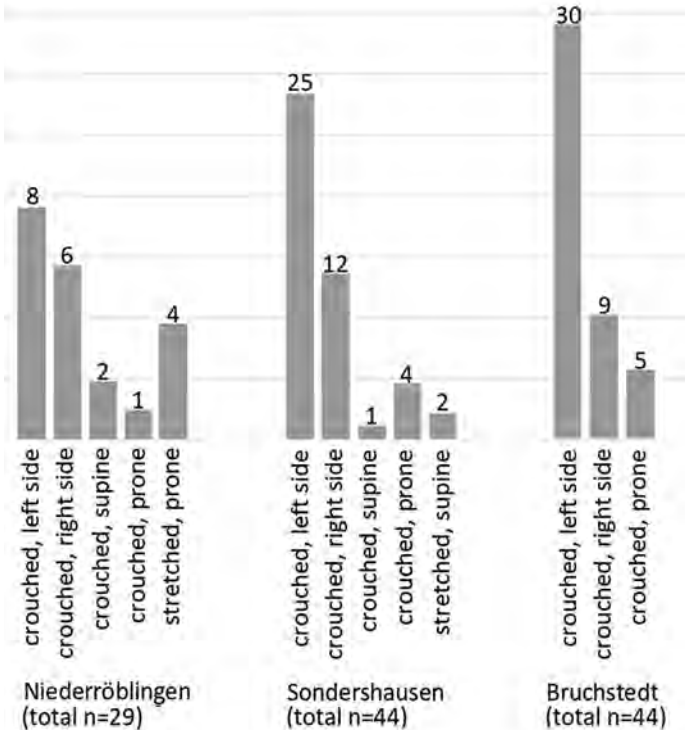

Fig. 6. Skeletal positions in Niederröblingen compared to the cemeteries of Sondershausen and Bruchstedt.

Among the 24 individuals for which an orientation could be determined, the majority were placed with their head pointing northeast, directly followed by northwest and east (Fig. 7). West, southwest and southeast were represented with two burials each, while only one skeleton was oriented towards S-N. Similar to the skeletal positions, there seemed to be no single preferred orientation of the dead in Niederröblingen. Instead, 13 (54.2%) skeletons were found with heads roughly pointed to the east (with deviations to the northeast and southeast), and 11 (46.8%) were roughly oriented toward the west. Burials of children showed a higher variation compared to those of adults with respect to the orientation, while the crouched position on the left was more predominant among children than adults, whose posture varied more locally (*Stolle 2021.9*).

Comparison

As in Niederröblingen, the majority of contemporaneous settlement burials consisted of individual interments. Nevertheless, multiple burials tended to occur more frequently within the settlements than in cemeteries (*Hofmann*, *Bickle 2011.188*). It is noticeable that most of these cases involved either the mutual burial of children and adults or, to a lesser extent, joint interments of children (*Bickle*, *Fibiger 2014.216; Siemoneit 1997.96*). The former was also the case for both graves containing multiple individuals in Niederröblingen. In general, an actually simultaneous interment is nearly impossible to determine, and thus subsequent burials cannot be ruled out. The fact that both complete and dislocated skeletons occurred in some multiple burials (*Pechtl*, *Hofmann 2013.126*), such as in NRB 16 in Niederröblingen, seems at least to indicate multiple-phase burials. One possible scenario would be the subsequent reburial of an individual after the death of one of their relatives.

The complete absence of cremation burials in Niederröblingen is hardly surprising, as, to date, no con-

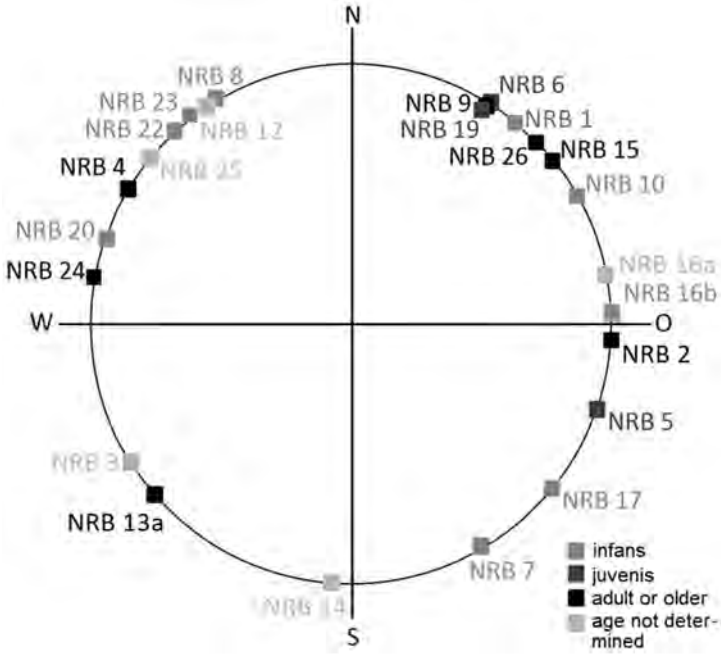

Fig. 7. Exact skeletal orientation in Niederröblingen, direction of the head.

firmed traces of comparable burial rites are known from any *Linearbandkeramik* settlements (*Pechtl*, *Hofmann 2013.129; Trautmann 2006.64*). Among the inhumations, the left-sided crouched position prevailed both in settlements and cemeteries (*Meyer* et al. *2013.111; Wilhelm-Schramm 2009.127*). Nevertheless, settlement burials tended to feature a higher number of deviating postures (*Pechtl*, *Hofmann 2013.133; Veit 1996.183*), which at least in some cases may be due to the fact that the position of the bodies was determined by the size and shape of pre-existing pits. On the whole, the right-sided crouched position was more common within settlements than on burial grounds, as were skeletons in a stretched or crouched supine position as well as prone burials (*Hedges* et al. *2013.374*). On the cemetery of Sondershausen more than half of the dead were deposited in a left-sided crouched position, while in Bruchstedt almost three quarters of the inhumations were found in this posture amounted, attesting to the stronger representation of this position in burial grounds (*Kahlke 2004. 52, 108; Peschel 1992.236*) (Fig. 6). Conversely, the fact that only about two-fifths of the skeletons in Niederröblingen were arranged in a left-sided crouched posture corresponds to the generally only slight predominance of this posture within the settlements.

Contrary to subsequent Neolithic cultures in Europe, like the Bell beaker or Corded ware culture, no regular sexual dimorphism in either the position or alignment of the dead is known from the *Linearbandkeramik*. The rather inconsistent alignment of the skeletons in Niederröblingen is also reflected in the overall data of *Linearbandkeramik* settlement burials. The variance within the settlements was again significantly higher than it was in contemporaneous cemeteries (*Pechtl*, *Hofmann 2013.124*), where a general orientation to the east was usually predominant. In Sondershausen and Bruchstedt, the vast majority of skeletons were aligned with the head pointing northeast (Fig. 8) (*Kahlke 2004.52, 108*). By contrast, within the settlements preferences seemed to vary regionally or even locally, while the preponderance of a certain direction was usually much less distinct (*Hedges* et al. *2013.374*).

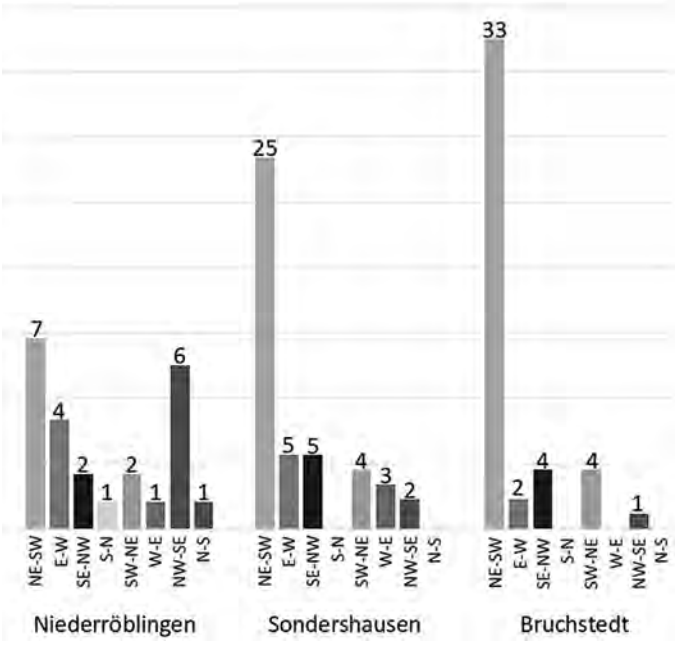

Fig. 8. Skeletal orientation in Niederröblingen compared to the cemeteries of Sondershausen and Bruchstedt.

Grave goods

Niederröblingen

A total of 14 of the 29 (48.3%) documented burials in Niederröblingen contained grave goods (Fig. 9). Four burials were clearly void of artefacts, while the remaining 11 skeletons were deposited in refuse pits, for which reason the objects found with the dead could not be positively identified as grave goods. Pottery vessels were most commonly found within the graves, having been found with 57% (n=8) of burials containing grave goods. Two graves were equipped with a cup (NRB 2, NRB 3) and a round-bottomed jar (a so-called *Kumpf*) (NRB 8, NRB 17), respectively, whereas NRB 8 also contained a bottle with eyelets, and thus was the only local burial containing two different vessels. All of the above were decorated in the characteristic *Linearbandkeramik* style. Second in number were animal bones – most likely the remains of pieces of meat – as well as ornaments made from *Spondylus gaederopus* shells, which were found in four graves (29%). NRB 1 contained an extensive ensemble of *Columbella rustica* shells, NRB 7 three polished tubular bones of a larger waterfowl, and NRB 20 five pieces of jewellery fashioned from pierced dog teeth. In most cases, the grave goods were placed close to the head, slightly less often in the pelvic area. Distinct differences in the furnishing of child and adult burials could not be determined (*Stolle 2021.9–11*).

Among the children and adolescents, exactly half of the interments (n=8) were supplied with clearly identifiable grave goods, while among the adults the percentage of furnished

graves was about 44% (n=4). Regarding the quantity and exclusivity of the objects, no clear connection to the age and sex of the dead could be determined. Instead, a seemingly outstanding treatment of certain individuals seems to have existed. An example of this would be the *infans I* burial NRB 20, which was surrounded by a circular ditch and which, in addition to animal bones, contained two flint blades and five disc beads furnished from *Spondylus gaederopus* shells, which were otherwise rarely found in the settlement. Furthermore, it contained a locally unique necklace fashioned from pierced dog teeth (*Stolle 2021.10*). In addition to the unusual construction of the grave pit, the amount and quality of burial goods seems to suggest a special importance was assigned to this individual, which is all the more astonishing considering the young age of the skeleton.

Comparison

While about 65% of all *Linearbandkeramik* burials were equipped with grave goods (*Bickle* et al. *2011.1245*), the percentage in cemeteries (70%) was significantly higher than in settlement burials, where only about half of the graves contained burial goods (*Hedges* et al. *2013.374*). The numbers of furnished graves in Bruchstedt and Sondershausen reflect this trend, with a percentage of 61% in the former and 80% in the latter graveyard (*Kahlke 2004.60, 111*) (Fig. 9). However, ascertaining the exact numbers within the settlements is complicated by the sometimes unclear determination of actual grave goods, as opposed to rubbish in refuse pits. Pottery vessels generally dominated, as was usually the case in Neolithic burials, and were found in approximately half of the burials containing grave goods both within settlements and cemeteries (*Hedges* et al. *2013.374*).

Most of the other grave goods documented in Niederröblingen were representative as well, as almost all of them served as staples in the general ensemble of contemporaneous settlement burials. In particular, jewellery made from *Spondylus gaederopus* shells was placed in graves comparatively often in southern Saxony-Anhalt and northern Thuringia (*Küßner 2014.51*), so their occurrence in four of the burials from Niederröblingen is not exceptional. More striking seems the complete absence of adzes and other polished stone tools, as well as the fact that flint artefacts only occurred in two graves. Both categories of objects, however, were generally found less often within settlements than in contemporaneous cemeteries (*Hedges* et al. *2013.374*).

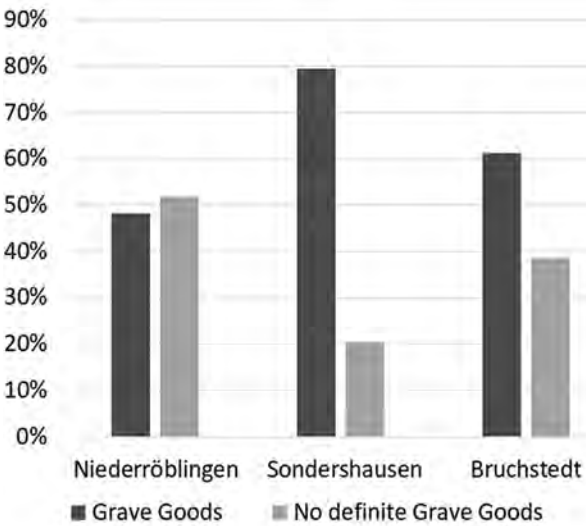

Fig. 9. Percentage of grave goods in Niederröblingen compared to the cemeteries of Sondershausen and Bruchstedt.

As a rule, it is exceedingly difficult to assess the importance of certain grave goods, especially since their symbolic value could either be connected to immaterial local traditions, to personal or ancestral significance, or otherwise be distinguished from the more clearly identifiable material value. Still, in some cases singular grave goods of a clear supra-regional importance could be recorded in Niederröblingen. One of these would be the assemblage of beads made from the shells of *Columbella rustica*, which only occurs in the Mediterranean Sea and Atlantic Ocean, therefore serving as evidence for the existence of established long-distance trade networks. Comparable objects made from this type of snail-shell are known from *Linearbandkeramik* sites in France, Switzerland and Southwestern Germany. Still, the burial from Niederröblingen is so far the only known case of such artefacts from Central Germany (*Clasen*, *Müller 2011.214*). The canine teeth serving as grave goods for the small child burial from NRB 20 are as of today almost unparalleled. A similar group of objects could be documented in the contemporaneous Slovakian cemetery at Nitra, where an adult male was equipped with the remains of a chain featuring pendants made from human and canine or vulpine teeth (*Pavúk 1972.11*). As a rule, jewellery made from animal teeth only regularly appears in the Central European Middle Neolithic (*Fehlmann 2008.186*). Even from an intra-site perspective, the child burial in NRB 20 shows signs of a higher-than-usual expenditure, as far as grave goods and construction are concerned, which opens up the question of the potential social importance of the individual within its group.

Within settlements, about half of both male and female burials were usually equipped with objects (*Hedges* et al. *2013.374*). Considering the frequency of grave goods within *Linearbandkeramik* child burials in general, which tallies at about 69% in cemeteries and 51% within settlements (*Bickle*, *Fibiger 2014.216, Tab. 2*), it is evident that the numbers correspond almost exactly to the general frequency across all age groups, meaning that children were allotted grave goods about as often as adults. The major exception would be infant burials, whose graves less frequently, yet still in about half of the cases, contained objects. That notwithstanding, it seems somewhat unusual that all graves containing locally exclusive burial goods belong to children (NRB 1, NRB 7, NRB 20). Still, examples of child burials equipped with rare grave goods are not unheard of, and comparable cases are known from other contemporaneous sites (*Siemoneit 1997.145*). One of these was recorded in the French site of Rixheim, Dep. Haut-Rhin, where a child of about 10 years of age was equipped with a necklace consisting of marble beads, otherwise rarely found in *Linearbandkeramik* sites (*Storch 1984.48*).

On the concept of regularity among *Linearbandkeramik* burials

The decidedly vague concept of 'irregular burials' (Germ. *Sonderbestattungen*), which for a long time was used to gauge the social implications of certain interments perceived to be unusual, has been rightfully criticized in more recent studies (*cf. Hofmann 2009.220; Pechtl*, *Hofmann 2013.123* et pass.*; Müller-Scheeßel 2011.6f; Wilhelm-Schramm 2009. 128*). Despite the fact that there are plenty of documented *Linearbandkeramik* graves, the extent of information about the contemporaneous interment practices is still somewhat too sparse to allow a determination of clear cultural rules and by extension a dichotomous classification into 'regular' and 'irregular' burials. Recent findings suggest that such a categorization is certainly not practicable with regard to burials within settlements, as opposed to those in cemeteries. The initially strong quantitative imbalance between these two categories has successively shifted to a more even distribution over the years. At the same time, there are areas from which hardly any cemeteries are known, while most information on funerary rites stems from settlement burials, as is the case in Poland (*Czekaj-Zastawny 2021*).

In general, reconstructions of the *Linearbandkeramik* population size suggest that only a small percentage of the contemporaneous populace might be represented in all extant burials (*Peter-Röcher 1997.60; Veit 2008.46*). According to the most recent calculations, it is presumed that only about two fifths, possibly even only around one fifth of the totality of *Linearbandkeramik* people can be archaeologically accounted for through burials (*Pechtl*, *Hofmann 2013.132*). Conceivably, cremations were carried out far more frequently than the findings seem to suggest, as they are inherently harder to determine. Natural and man-made erosion could have furthermore lowered their number, due to the fact that pits for cremation burials were usually dug significantly shallower than those for inhumations (*Trautmann 2006.39*).

A designation as an 'irregular' burial would suggest the complete absence of certifiable rules and regularities, which was hardly the case, neither within the examined settlements nor within the culture in general. For instance, in Niederröblingen even individuals deposited in a prone position, which occasionally is interpreted as an indication of irreverence towards the buried individual, were sometimes equipped with grave goods, as can be seen in the local graves NRB 3 and NRB 24. As a matter of fact, in almost all interments in Niederröblingen at least some characteristic elements of the *Linearbandkeramik* burial customs were observed. Instead of a clear-cut antithesis to cemetery graves, the local burials seem instead to form part of a nuanced ritual structure, corresponding to the concept of *"diversity in uniformity"* first suggested by Pieter J. Modderman, which can be frequently observed in various areas of *Linearbandkeramik* life and alludes to the possibility of regional or individual variation within a nonetheless mostly uniform cultural framework (*Modderman 1988.63*).

The majority of interments, which used to be treated as special cases, set apart from the established standard burial, would therefore more likely represent *"extreme points within a continuum"* [5] (*Müller-Scheeßel 2013.7*) of burial customs. Thus, interments within settlements presumably also formed an integral, if somewhat differential, component of contemporaneous grave rituals. The widely documented supra-regional similarities of settlement burials nonetheless suggest a common motivation behind the choice of location, the nature of which shall be discussed in the following section.

5 Germ. "*Extremata in einem Kontinuum*".

To systematically approach these issues, one has to ponder what exactly was to be achieved by a proper burial and who was the main beneficiary of abiding by certain social rules. Was the process mainly supposed to ease the deceased's transition into the afterlife? Was it primarily a device for the living to remember their loved ones by, or was it meant to reinforce the cultural values of the remaining group? As often is the case, the answer might lie somewhere in between, although different aspects seem to have been stressed with different parts of the treatment.

Despite the overlying similarities alluded to above, it is impossible to determine a single, appropriate set of burial customs for the *Linearbandkeramik*, as with every interment, various factors like age, sex, social gender, an individual's position within the community and their manner of death might have influenced the precise burial practices. Recent isotope analyses even shown that a person's area of origin might have affected their treatment in death (*Hofmann 2016.239; Hedges* et al. *2013.367–369*). Therefore, a single cause for an internment within the settlement cannot be determined, as the respective cultural context within the group potentially always influenced the decision. Even within a single community, different reasons and motivations are likely to have affected the burial customs (*Veit 2016.37*). Still, the unlikelihood of a dichotomous scenario of regularity and an antithetical irregularity does not mean that one cannot and should not try to understand what affected the burial location, as certain patterns can often still be observed, the examination of which permits us to at least infer some of these motivations.

Interpretation of *Linearbandkeramik* settlement burials. What do the structural differences tell us about the settlement burials?

While it can be assumed that grief and emotion have always formed a universal part of basic human behaviour (*Tarlow 2012*), it is very likely that coping mechanisms have taken on varying forms in different sociocultural contexts, for example when being regulated by collective requirements of the respective group (*Veit 2013.12*) or influenced by learned emotional responses dependent on the cultural context, as is believed by scholars following a constructivist approach (*Tarlow 2012.170–172*). Considering the fact that the *Linearbandkeramik* was geographically and chronologically extremely widespread, it is therefore likely that a number of temporal, regional and even local peculiarities developed in the burial rites as in many other aspects of the culture (*Modderman 1988.63*). Consequently, over the years some authors have voiced justified criticism of the assumed premise of a uniform burial custom for the entire culture (*cf. Hofmann*, *Bickle 2011.185*). Surprisingly, however, even with settlement burials certain cultural norms and burial practices were often adhered to, as has been outlined above.

Considering the existence of designated cemeteries, which certainly represented a product of community efforts, these same recurring elements contradict the assumption of complete individualism in the choice of the burial place and indicate a community-coordinated selection of individuals interred within the settlements. The fact that the heterogeneity in appearance is nevertheless more pronounced in comparison to the cemetery burials indicates that the reaction of a living community to the death of one of its members still was by no means rigidly standardized, but instead apparently determined by a combination of numerous factors based on which the decision about the most appropriate form of burial practice was made (*Pechtl*, *Hofmann 2013.133; Veit 1996.211; 2013.19*). The occasional assumption that this diversity in characteristics precludes the status of the individual within the group as an influence on the burial customs (*cf. Hofmann 2009.222–223*) cannot be agreed with, at least not completely. Slight, yet recurring, differences in the material evidence suggest that burials in cemeteries tended to be carried out with greater care when compared to those in settlements. The comparison of Niederröblingen with contemporaneous cemetery burials revealed that individual characteristics of the treatment of the deceased, in particular the posture and orientation, showed a generally greater variance within the settlements. The same is true for other contemporaneous sites (*Kahlke 1962.110; Peschel 1992.236*). This might be due to the fact that in many cases pre-existing settlement pits were reused for the burial, and the dead were placed according to the shape and alignment of these.

A lower average frequency and amount of grave goods, which could often be observed in settlement burials, was also reflected in Niederröblingen. The most regularly documented objects were meat and pottery vessels, the procurement of which would have required comparatively little effort. Conversely, graves equipped with jewellery were only be recorded in a few cases. Furthermore, in sites in which the occupation layer was preserved, a generally lower depth of designated burial pits could be observed

compared to those in cemeteries (*Pechtl*, *Hofmann 2013.128*). Double and triple burials, the increased occurrence of which was usually also characteristic of inhumations within settlements, could be documented in at least two cases in Niederröblingen. Along with the occasional deposit of complete skeletons and isolated human bones in supposedly pre-existent settlement pits, it seems that for many of the burials in Niederröblingen and other *Linearbandkeramik* settlements less effort was expended than for the majority of contemporaneous burials in cemeteries.

However, as at least some of the burial customs represented on the cemeteries were often observed within the settlements, there is no evidence of a deliberate disparagement of the dead. Instead, the generally lower expenditure seems to be the result of a somewhat heightened indifference towards at least some individuals buried inside the settlements, corresponding to a 'ritual economy' that is often observed in this context (*Kraus 2006.15; Veit 1996.205; 2008.49*). Conversely, access to the cemeteries seems to have been concomitant with a higher degree of consistency in the burial customs. The social and emotional esteem for the deceased would therefore be directly reflected in the expense invested in the burial (*Bickle* et al. *2011.1254; Meyer* et al. *2011.115*).

Who was buried in the settlements?

Given the above, one has to wonder which individuals were treated in a manner different from the majority of the deceased. This in turn raises the question as to whether LBK burials were primarily orchestrated to facilitate the deceased's passage to the afterlife, or if they were of primary importance to the remaining group members, by either mediating their emotions (*Williams 2007.109–111; Nyberg 2010.30–31*) or reinforcing their cultural identity by following a set of predefined and well-established rules, basically serving as a ritual of cultural memory following the concept of Aleida and Jan Assmann (*Assmann 1988.12–16*).

It is highly likely that the burial served multiple functions, and even if it was not consciously organized with the group identity in mind, the latter would have been automatically reinforced by following existing patterns of propriety in the treatment of the dead, serving as an example of institutionalized communication (*Assmann 1988.12*). Nevertheless, within a given collective framework of cultural rules, the possibility to carry out the specifics of the burial situationally might also have existed, which would account for the existing variation of burial rites outlined above. In these cases breaking, ignoring or subverting existing rules might have been acceptable, as the deceased were not considered part of the group. Thus, the ritual economy observed in many settlement burials might directly reflect esteem for the individual, while still upholding collective traditions.

In the course of comparative ethnographic studies, a differential burial of individuals who had either already assumed a socially marginalized position during their lives or had died in a way perceived as unnatural could often be observed (*Veit 2013.19*). In a segmentary society, the position within the group would probably have been defined by the part an individual played for the continued existence and further development of the community, for example by providing a specialized technical skill-set or holding a position of ritual or religious importance (*Meyer-Orlac 1997.3*). A more deterministic connection between social status and factors like age, gender, geographic origin and physical or mental health is also conceivable (*Häusler 1996.61; Meyer-Orlac 1997.3; Orschiedt 1998.35; Veit 1996.202*), especially since these factors could very well have influenced the ability of the individual to economically support the group. In this context, the comparatively low age of most individuals from Niederröblingen and other *Linearbandkeramik* settlements could be ascribed to the fact that children were unable to make a significant contribution to the continued existence of the community (*Orschiedt 1998.37; Scott 1999.98*).

At the same time, it is also very likely that children, especially young ones, were simply not considered full members of the group (*Brather 2014.19; Veit 1996.204*), as they had not reached a certain level of mental or physical development or had not yet completed any necessary rites of passage. Both scenarios would explain the increased numbers of younger children recorded in Niederröblingen and other contemporaneous settlements, without contradicting the occasional occurrence of (mostly older) children in cemeteries. The age distribution clearly suggests that the likelihood of interment in a cemetery increased with age (*Hedges 2013.374*). Unusual causes or circumstances of death may also have precluded a burial with the majority of the group (*Schwidetzky 1965.231*), and furthermore could have led to an anomalous treatment of the individuals, like prone burials or extreme crouched positions suggesting an initial binding of the body, which were observed

to a heightened degree within settlements. These could have served as apotropaic measures meant to prevent the return of the dead (*Aspöck 2008.21; Tsaliki 2008.3, Tab. 1.2.*). The possibility that children who suffered a perinatal death (*Scott 1999.98; Veit 2013.12*), or individuals who died from infectious diseases (*Schwidetzky 1965.231*) might have been regarded as victims of 'unnatural' deaths would also explain the virtual absence of younger children in cemeteries.

Consequently, the location and appearance of *Linearbandkeramik* burials, including the settlement burials of the Niederröblingen site, appear to be the result of a case-specific decision based on communal notions of appropriateness, the personal relationship of the bereaved to the deceased, and simple practical exigencies. Since the majority of settlement burials seem to have been carried out with an altogether smaller effort, it stands to reason that most of the individuals were likely considered with a higher degree of indifference than the ones buried in cemeteries. Individual cases of a more careful treatment at the investigated sites are almost exclusively limited to children, whose perceived deviance from the social norm would not have been a result of their actions but could rather be ascribed to the fact that they were not yet considered to be a full part of the group. A careful and loving treatment by surviving family members would be appropriate in these cases. Additionally, the likelihood of a surviving family member supervising the burial process would be higher for children than for adults. Outside the closer circle of relatives, a higher level of indifference towards an individual could be expected. Adults, on the other hand, might have been considered responsible for their position within or outside the community, and thus treated in a way that might have directly reflected their esteem in life, which was likely a low one. Social deviancy could have been dealt with in various ways, but burial location might have been one of these.

Thus, the majority of burials seem to reflect the existence of individual decisions within a pre-set framework of cultural appropriateness. Accordingly, the bereaved seem to have been given a certain amount of freedom in carrying out each individual burial, while the decision about the location of interment was likely a collective one, dependent on the prevailing cultural norms. Occasional deviations from this rule, as evidenced by burials of small children within the cemeteries, could be cases in which *"personal and affective factors trumped normative ritual"*, as has been observed in burial rituals in late Bronze-Age Transylvania (*Tarlow 2012.173*).

Conclusion and summary

Earlier in the paper, the question was raised as to whether the dead or the living were the likely main beneficiaries of a 'proper' burial. The observations outlined above seem to indicate that different aspects of the burial rites could be interpreted as the results of different concerns in that regard.

If we believe the possibility to be buried in a cemetery to have been socially regulated by the group, as the demographic evidence suggests, the location of interment would have mattered to the living to preserve a sense of propriety and a certain consistency in the symbolic composition of the group. An individual's affiliation with the community during his or her lifetime might have been represented in death through a shared interment with the other group members. Conversely, the exact burial place of individuals who had not yet passed certain rites of passage or were not considered part of the collective for different reasons would not have mattered, as long as they were buried in a place separate from the actual members of the group. This might explain the rather small percentage of children in the contemporary graveyards, a part of which is represented through inhumations inside the settlements. Nature burials, as practised in several more recent traditional societies, would also be a distinct possibility. As traces of these would be almost impossible to determine, they could account for the fact that especially infants and young children are still underrepresented, even if the numbers of burials in settlements and in cemeteries are added up. If the access to graveyards was thus socially regulated by the group, it stands to reason that the burial process of the dead allowed into the cemeteries served to reinforce the identity of the living members by following certain guidelines of propriety.

While the dead in cemeteries thus had to be treated in certain collectively acceptable ways, it seems that for settlement burials a higher degree of variation was admissible. The heterogeneity in skeletal positions and orientations could to some degree be explained by the utilization of pre-existing pits, to which the bodies had to be adjusted, while some cases seem to suggest the implementation of certain apotropaic measures. While it is not possible to determine a clear-

cut normative *Linearbandkeramik* burial template, the overall treatment of the dead indicates generally higher esteem for individuals buried in cemeteries, as opposed to those deposited within settlements.

Coming back to the question of regularity posed above, settlement burials as a possible way to deal with non-members of the group could constitute a regular interment of young, uninitiated children as well as an irregular burial of adults standing at the periphery of society, both fulfilling the same structural function in preserving the integrity of the community. Accordingly, death could have been dealt with appropriately from a societal viewpoint via the location of interment, while the bereaved would still have been entitled to deal with the specific circumstances of burial as they saw fit. This might account for the higher variation in the customs, as well as the expense invested in the burial of some individuals, especially children. Elaborately constructed graves and those that were copiously supplied with rare grave goods, like NRB 1, NRB 7 and NRB 20 from Niederröblingen, could have resulted from a strong expression of personal affection. Conversely, an explicit ritual economy could hint at a higher degree of indifference toward the buried individual, both from an individual emotional standpoint and from one of propriety as dictated by group rules. The latter could already have been regulated by choosing the burial location, which would have adequately signified the dead as beyond the sphere of the group, and therefore not necessarily subject to their burial rites.

The interments from Niederröblingen are representative of this in that, despite certain regularities in the treatment of the dead, which collectively differentiated them from cemetery burials, their increased variability reflects the omnipresent complexity of the contemporaneous ritual structure according to the oft-observed *"diversity in uniformity"* in *Linearbandkeramik* traditions. This might be the result of an intersection of public and private space during the burial process, where communal notions of proper practices met with personal expressions of grief. It goes without saying that this is just one of many possible scenarios explaining the phenomenon of *Linearbandkeramik* culture settlement burials, and future findings might help us understand the phenomenon better. Undoubtedly, this aspect of early Neolithic life still offers great potential for further analyses of agency and the possibility of individual decisions within the framework of cultural norms.

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A unique funerary and ritual complex at the border zone of the Northern and Eastern European Plains as a record of cultural and social changes at the turn of the Neolithic and Bronze Age

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ABSTRACT - *In the 3rd millennium BC, the area of the Masurian Lake District, located at the border zone of the North and Eastern European Plains, was still dominated by hunter-gatherers. It was then that the Late Neolithic farming and pastoralist communities reached the region, where cultural and social changes were initiated. Tracing these changes is possible through an analysis of the unique funerary and ritual complex on the island of Lake Łańskie. Burials of representatives of the elites of ranking communities from the Late Neolithic were found there, as well as the discontinuation of such burials in the Early Bronze Age, which has already been associated with egalitarian communities.*

KEY WORDS – *Łańskie Lake ; Neolithic; Bronze Age; funeral rituals; grave goods; social status; stratified society*

Unikatni pokopni in obredni kompleks kot zapis kulturnih in družbenih sprememb na prehodu iz neolitika v bronasto dobo na mejnem območju med Severno- in Vzhodnoevropskim nižavjem

IZVLEČEK – *V 3. tisočletju pr. n. št. so na območju Mazurskih jezer, ki se nahajajo na mejnem območju severno- in vzhodnoevropskega nižavja, še vedno prevladovali lovci in nabiralci. Takrat so poznoneolitske poljedelske in pastirske skupnosti dosegle regijo in začele so se kulturne in družbene spremembe. Spremembam je mogoče slediti s pomočjo analize unikatnega pokopnega in obrednega kompleksa na otoku na jezeru Łańskie. Najdeni so bili pokopi elit hierarhično rangiranih skupnosti iz mlajšega neolitika, opazna pa je tudi prekinitev, povezana z egalitarnimi skupnostmi v zgodnji bronasti dobi.*

KLJUČNE BESEDE – *jezero Łańskie; neolitik; bronasta doba; pogrebni običaji; pridatki v grobovih; socialni status; hierarhične družbe*

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Introduction

In the Late Neolithic, the Masurian Lake District, covering an area of approximately 13 180 km^2 in the border zone of the North and Eastern European Plains (Fig. 1; *Kondracki 2009.104*), was still dominated by hunter-gatherer communities, classified as belonging to the Neman Cultural Sphere (NCS). This cultural situation persisted despite the penetration of the area by agricultural and pastoral population groups as early as the 5th millennium BC, which intensified in the 3rd millennium BC (*Okulicz 1973; Gumiński 2001; Manasterski 2009; 2016.19,21; Manasterski* et al. *2022a*).

Initially, these were representatives of the Late Band Pottery and Funnel Beaker cultures, and although they did not form incumbent local groups engaged in cereal cultivation, they interacted with the autochthons of the Zedmar culture (ZC) and the NCS (*e.g., Gumiński 2001.133,146–151; Charnyavski 2011*). From the end of the 4th and the beginning of the 3rd millennia BC, communities of the Globular Amphora culture (GAC) and Corded Ware culture (CWC), as well as a population identified with the Bell Beaker (BB) cultural package, began to arrive in the Masurian Lake District. They contributed to the formation of the Ząbie-Szestno Group (Z-SG), a syncretic cultural unit belonging to the NCS (*Manasterski 2009; 2016.21*). This group took part in the formation of the Trzciniec Cultural Sphere (TCS) at the turn of the Neolithic and Bronze Age. Archaeological traces remain of all the aforementioned groups, which became the basis for creating a chronological and cultural picture (see Graph 1).

However, those traces of a funerary nature belong mainly to the GAC and CWC, and are mostly known from archival discoveries (Tab. 1, see bellow).

Isolated finds also come from this area. These are mainly weapon elements – stone axes, identified with

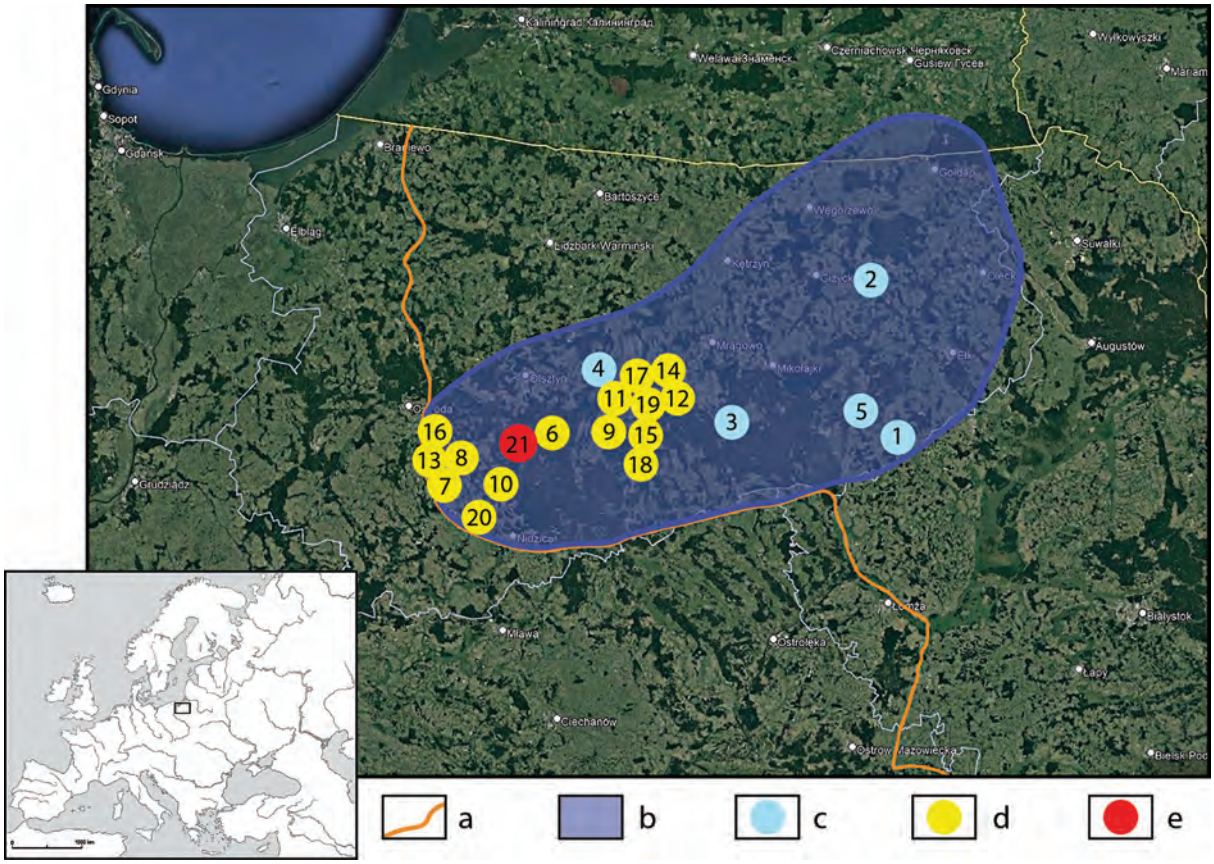
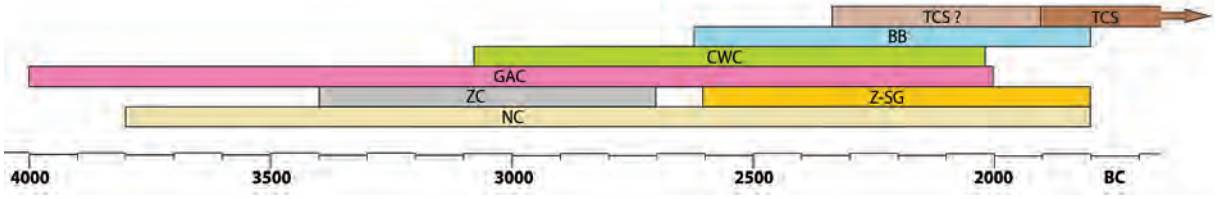


Fig. 1. Masurian Lake District in the border zone of the North and Eastern European Plains (according to* Kondracki 2009*).* a *border between the North and East European Plain;* b *range of the Masurian Lake District;* c *graves of the CWC (*1 *Danowo,* 2 *Dudka,* 3 *Koczek,* 4 *Nerwik,* 5 *Rybitwy);* d *GAC graves (*6 *Bałdy,* 7 *Dąbrówno,* 8 *Frygnowo,* 9 *Grom,* 10 *Januszkowo,* 11 *Małszewko,* 12 *Miętkie,* 13 *Naprom,* 14 *Rańsk,* 15 *Romany,* 16 *Rudno,* 17 *Szczepankowo,* 18 *Szczytno,* 19 *Trelkowo,* 20 *Wierzbowo);* e *funerary and ritual complex (*21 *Ząbie). The numbers of sites on the map correspond to the numbers of sites in Table 1.



Graph 1. Cultural situation in the Masurian Lake District in the Neolithic and Early Bronze Age (according to* Czebreszuk 1996.190; Szmyt 1996.75; Gumiński 2001.146; Józwiak 2003.71; Furholt 2003; Manasterski 2009.132; Budziszewski, Włodarczak 2010.114, 120, 121; Makarowicz 2010.34–45; Furmanek *et al.* 2015.535–537*).

the CWC, and flint daggers, associated with the BB phenomenon (*Kilian 1955.Karte 4; Januszek 2020. Fig. 71B*). Among the burials, the GAC graves recorded in the western part of the Masurian Lake District dominate in number. The CWC graves, on the other hand, are scarce and found in the central-eastern part of this lake region. Unique in the area, however, is the funerary and ritual place on the former island in Łańskie Lake, which consists of graves and funerary and ritual features (Fig. 2). It is situated within the Ząbie 10 site, in the central part of the area of the GAC grave cluster (Fig. 1). No graves belonging to this culture, however, have been recorded at the site or in its vicinity (*Manasterski 2009*). The site Ząbie 10 is located in the western part of the Masurian Lake District (Fig. 1). It covers the area of a former island in Łańskie Lake, consisting of two kame hills (Fig. 2), where the remains of human activities from the Mesolithic to modern times were discovered *(Manasterski 2009.28, 62–81, 96–99, 111–115; 2016.55–82; Waluś 2011.283, 284; Januszek 2020.84, 100, 101,103; Manasterski* et al. *2022a.Fig. 10.1–4*).

This paper considers three main research aspects of the unique funeral and ritual place found at the island in Łańskie Lake. The first is the chronological and cultural identification of the individuals buried at the site. The next is the investigation of their social status. The last demonstrates the role of the various communities represented in the cultural diffusion leading to the formation of the syncretic Ząbie-Szestno group.

Methods

For the cultural identification of the buried individuals, the types of funerary features, the completeness and arrangement of the remains and the anthropological markings of the sex and age of the deceased were taken into account (*Kałwak, Karczmarek 2000. 86*; *Manasterski* et al. *2001.146–148, 159–161; and archival, unpublished analyses*), as well as the objects accompanying the human remains. Particular attention was paid to the contents of each feature. Pottery was subjected to typological, stylistic and technological analysis based on the systematics of ceramic evidence by Aleksander Kośko (*1979.41–52*) and Janusz Czebreszuk (*1996.11–44*). For flint artefacts, a typological and technological analysis was carried out on the basis of the literature on the subject (*Migal 1987; Ginter, Kozłowski 1990.79–169; Inizan* et al. *1999; de la Peña 2015*), and the varieties of raw material were determined based on a comparative analysis the lithic collection from the Faculty of Archaeology at the University of Warsaw. The stone tools were typologically defined according to the systematics of Kośko (*1979.30–40*) and

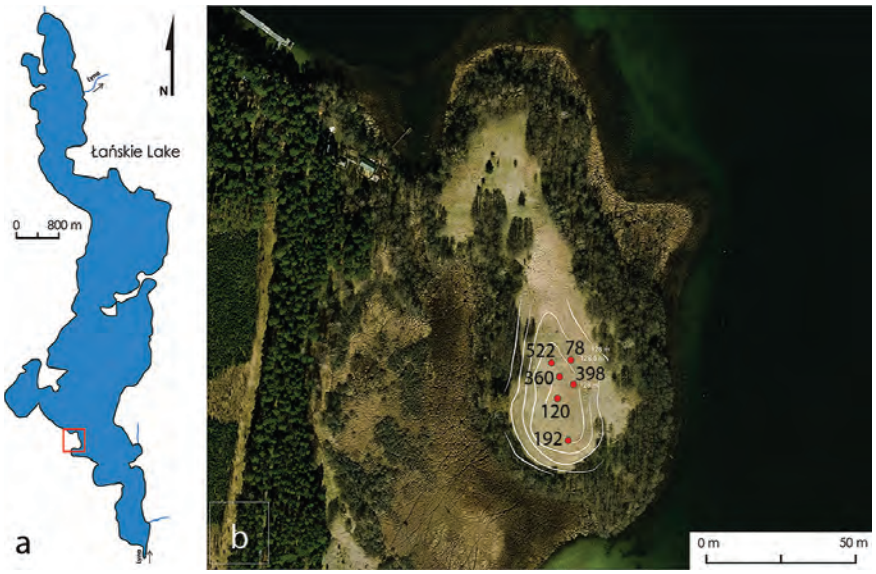


Fig. 2. Funeral and ritual complex at the site Ząbie 10 situated at the former island:* a *site location,* b *location of graves 78, 120 (120a, 120b), 360, 398 and funeral and ritual features 192 and 522.

Czebreszuk (*1996.57–60*). Due to the high value of these artefacts they were excluded from the process of making sections of the studied specimens. Only the observation of the rock surface was carried out, using a stereoscopic microscope in water immersion, according to the methodology used by Antonin Přichystal (*2009*).

The amber ornaments were identified typologically and stylistically based on the systematics of Ryszard F. Mazurowski (*1985*), Katarzyna Kwiatkowska (*1996*) and Curt Beck and Stephen Shennan (*1991*), and chemically by Fourier-transform infrared spectroscopy (FTIR spectroscopy) to identify the type of fossil resin (*Manasterski* et al*. 2022b*). The chemical composition of the metal lamella from feature 360 was analysed with an EDAX spectrometer in the laboratory of the Institute of Archaeology and Ethnology of the Polish Academy of Sciences in Warsaw. The bone ornaments were determined typologically based on the systematics of Czebreszuk (*1996.62*) and Jaroslav Peška (*2002*). Osteological determinations to identify animal species were made for both ornaments and remains from the analysed features. The osteological data come mostly from unpublished, archival analyses.

In order to establish the temporal sequence of the formation of graves and funerary ritual features, data resulting from the typological-cultural analyses (relative chronology) were juxtaposed with radiocarbon dates (absolute chronology) from particular features. The relative chronology was established on the basis of culturally diagnostic features of the burials and objects accompanying the human remains.

Based on models of society for the archaeological study of status (*Berreman 2001; Wason 2004*), a hypothesis was also presented regarding the functioning of ranked communities with emergent elites at this site.

Materials

The subject of the analysis are seven features (78, 398, 360, 120a, 120b, 192, 522) discovered at the Ząbie 10 site. They contained human skeletal remains accompanied by ecofacts and artefacts from various raw materials. The listed features were divided into two categories: graves and funerary-ritual features. The first category includes relatively large pits containing burials of the unburnt deceased. The second category consists of small pits containing a small quantity of skeletal material derived from human limbs.

Graves

Feature 78

A grave pit probably rectangular in outline with rounded corners, with an E-W alignment, partially destroyed by two Early Iron Age pits (Fig. 3.a; *Kałwak, Karczmarek 2000*).

It was dug in a layer of yellow-grey sands of glacial origin. The undisturbed part contained the upper part of a human skeleton in anatomical arrangement, but with post-depositional displacements, belonging to a male of late *juvenis*/early *adultus* age. He was laid on his left side with his face turned to the S, next to which was a post-depositionally destroyed beaker (Fig. 3.a1,b1). It was made from a ceramic paste with a significant addition of mineral admixture from crushed granite. It has a misshapen S-shaped form, deformed before firing, with a flat bottom and a rather high, flared neck and a rim bent slightly inwards. The neck of the vessel has 11 circumferential cord impressions, under which are two rows of obliquely imprinted rectangular stamps. An analogous decoration, but consisting of a single band of such stamps, was made between the rim and the last cord impression. Fragments of freshwater mussel shells from the order *Unionidae* and fish vertebrae from pike (*Esox lucius*), perch (*Perca fluviatilis*) and a fish from the carp family (*Cyprinidae*) were found in its interior and near the vessel. Four flint artefacts, made from chalky erratic materials, were discovered in the vicinity of the deceased's hands (Fig. 3.a2). Prominent among these were an end-scraper made from a flake (Fig. 3.b6), a flake made by direct percussion with a hard hammer (Fig. 3.b7), a flake made with the bipolar splintering technique which was broken at the base (Fig. 3.b8) and a chip (Fig. 3.b9). There were three pendants on the neck and chest of the deceased (Fig. 3.a3,b2–4). An analogous fourth specimen (Fig. 3.a3,b5), together with a lump of red ochre (Fig. 3.a4) and small fragments of the skull and ribs of the deceased, was found in an Early Iron Age pit that breached the grave cavity to the north. The pendants were L-shaped specimens made of deer antler, shaped to mimic the tusks of a red deer. After the deceased had been deposited, the grave cavity was backfilled with a light grey and pearly mixture of clayey sand and lacustrine chalk, which was clearly distinguishable from the yellow-grey sandy surroundings of the grave.

Feature 398

An oval grave pit, dug in a layer of yellow-grey sands of glacial origin, in which a child of *infans* I age was buried, placed in a contracted position on its left side along the E-W axis (Fig. 4.a; *Manasterski 2009.27*).

The burial contained only the postcranial skeleton. Above the pelvic bones of the deceased were two belt buckles made of deer antler (Fig. 4.a1,b1–4). Pairs of attachment perforations drilled on both sides are visible at their ends. The exterior of both artefacts is covered with a relief zigzag ornament, which runs in two rows around the perimeter and along the centre of each. The deceased's equipment also included four pendants, discovered around the neck and chest, which were made from otter and badger tusks (Fig. 4.a2,b5–8). The grave was backfilled with a light grey and pearly mixture of clayey sand and lake chalk, which contrasted with the surrounding ground.

Feature 360

A grave pit with a roughly rectangular outline, dug in a layer of yellow-grey sands of glacial origin. The upper part of the burial pit had been disturbed by Early Iron Age settlement activity. At its bottom was the almost complete skeleton of a male of *maturus* age.

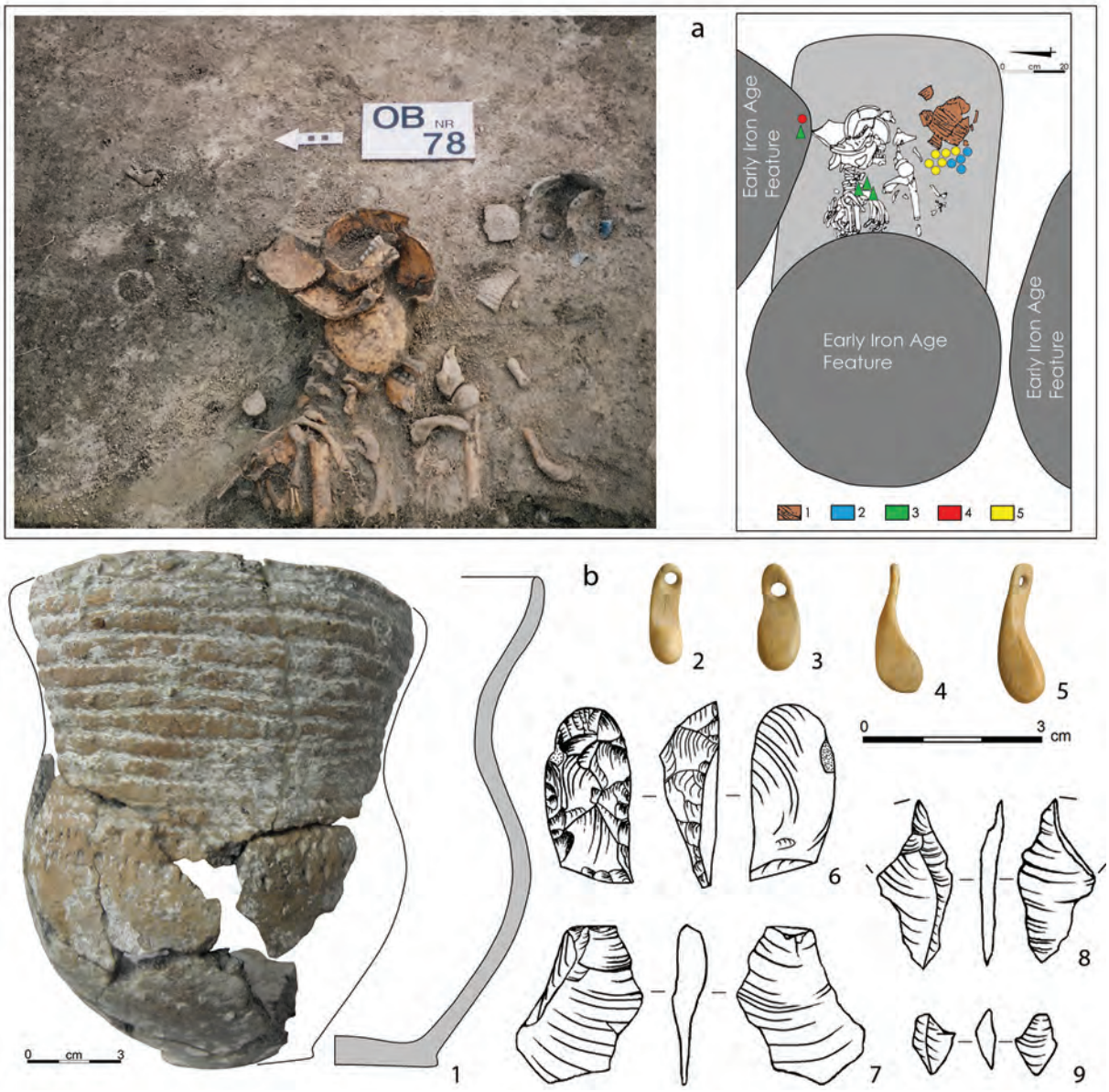


Fig. 3. Inhumation grave (feature 78):* a *plan of the burial cavity (*1 *beaker,* 2 *flint artefacts,* 3 *deer antler pendants,* 4 *ochre nugget,* 5 *fish vertebrae);* b *burial equipment (*1 *beaker,* 2–5 *deer antler pendants;* 6–9 *flint artefacts) (according to* Manasterski 2009.257; Januszek 2020.88 *– with modifications by the authors; photo by D. Dobrzyńska, D. Manasterski and M. Bogacki).

Fig. 4. Inhumation grave (feature 398):* a *plan of the grave (*1 *belt buckles,* 2 *pendants);* b *equipment of the deceased.* 1–4 *belt buckles (*1,2 *obverse and* 3,4 *reverse) from red deer antlers;* 5–7 *pendants from otter tusks;* 8 *pendant from badger tusk (photographs by M. Bogacki).

Some of the deceased's bones had been post-depositionally disturbed by burrow-digging animals (badger or fox) (Fig. 5.a).

The severely shrunken skeleton was arranged along the E-W axis. The head was at the E and was facing N (Fig. 5.A,B). Beside the clavicle of the deceased was found a completely patinated small green lamella, probably of bronze (Tab. 2; Fig. 5.b3,c6).

A quadrangular ground diabase stone axe was discovered near the hands (Fig. 5b.1,c.2). Immediately above the head was a flat bipolar-splintered piece of chalky erratic flint (Fig. 5.b2,c3), and about 20cm from the face a flint flake of similar raw material made with the bipolar splintering technique was discovered (Fig. 5.b2,c4). Meanwhile, under the foot was a distal fragment of a flake of chalky erratic flint (Fig. 5.b2,c5). Several small fragments of the same vessel were found near the pelvis of the deceased (Fig. 5.b4), and on two of them a zoned ornament was visible (Fig. 5.c1). This was formed by horizontal double incision lines separating an unornamented zone and a zone ornamented with criss-cross patterns. Near the vessel were also fragments of a freshwater mussel of the order *Unionidae* and fish vertebrae of sea trout (*Salmo trutta*) and pike (*Esox lucius*). The grave cavity backfill, which was grey-brown in colour, contained a significant amount of lake chalk lumps of various sizes.

Cu	Mg	Al	Si	P	Pb	Sn	Ca	Fe	Ni	Zn
36.33	0.11	0.48	1.95	6.21	0.86	51.13	1.06	1.18	0.37	0.31

Tab. 2. Chemical composition of the lamella (patina) from feature 360.

Feature 120

These are actually two separate burial pits, located one above the other (Fig. 6). The upper grave has been numbered 120a and the lower grave 120b.

Feature 120a

An oval grave pit, with its longer axis oriented along an E-W line, the upper part of which had been disturbed by Early Iron Age settlement activity. The central part of the burial pit contained the incomplete remains of two individuals, a female *adultus* and a male *juvenis* (Fig. 7.a).

These comprised the two skulls lacking mandibles, facing east, and the long bones. The fill of the grave cavity also contained bone fragments of animals (Fig. 7.a3), such as a pig (*Sus scrofa f. domestica*), cattle (*Bos primigenius f. taurus*), sheep/goat (*Ovis orientalis f. aries/Capra aegagrus f. hircus*), horse (*Equus ferus*), roe deer (*Capreolus capreolus*), beaver (*Castor fiber*), turtle (*Emys orbicularis*), freshwater mussel of the order *Unionidae* and a species-unspecified bird (*Taberska 2001*), as well as fish vertebrae of pike (*Esox lucius*), pikeperch (*Sander lucioperca*) and fish of the carp family (*Cyprinidae*). In addition to this, pottery fragments from three dif-

ferent vessels were also discovered (Fig. 7.a1,b1–3). These were made of ceramic paste with mineral admixture from crushed granite with a small quantity of river sand. One of these was an S-shaped pot with a circumferential moulding (Fig. 7.b1). The others are from a further two vessels differing in the thickness of the walls and the manner of the ornamentation (Fig. 7.b2,3). Flint artefacts made from chalk erratic raw material were also found in the grave (Fig. 7.a2,b4–18). These include: two single-platform blade cores, reduced with a hard hammer (Fig. 7.b5–6), two blades from single-platform cores (one partly cortical with a broken distal part – Fig. 7.b7, and the other forming a composite with a smaller core – Fig. 7.b4), two micro-retouched blades with a broken off distal part (Fig. 7.b.8–9), four retouched flakes made with the bipolar splintering technique (one cortical – Fig. 7.b10, two partially cortical – Fig. 7.b11–12, and one from a bipolar-splintered piece – Fig. 7.b13) and five chips (Fig. 7.b14–18). The grey-brown burial pit backfill contained numerous lake chalk lumps of varying sizes.

Feature 120b

A grave pit of rectangular outline with rounded corners (Fig. 8.a) oriented with its longer axis along an E-W line.

A deceased *maturus* male was laid on the flat bottom of the pit on his left side. His head was to the east and his face turned to the south. The buried man died as a result of injuries, most likely inflicted with an axe (*Manasterski* et al. *2001.162*). Around the neck, waist and on the right hand and near the left foot were a total of 50 nodule beads of various sizes made of succinite (Baltic amber); (Fig. 8a1,C) (*Manasterski* et al. *2022b*). These included rounded nodule beads with V-shaped perforations drilled from the flat side (Fig. 8.c1), square nodule beads with V-shaped perforations drilled from the flat side (Fig. 8.c3), square nodule beads convex on both sides with V-shaped holes (Fig. 8.c4), rectangular nodular beads with V-shaped lenticular perforations (Fig. 8.c5), various sized rectangular nodular beads with W-shaped perforations drilled from the flat side (Fig. 8.c6–8) and damaged

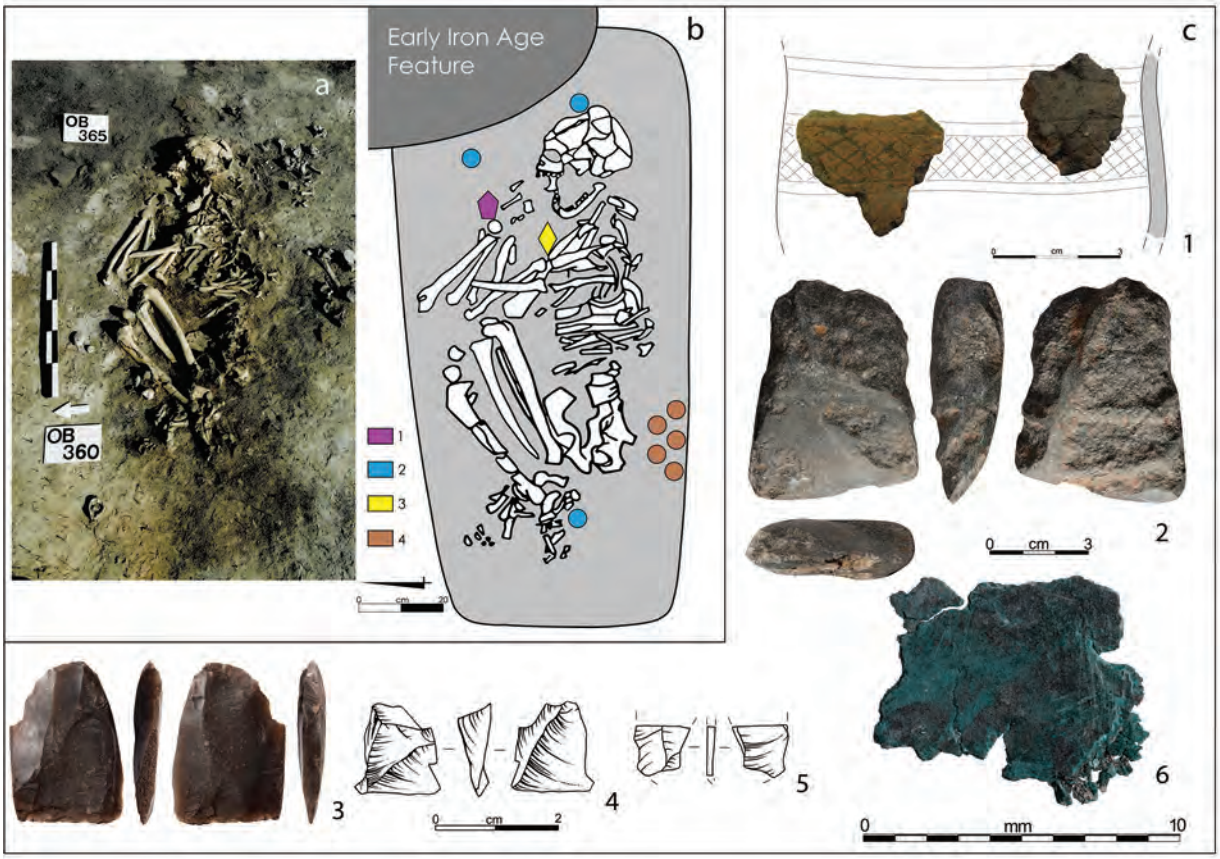


Fig. 5. Inhumation grave (feature 360): **a** ***plan of the grave at the higher level;*** **b** ***plan of the grave at the lower level (*****1*** ***stone axe,*** **2** ***flint artefacts,*** **3** ***fragment of bronze (?) ornament,*** **4** ***fragments of a pottery vessel);*** **c** ***burial equipment (*****1*** ***fragments of a pottery vessel,*** **2** ***stone axe,*** **3–5** ***flint ar-tefacts,*** **6** ***fragment of a bronze (?) ornament (according to*** **Manasterski 2009.269** ***with authors' modifications; photographs by P. Kobek, M. Bogacki, D. Manasterski).***

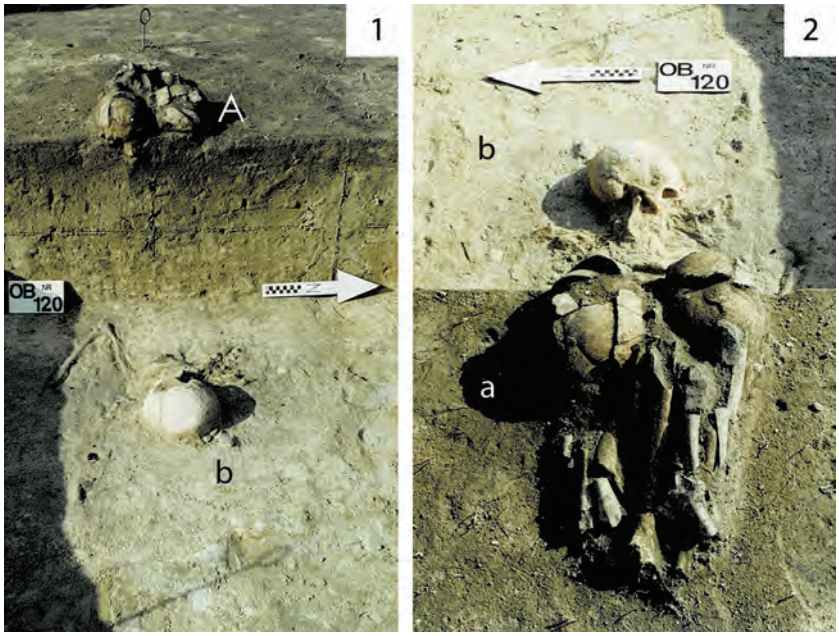


Fig. 6. Layout of inhumation graves 120a and 120b (features 120).* 1 *view from the East;* 2 *view from the West (photographs by P. Kobek).

and repaired beads (Fig. 8.c2). In the vicinity of the hands were the remains of a small, *c.* 30cm long fish, the species of which was not determined (Fig. 8.a3) and a scraper made from a flake of black-coloured erratic flint (Fig. 8a2,c9). The grave cavity was backfilled with lake chalk.

Funeral-ritual features

Feature 192

A small pit with an almost circular outline, about 60cm in diameter and about 35cm deep, in which hand and wrist bones were discovered in an anatomical arrangement, located in its SE part (Fig. 9; *Manasterski 2009.26*).

Below the hand were three flint artefacts (Fig. 9.a). These include two flakes of Cretaceous erratic material made with the bipolar splintering technique (Fig. 9.b1–2) and a burnt flake of indeterminate flint made with the bipolar splintering technique (Fig. 9.b3). The fill of the feature also contained five small, unornamented fragments of a vessel made of ceramic paste containing a mineral admixture from crushed granite and a small quantity of river sand. In addition, several bone fragments of a fish, the species of which was not determined, and a shell of a freshwater mussel of the order *Unionidae* were found. The grey-brown coloured pit backfill contained a considerable number of lake chalk nuggets of various sizes.

Feature 522

A small pit with an almost circular outline, about 60cm in diameter and about 25cm deep (Fig. 10.a).

Its upper part was destroyed in the Early Iron Age. On its bottom in the central part stood a small, cracked S-shaped beaker, made of ceramic paste with mineral admixture from crushed granite and a small quantity of river sand (Fig. 10.a1,b1). The vessel was decorated in the upper part with a zoned-metopic motif. The composition consists of five circumferential incised lines emphasized from below by a band of diagonal indentations. The diagonal indentations motif was also used to create three vertical double bands cut at equal intervals across a zone consisting of five horizontal incised lines. Two flint artefacts made from Cretaceous erratic raw materials were found near the vessel: a flat bipolar-splintered piece (Fig. 10.b2) and a blade made with the splintering technique (Fig. 10.b3). Next to these were found human remains: a phalangeal bone of the hand and four bones of the foot, including three phalanges and a sesamoid. In addition, several shell fragments of a freshwater mussel of the order *Unionidae* and a skeleton of a pike (*Esox lucius*) were discovered in the feature. The grey-brown coloured pit backfill contained a significant number of lake chalk nuggets of various sizes.

Results and discussion

Archaeological taxonomy and relative chronology of graves and funeral-ritual features

Two of the examined graves, features 78 (Fig. 3) and 398 (Fig. 4), showed an arrangement of corpses in a pattern characteristic of CWC burials, where the adult deceased were usually laid in a contracted position – men usually on the right and women on the left side (*Kempisty, Włodarczak 2000.132; Czebreszuk 2004a*). Both burials were of single individuals and equipped in a manner characteristic of this culture: in the first case with an S-shaped beaker decorated with cord impressions, and in the second case with flat heart-shaped belt buckles made of deer antler. The latter are characteristic only of CWC finds from Cen-

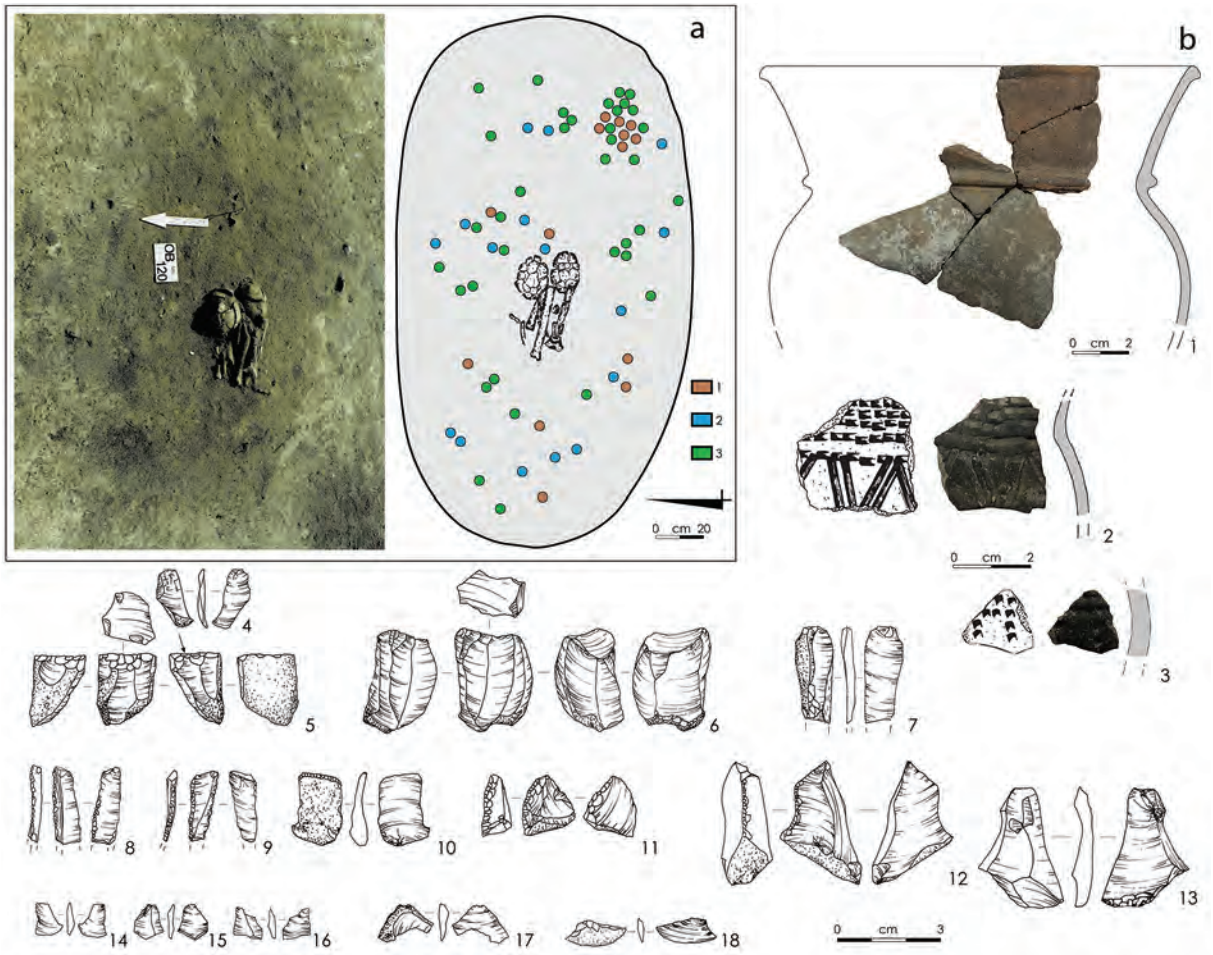


Fig. 7. Inhumation grave (feature 120a):* a *plan of the grave (*1 *fragments of pottery vessels,* 2 *flint artefacts,* 3 *animal bone fragments);* b *burial equipment (*1–3 *fragments of pottery vessels,* 4–18 *flint artefacts) (according to* Manasterski et al. 2001 *with authors' modifications; photographs by P. Kobek, D. Manasterski).

tral Europe and the south-eastern Baltic coast, and date to the 1st half of the 3rd millennium BC (*Peška 2002; Pospieszny 2015.266*).

A further two graves with remains in an anatomical arrangement (features 120b – Fig. 8 and 360 – Fig. 5) can be associated with BB funerary traditions. In both cases, this is indicated by the shape of the grave pits, in grave 120b by the arrangement of the human remains according to biological sex, and in grave 360 by the equipment of the deceased. However, the different arrangement of the latter may have been related not so much to his biological sex as to his social position (*Machnik 1979.414; Czebreszuk 2004b; Soriano* et al. *2021*). The similarities are also clear in the distribution of the grave goods, most visibly in the case of feature 360. These included a pottery vessel with a zoned ornamentation (Fig. 5.c1), typical of this cultural grouping, and a metal lamella with a chemical composition similar to the plate discovered in the BB ritual feature at the Supraśl 3 site (*Wawrusiewicz* et al. *2015.Fig. 62.2*). However, it should be noted that both lamellae were heavily corroded and only the patina was subjected to chemical analysis. Feature 120b contained a set of amber ornaments (a necklace, a belt and two bracelets) comprising a total of 50 beads (Fig. 8.b). These included rounded (Fig. 8.c1) and square (Fig. 8.c3–4) specimens, characteristic of BB, as well as unique forms with a rectangular outline (Fig. 8.c5–8). Rounded beads with V-shaped perforations are a common type across almost the entire BB phenomenon area, although they differ in raw material (ivory or amber) and formal details (*Hájek 1957; Harrison 1977; Czebreszuk, Makarowicz 1993; Budziszewski, Włodarczak 2010.66; Czebreszuk 2011.41–43*). Closest to the Masurian Lake District, this type of amber ornament has been recorded in the ritual-feature of the BB in the Northern Podlasie Lowland and in cemeteries of the Eastern BB group located in the Czech Republic (*Manasterski* et al. *2020.384; Hájek 1957*). Square specimens are known from the Iberian Peninsula, but were made

from ivory (*Harrison 1977.39, 207, 223–224, 234*). The analogous beads from Ząbie 10 can therefore be regarded as imitations of Iberian prototypes, made from a no less prestigious raw material – amber. On the other hand, the unique rectangular forms, characterized by the same manufacturing technology as the square specimens, can be regarded as a local variation of square beads, resulting from the composition layout of the necklace, belt and bracelets.

Vessel fragments in varying states of preservation were discovered in grave 120a and in features 192 and 522. They are associated with the earliest phase of TCS pottery, which combines stylistic features of earlier cultural units, including the NCS and BB phenomenon (*Makarowicz 1998.129–142; 2010.19–24; Czebreszuk 2001.81–83; Manasterski 2009.62–81; 2016.113–137*). In the case of the vessels from grave 120a and feature 522, this is indicated by their techno-stylistic features, and with regard to the pottery fragments from feature 192, by technology.

The analysis of the distinctive materials retrieved from the graves and funeral-ritual features revealed three chronological-cultural horizons, related to the activity of the Late Neolithic communities of the CWC, BB and the early phase of the TCS from the beginning of the Bronze Age delineated for the territory of Poland. While in the case of the first two horizons it is clear that there are no common elements among the finds, there are apparent links between BB and early TCS activity in terms of pottery manufacture.

Absolute chronology of graves and funeral-ritual features

Materials from graves and funerary and ritual features were subjected to radiocarbon dating at different times in order to establish their age and sequence of formation. The results presented in Table 3 are mostly difficult to accept, as they fall outside the generally agreed chronological framework of the cultural units to which the presented features are associated.

In the case of the CWC for the Central and Northern European area, radiocarbon dates indicate a range of 3350–1680 BC, while for the Polish area only they range from 3090–2020 BC (*Furholt 2003.24–25, 39, 44–45, 55, 59–65, 78, 93, 103, 108, 112*). The two graves from Ząbie 10 exhibiting CWC features provided a total of seven dates, of which only two (3048–2901 BC from grave 78 and 2890–2668 BC from grave 398) fall within the chronological framework

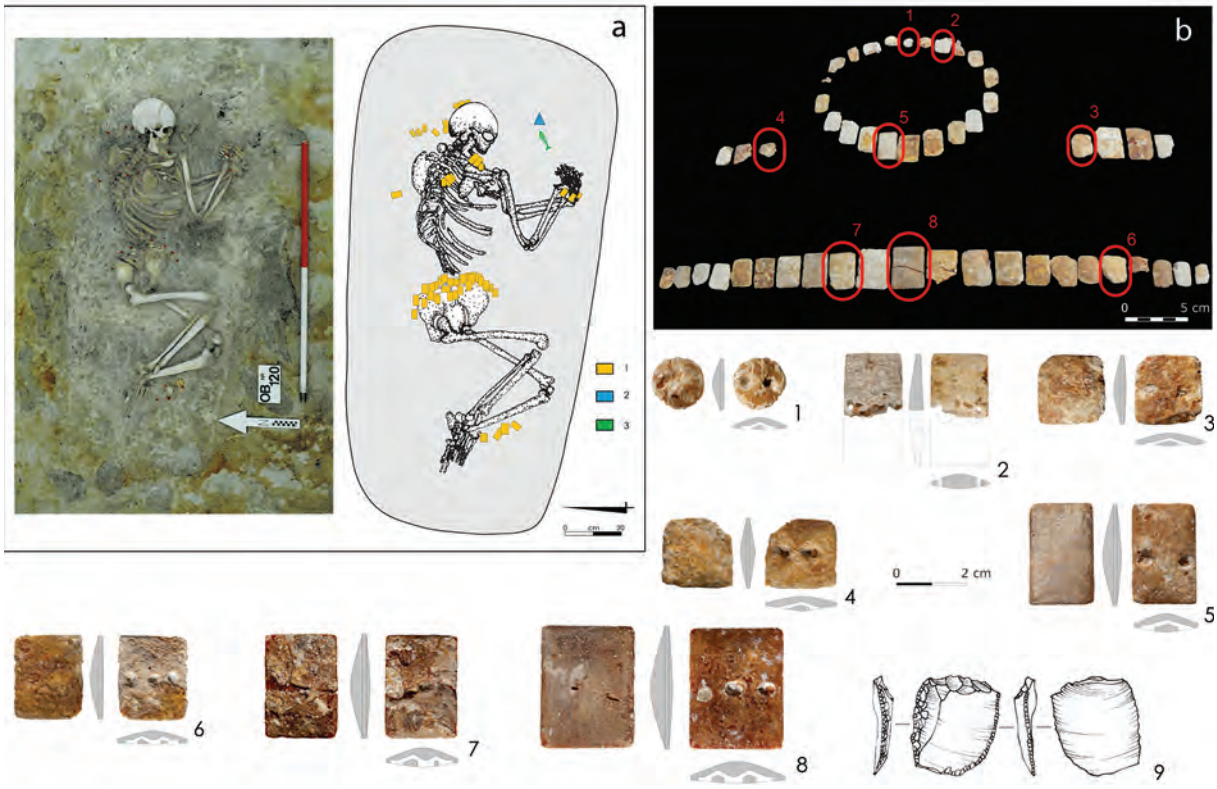


Fig. 8. Inhumation grave (feature 120b):* a *plan of the grave (*1 *amber ornaments,* 2 *flint tool,* 3 *fish skeleton);* b *amber ornaments (necklace, bracelets and belt);* c 1–8 *selection of amber beads from necklace, bracelets and belt,* 9 *flint tool (photographs by P. Kobek, M. Bogacki, D. Manasterski).

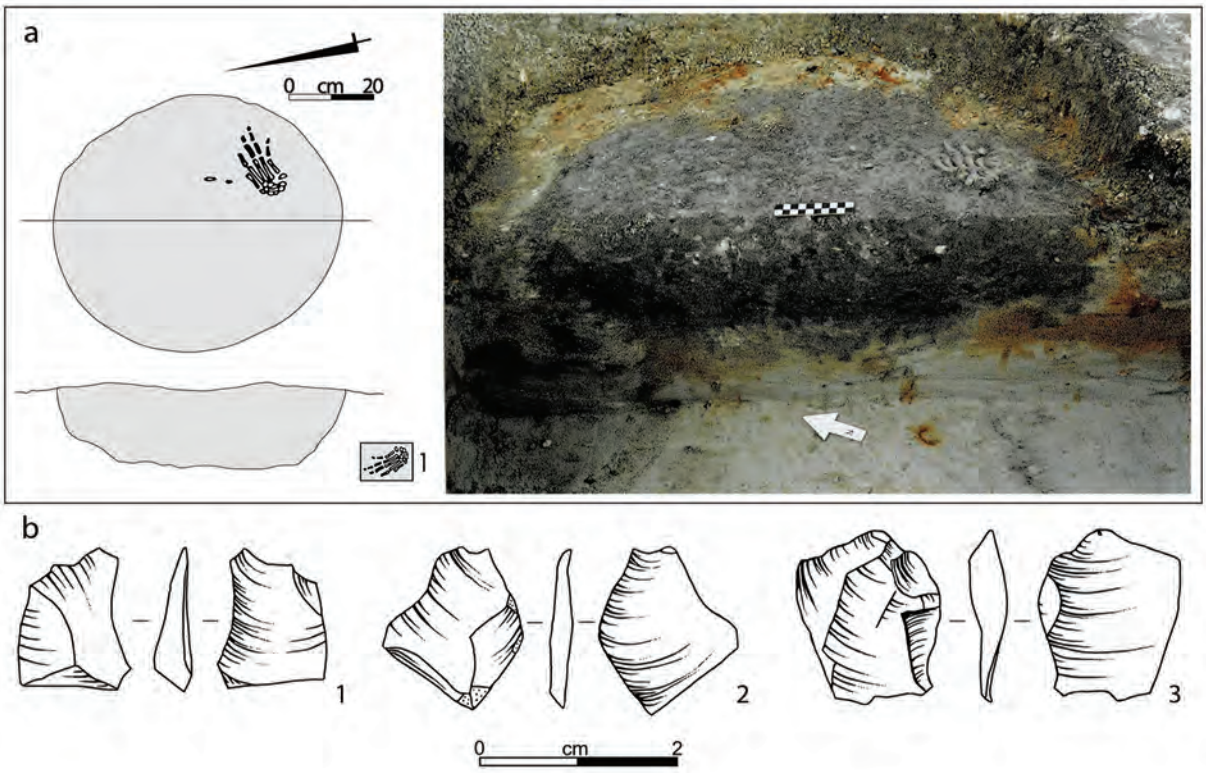


Fig. 9. Funerary and ritual feature (pit 192):* a *plan and cross-section of the pit (*1 *hand bones);* b *flint artefacts found below the hand (photographs by P. Kobek).

presented above. The radiocarbon dates obtained for the BB from Central Europe, on the other hand, range between 2920 BC and 1780 BC, and specifically for the Polish area between 2620 BC and 2140 BC (*Budziszewski, Włodarczak 2010.114, 120–121; Furmanek* et al. *2015.535–537; Olalde* et al. *2018.Tabs. 1–3*). For the graves from Ząbie 10 with BB features, three dates were obtained, of which only one, from grave 360 (2822–2663 BC), falls within the indicated chronological range and, surprisingly, is associated with the origins of this phenomenon in Europe.

However, it should be noted that the bones of the deceased associated with the CWC and BB showed elevated $\delta^{15}N$ values (Tab. 3; *Pospieszny 2015.270*). It is likely that the diet of these people was largely based on food from a freshwater reservoir containing 'old carbon'. This may have come from CO_2 from organic deposits and from calcium carbonate contained in the water of Łańskie Lake (*Pospieszny 2015.274; Kittel 2022*). Carbonate sediments have been deposited in this lake since the beginning of the Holocene (*Madeja 2013*). In contrast, the $\delta^{13}C$ values suggest an admixture of terrestrial animals in the diet of these people. How-

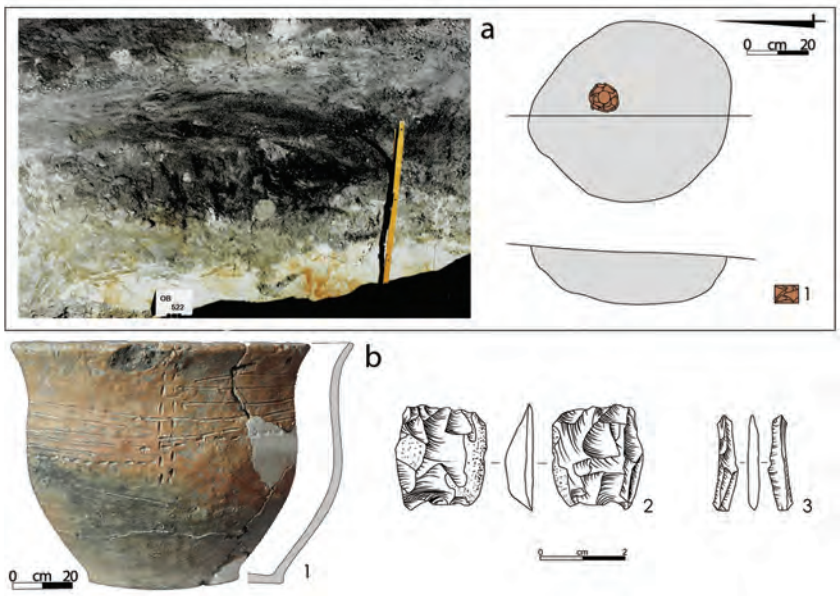


Fig. 10. Funerary and ritual feature (pit 522):* a *plan and cross-section of the pit (*1 *beaker);* b *artefacts from the fill of the pit (*1 *beaker,* 2–3 *flint artefacts); (photographs by D. Manasterski).

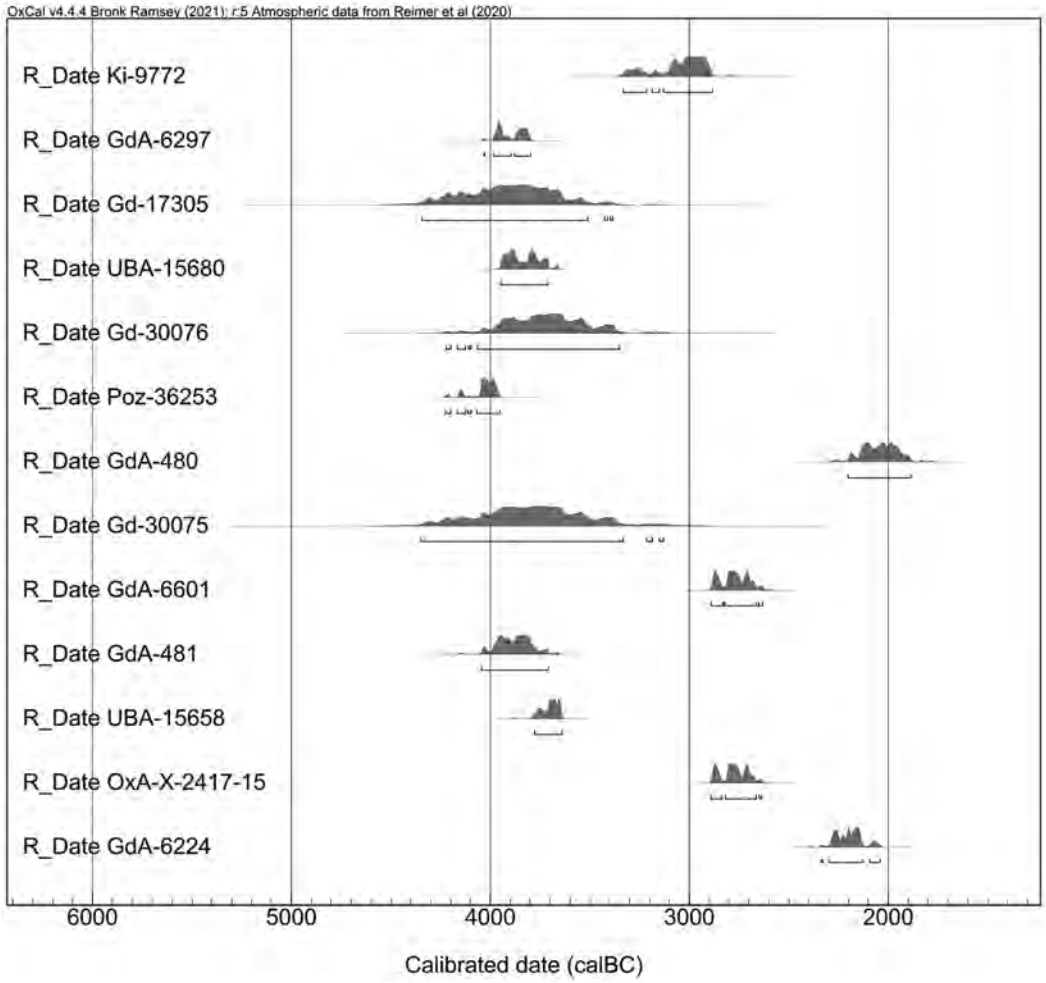


Fig. 11. Probability distribution of calibrated radiocarbon dates received for the graves and funeral-ritual features from Ząbie 10 site.

ever, differences in diet are evident between the individuals belonging to the CWC from graves 78 and 398 and the individual belonging to the BB from grave 360, whose diet was associated with more varied food (*Pospieszny 2015.270–272*). Similar results were obtained for Bavarian BB populations (*Asam* et al. *2006*). It should be noted that in the case of grave 398, dating from both human bone and deer antler, allowed an estimate of a dating shift associated with the freshwater reservoir effect of approximately 740 years (*Pospieszny 2015.274*).

In the case of the TCS, radiocarbon dates range between 2340 and 790 BC, and for the area of Poland alone, 2340–830 BC (*Makarowicz 2010.34–45*). The author of this TCS monograph, however, assumed the duration of this cultural phenomenon to be 1900–1000 BC, and thus disregarded the oldest dates oscillating between 2340 and 2000 BC as too early, because they are incompatible with the typological analysis of the pottery (*Makarowicz 2010.32–54*). Both features from Ząbie 10 (192 and 522) containing ceramics characteristic of the early TCS phase were given ^{14}C dates (Tab. 3) which fall within the range of overly early dates for the beginning of the TCS phenomenon as questioned by P. Makarowicz. However, it can be assumed that a vessel from feature 522 with features combining BB and TCS styles should be included in the initial TCS phase, and therefore that the obtained date of 2300–2125 BC should be accepted as correct. The dating of feature 192 (2200–1880 BC), which contains fragments of a vessel technologically identical to the vessel from feature 522, should be treated similarly.

In summary, it can be concluded that graves with CWC characteristics can be dated to the 1st half of the 3rd millennium BC. The older of the two is probably grave 78, for which the most likely date is 3048–2901 BC, although a shift related to the reservoir effect cannot be excluded in this case. This was determined for samples from the second CWC burial (feature 398), in

which the human bones were dated to 3776–3646 BC whereas the deer antler buckles were dated to 2890–2668 BC, and the reservoir effect was estimated to be 740 years (*Pospieszny 2015.274*). The buckles from this burial fall within the chronological range of the occurrence of CWC graves with buckles in Europe (*Peška 2002.275*).

In the case of the graves with BB burial characteristics (features 120b and 360), based on the obtained dates it is possible to assign them to the end of the 1st half of the 3rd millennium BC. The date indicating the range 2822–2663 BC, obtained from grave 360, is related to the origins of this phenomenon in Europe, although it cannot be ruled out that it was affected by a reservoir effect. In the case of grave 120b, dates were obtained that fall within the range 4226–3954 BC, but a shift in this dating related to a reservoir effect of about 1500 years would indicate a range of approximately 2700–2400 BC (*Pospieszny 2015.274*).

In contrast, the chronological position of grave 120a can only be determined on the basis of pottery characteristics of the initial TCS phase. Ceramics of this type were also found in feature 522, which were radiocarbon dated to 2300–2125 BC. It can therefore be assumed that a relocated double burial of older human remains (feature 120a), for which a date of

Feature	Lab code	^{14}C dating technique	Sample	^{14}C age (BP) cal BC (95.4%)	Stable isotopes in the collagen		References
					δ^{13}C VPDB (‰)	δ^{15}N AIR (‰)	
78	Ki-9772	LSC	Human phalange	4370 ± 703048-2901			*Waluś & Manasterski 2004.34*
78	GdA-6297	AMS	Ceramic paste of vessel	5120 ± 35 3885-3795			
78	Gd-17305	GPC	Human tooth	5087 ± 200 4350-3350			*Manasterski 2009.133*
78	UBA-15680	AMS	Human maxilla	5024 ± 36 3944-3711	-21.7 ± 0.22	13.5 ± 0.15	*Pospieszny 2015.269*
120a	Gd-30076	GPC	Human tooth	4920 ± 170 4300-3100			Manasterski 2009.133
120b	Poz-36253	AMS	Human metatarsal	5210 ± 40 4226-3954	-23.5 ± 0.3	12.5 ± 0.3	*Pospieszny 2015.269*
192	GdA-480	AMS	Human phalange	3660 ± 60 2200-1880			*Manasterski 2009.133*
360	Gd-30075	GPC	Human metatarsal	4990 ± 230 4346-3127	-20.5 ± 0.3	12.1 ± 0.3	*Manasterski 2009.133; Pospieszny 2015.268-369*
360	GdA-6601	AMS	Ceramic paste of vessel	4185 ± 35 2822-2663			
398	GdA-481	AMS	Human pelvic	5100 ± 70 4040-3710			*Manasterski 2009.133*
398	UBA-15658	AMS	Human femur	4927 ± 35 3776-3646	-21.4 ± 0.22	15.5 ± 0.15	*Pospieszny 2015.269*
398	OxA-X-2417-15	AMS	Deer antler	4187 ± 31 2890-2668	-22.5 ± 0.3	5.6 ± 0.4	*Pospieszny 2015.269*
522	GdA-6224	AMS	Ceramic paste of vessel	3775 ± 35 2300-2125			

Tab. 3. Radiocarbon dates for the graves and funeral-ritual features from Ząbie 10 and results for the analysed stable isotopes in collagen.

4300–3100 BC was obtained, was made at this time. Slightly later, but also in the initial phase of the TCS, was feature 192, dated to 2200–1880 BC.

Funeral and ritual complex

The graves and funerary-ritual pits from the site Ząbie 10 formed an ensemble of funerary features, all located at a similar height at the top of a contemporary hill. It consisted of graves established in the 1st half of the 3rd millennium BC and funerary and ritual pits established in the 2nd half of the 3rd millennium BC. The hill's use for funerals and ritual was initiated by the CWC community by depositing on the eastern side of the slope first the deceased in grave 78 and then a child in feature 398. Both burials were among the earliest within the CWC period. Such behaviour continued with the deposition of the deceased on the highest part of the hill, to the west of the earlier CWC graves, following the ritual typical of the BB phenomenon (features 360 and 120b). After an interval, a burial of the relocated, incomplete remains of previously deceased individuals (feature 120a) was made directly above grave 120b, associated with the initial phase of the TCS. Immediately to the north of it, a funerary and ritual feature was established (feature 522) also associated with this cultural sphere and period, containing the remains of human upper and lower limbs. The use of this place for funerary and ritual purposes was completed by the establishment of feature 192 still in the initial phase of TCS formation. This feature, with its human hand remains, was on the southernmost part of the hilltop, away from the grouping of earlier graves. However, it was located on a N-S axis connecting the other features from the initial phase of the TCS, which also contained incomplete human skeletal parts (features 120a and 522). Neither the graves nor the funerary-ritual pits formed stratigraphic relationships with each other. The exception was feature 120, which indicated a temporal succession between the BB burial (feature 120b) and a grave from the initial phase of the TCS (feature 120a), without disturbing grave 120b. The subsequent layout of the burials thus probably resulted from knowledge about the previous inhumations. All the graves were orientated with their longer axis on an E-W line. They therefore formed a complex planned in relation to the directions of the world on a strictly defined area of the hill.

Treatment of human remains

Some of the graves had been disturbed by settlement activity in later periods and by post-depositional factors (features 78, 398, 360), resulting in displacement of some parts of the skeleton. However, this did not affect the assessment of the completeness of the human remains and their arrangement in the graves and features. Thus, it could be observed that in feature 78, a young adult male, with CWC equipment, was laid on his left side. In feature 398, the remains of a headless child with CWC equipment were deposited. Decapitation therefore took place before the deceased was buried. However, it is uncertain whether it was the cause of the child's death or whether it occurred post-mortem. In the case of the deceased adult males associated with the BB phenomenon, their complete remains were deposited lying on different sides. The individual from feature 360 was laid on his right side, while the one from feature 120b was laid on his left side. In addition, the remains of the latter bore traces of the injuries that were the cause of his death. By contrast, the grave and features from the initial TCS phase contained incomplete human remains. These were burials of fragments of deceased humans, transferred from other places. With regard to grave 120a, the incomplete remains of two individuals – two skulls and parts of a postcranial skeleton – were deposited in a large cavity. In features 522 and 192 there were only fragments of human limbs (feature 522 – a bone from the hand and a few bones of the foot without anatomical arrangement; feature 192 – bones of the hand and wrist in anatomical arrangement). However, they do not result from the exhumation and transference of the dead previously deposited in these features, as these cavities are too small to have accommodated a human corpse in its entirety.

Common grave goods

In the graves and funerary and ritual features, regardless of the completeness of the human remains placed in them, there were intentionally deposited objects. These were mostly fragments of pottery vessels. Only one of the CWC graves and one feature belonging to the initial TCS phase contained almost complete ornamented beakers, typical of the aforementioned cultural units. In contrast, pottery vessels were absent in the child CWC grave (feature 398) and the adult male BB grave (feature 120b). Most of the grave and funerary-ritual pits also contained flint artefacts of similar Cretaceous erratic flint. Not distinctive of a specific cultural unit, tools were placed only in some graves. These included an end-scraper from a flake in a CWC grave (feature 78), a scraper from a flake in a BB burial (feature 120b) and retouched blades and retouched flakes made with the splintering tech-

nique in a grave from the initial TCS phase (feature 120a). In addition, the products of the flake core exploitation method (flakes) and the bipolar splintering technique (bipolar splintered pieces, flakes and chips) were deposited in almost every grave and funerary features. The exceptions are the CWC child grave, where no flint objects were deposited, grave 120b (BB), containing only a scraper, and grave 120a (TCS), where, in addition to tools and products of the blade method and bipolar splintering technique, two blade cores were also inserted. It should be emphasized that the products of the bipolar technique were placed intentionally next to the burials from the very beginning of the funerary and ritual complex at the Ząbie 10 site, starting from the oldest CWC grave (feature 78) through the BB grave (feature 360) to the time of the grave and features of the initial phase of the TCS (features 120a, 522 and 192). In addition to this, elements linking the equipment of almost all graves are the presence of freshwater fish remains and bivalve shells of the order *Unionidae*. The exceptions are the grave of a child from the CWC, where no fish or bivalve remains were recorded, and the grave of an adult male representative of the BB, where no bivalve shell was recorded, only a fish. In comparison, only the transferred burial from the initial phase of the TCS with the remains of two deceased (feature 120a) contained post-consumptive remains of wild and farmed animals.

In addition to the aforementioned similarities and exceptions in terms of the common equipment of the deceased, similar content of the burial pit backfill and funerary-ritual features is also evident, consisting of grey-brown soil mixed with lumps of lake chalk. The exception here is grave 120b, backfilled exclusively with lake chalk.

Exceptional grave goods and elements of clothing

Only in the CWC and BB graves were unique or rare objects recorded for these cultural units. In CWC graves, these include predator tusk pendants and ornamented deer antler belt buckles of a size suitable for an adult individual discovered in a child's grave (feature 398; Fig. 4) and deer antler pendants mimicking the tusks of this animal, as well as a lump of red ochre in a man's grave (feature 78; Fig. 3). In contrast, graves associated with the BB phenomenon include a metal lamella and a diabase axe from a man's grave (feature 360; Fig. 5) and a set of amber ornaments also found alongside a man (feature 120b; Fig. 8).

Overall, it should be emphasized that the buried deceased, regardless of cultural affiliation (CWC or BB), were distinguished by their rare ornaments, which formed part of their clothing. Only the ornaments of individuals associated with the BB phenomenon were made of prestigious and difficult-to-access raw materials (copper/bronze, amber). On the other hand, exceptional grave gifts include a lump of red ochre in a CWC burial, as well as a stone axe with which a deceased representative of the BB community was equipped.

Cultural syncretism in funeral rituals

Although most of the graves from the Ząbie 10 site can be attributed to specific cultural units, the CWC features (78 and 398) are not entirely typical, as they contain certain components attributable to other cultures. Both are considered as being some of the earliest graves within the CWC. Apart from items of deceased equipment typical for this cultural grouping, objects associated with another culture were also recorded. These include deer antler pendants that interestingly imitate the tusks of this animal (Fig. 3.2–5) and a lump of red ochre from grave 78, and predator tusk pendants from grave 398 (Fig. 4.5–8). Finds of this type are known from Yamnaya culture burials, dated in their area of origin to the period 3300–2600 BC (*Häusler 1976.66–68, Tafel 26:19; Morgunova, Khokhlova 2013; Marciniak* et al*. 2017.197–210*). In contrast, pendants from wolf and dog teeth are found in classical CWC graves (*Pospieszny 2015.268*). This is also confirmed by the closest CWC grave assemblage from Krusza Zamkowa (Kujawy), the burial of a child equipped with, among other things, pendants made of dogs' teeth (*Kośko 1992.86–89*). The burial of the child from Ząbie coincides in date with the burial of the child from Krusza Zamkowa, and both belong to the oldest CWC horizon in Europe (*Goslar, Kośko 2011.410–413*). They also relate in design and arrangement of the corpse to Yamnaya culture burials (*Kośko 1992.91; Goslar, Kośko 2011.413*). However, the one from Ząbie 10 differs in having an incomplete skeleton of the deceased, poorer equipment and the absence of a barrow mound. References to elements typical of Yamnaya culture funerary rites are also evident by the presence of a lump of red ochre (feature 78).

Red ochre was sprinkled on women's heads in the Yamnaya culture, and lumps of this dye were deposited near the heads or directly in front of the faces of the dead (*Woźny 2011.67*). On another note, the pen-

dants from the CWC graves from Ząbie 10, in addition to their analogies in the Yamnaya culture, may also be reminiscent of local traditions of hunter-gathering communities, in which they may have personified the totemic animal ancestor of a clan or family. This is all the more plausible because in the Masurian Lake District pendants of various wild animal species have been found at ZC hunter-gatherer sites, and in the wider north-eastern European region, such as at the Zvejnieki cemetery in northern Latvia (*Guminski 2003a.75; Larsson 2006*). Furthermore, the substitute deer tusk pendants – antler pendants imitating the tusks of this animal – are another example of resurfacing memories of hunter-gathering traditions among the Late Neolithic CWC community, possibly indicating strong ties with the local pre-Neolithic population. The presence of both types of ornaments may also reflect the acculturation of local hunter-gatherer communities as a result of the influx of representatives of pastoral communities. The hypothetical transmission of 'Yamnaya' cultural patterns around 3100–2900 BC, as assumed by A. Kośko, following the presumed Pontic-Baltic route, is so far best documented by barrow graves at Bożejewice and Krusza Zamkowa in Kujawy (*Goslar, Kośko 2011.413*). The CWC graves from Ząbie in the Masurian Lake District may therefore also be the result of these influences on the local community.

The TCS grave (feature 120a) with the translocated, incomplete remains of two deceased does not belong to the standard burials of this group, although analogous funerary practices have been recorded in different areas of this cultural sphere (*Makarowicz 2010.242–269*). However, the continuation of local funerary traditions associated with the functioning of the ZC hunter-gathering community in the Masurian Lake District region cannot be ruled out. Analogous instances were recorded at the cemetery of this cultural unit at Dudka (*Gumiński 2003b*).

The features 522 and 192 containing intentionally deposited fragments of human limbs and culturally identifiable pottery that are unique to TCS, and these may represent a revival of ritual customs initiated by communities associated with the BB phenomenon in the North Podlasie Lowland. There, small quantities of burnt human remains were discovered in two ritual features alongside artefacts made of various raw materials (Supraśl 3 site, features 1 and 6; *Manasterski* et al*. 2020.377, 379–380, 385*). Additional confirmation of a distant connection to the BB phenomenon may also be provided by an early TCS beaker from feature 522, characterized by an already reduced zoned-metopic decoration.

Social status of the deceased and ranked communities

The absence of graves for the wider population belonging to the Neolithic and Early Bronze Age cultural units at the site leads us to assess the burials discussed above as being dedicated to privileged individuals in the relevant community. In the individual graves, representatives of the CWC and those associated with the BB phenomenon were singled out. In the case of the CWC, this included a young adult male and also a child. The ochre lump discovered in the grave of an individual anthropologically identified as male (feature 78) may indicate that he was buried according to the ritual designed for women in the CWC. This is also confirmed by the positioning of his corpse on his left side – characteristic of female burials. Perhaps his distinguished position, as indicated by his burial, linked him, on the one hand, to the Yamnaya cultural tradition, where ochre accompanied the burials of women of higher social status (*Woźny 2011. 67*), while on the other hand supporting the matrilineal principle of kinship for the inheritance of status. The second of the CWC graves, a child burial, was distinguished by bone buckles. These objects are among the few finds known from the CWC, and are predominantly discovered in the graves of adult individuals (*Czebreszuk, Łoś 1999.98; Kilian 1955.59, 64, Abb. 290.I, 291.I*). These ornaments are rare and therefore indicative of some social distinction. However, the known specimens, despite their general similarities, show stylistic differences and have been divided into different types (*Peška 2002*). This division may relate to the symbolism distinguishing elite lineages. The presence of differently decorated buckles in the known graves of children (the grave from Krusza Zamkowa and the grave from Ząbie) may suggest the deceased inherited their social position from a distinguished relation. The remarkable stylistic similarity of the buckles from the child burial at Ząbie with those discovered next to an adult in a CWC barrow at Wiskiauten/Mochowoje on the Sambian Peninsula (*see Okulicz 1973.Fig. 45.d,f; Peška 2002.Obr.11.3*) may indicate an ancestral identity within the CWC group penetrating the area of the Masurian Lake District and the Sambian Peninsula. It can therefore be suggested that the buried child belonged to an elite lineage within this CWC group.

With regard to the BB burials, adult males were distinguished. One was deposited on his right side (feature 360) – atypical for an individual from the eastern province of this phenomenon's range, where the position of the deceased's body was determined by sex division supplemented by age groups (see *Soriano* et al. *2021*), and perhaps this was related to his social role during life. Outside Central Europe, in the so-called 'profession groups', only 'warriors' were buried according to a pattern of corpse arrangement that determined their sex. These were men usually equipped with daggers, arrowheads and wrist guards (*Soriano* et al. *2021*). In the case of the individual from Ząbie 10, no such elements can be identified, only a diabase axe found with him that perhaps denoted some profession or social category. During the BB period, stone axes were extremely rare in graves (*Harrison 1977; Turek* et al. *2003.195*). It can thus be considered a unique grave gift with a special significance assigned by the burying community. In addition, the buried individual was distinguished by a metal lamella, which was the remnant of some kind of ornament. This type of object is among the oldest metal finds in the Masurian Lake District, which also include a copper dagger from the presumed CWC grave at Rybitwy (see Table 1.no. 5). The buried individual may have been associated with the BB social elite due to the prestigious and exotic raw material found in this grave. According to some scholars, BB burial rituals were restricted to social leaders and their relatives, as the only ones who could afford to display exotic raw materials (*Soriano* et al. *2021*).

Similarly prestigious ornaments were also worn by another man associated with this cultural phenomenon, buried in grave 120b. In this case, it is not the grave goods that attest to his social position but the unique ornaments he wore. It can thus be concluded that he had held a distinctive social position and was therefore not buried in the standard way with pottery and other objects indicating sex or membership of a specific social group, such as warriors. His ornaments, characterized by their quality of workmanship, raw material and quantity (*Manasterski* et al. *2022b*), may have been not only an expression of prestige, but also a symbol of a local leader. In addition, this was the only burial among those discussed above to be backfilled exclusively with lake chalk not naturally occurring in the island area. The backfill of the earlier graves and later features contained only an admixture incorporating lake chalk nuggets, which had been specially excavated and transported to the burial ground. It is reasonable to believe that the deliberate addition of chalk was significant in the funerary rituals of those buried on the island, and to regard it as one of the signs of their social status. Burial 120b, which stands out in this respect because the deceased and his elite amber ornaments were buried exclusively in chalk, may be indicative of this individual having the highest social position among those buried.

Archaeological traces of the funerary rituals of the aforementioned cultural units therefore indicate hierarchization within these communities, albeit in an undeveloped form, with a leading role for men.

In contrast, the burial (feature 120a) and funerary-ritual features (features 522 and 192) from the initial phase of the TCS are characterized by the impossibility of deciphering the social role of the dead. The burial is collective, in contrast to the earlier individual graves, and lacks distinctive furnishings highlighting the sex or social role of the deceased in question. The funerary-ritual features contain only symbolic elements of the anonymous dead. Only in one feature does an ornamented beaker stand out. Hence, one can conclude the lack of individuality of the burial and funeral-ritual features, and thus link them to egalitarian communities.

In summary, a change in the status of the buried dead is evident at this funeral and ritual place. In the Late Neolithic, the buried were chosen from ranked communities, distinguished by an undeveloped kin/role ranking social stratification. At the beginning of the Bronze Age, the deceased were anonymous individuals of unranked social status (or their token representation), associated with unranked societies.

Until the arrival of the CWC community in the Masurian Lake District, there was still a GAC group in the area alongside local hunter-gatherers, though probably few in number, who identified with the NCS. The latter, however, did not leave behind archaeologically detectable burials, which has led some researchers to interpret their social system as unranked (*Józwiak 2003.240–245*). GAC communities, on the other hand, were characterized by an early stage of chiefdom group-oriented social stratification (*Szmyt 1996. 206–207; Berreman 2001.7377; Wason 2004.37, 44– 45*). The individuals with the highest social rank in this group were older men, who were buried in megalithic tombs and furnished with objects mark-

ing prestige, as well as human and animal sacrifices (*Szmyt 1996.206–207*). Although graves of this type have been recorded in the Masurian Lake District (see Tab. 1), they have not been found at the Ząbie 10 site, despite the presence of GAC pottery in the cultural layer. It must therefore be assumed that the GAC community may have used the island exclusively for settlement and economic purposes. The GAC graves from the Masurian Lake District also lack elements associated with the NCS. The graves of the latter culture, on the other hand, still remain elusive to detection by archaeological methods. Despite the existence of the two communities side-by-side in the Masurian Lake District, there was no cultural diffusion between them in the social and funerary spheres reflected in the burials. The burial placement situation changed with the arrival of CWC and BB representatives. The communities of these newcomers left graves behind. In the case of the CWC, representatives of prominent lineages were buried, while in the case of the BB, representatives of elite social groups with various roles were buried. Again, there was no cultural diffusion with the local NCS in terms of social divisions and the funerary sphere. One of the latest burials indicating the existence of stratified communities with established elites is the grave of a local leader equipped with a set of elite amber ornaments (feature 120b), who was killed with a blow to the head that split his skull. It can be assumed that this is indicative of the decline of the elite, since the later funerary features (features 120a, 522 and 192), dated to the beginning of the Early Bronze Age, have an egalitarian character.

Role of communities represented by the deceased in the cultural diffusion that led to the emergence of the syncretic Ząbie-Szestno group

The CWC community was the first that buried their dead at the Ząbie 10 site. This community, influencing the local NCS hunter-gatherers, initiated a process of diffusion that resulted in the formation of a local Ząbie-Szestno group with syncretic characteristics. An analogous role in the process of the diffusion and development of this group was played by another allochthonous community associated with the BB phenomenon, which continued to bury the dead in the existing funeral-ritual place.

The presence of newcomers from both cultural groupings at the Ząbie 10 site is evidenced not only by graves, but also by fragments of vessels typical of them, found in small quantities in the cultural layer (*e.g., Manasterski 2009.Tabs. 8.3, 10.1, 17.6, 21.1, 26.7–8, 28.2; 2016.Figs. 11.3, 12.2–3, 13, 14.1, 3–4, 15.2–4, 16.1, 17.1*). In turn, impacts on the local population are evident in the syncretic ceramic forms. First, there are rare forms containing NCS and CWC cultural components (*e.g., Manasterski 2009.Tabs. 3.1, 17.4, 23.2, 34.2, 39.2, 48.10*), followed by vessels combining mainly stylistic and technological features of NCS and BB ceramic manufacture, already present in significant quantities (*e.g., Manasterski 2009.Tabs. 13.3, 14.2, 21.3,6, 30.2, 31.3, 6, 10; 2016.16.2–3*). Cultural diffusion also occurred between the newcomers themselves, as evidenced by a group of pottery with mixed CWC and BB characteristics (*e.g., Manasterski 2009.Tabs. 19.7, 11, 20.6, 24.3, 38.10; 2016.Figs. 11.2; 12.1*). The two communities were also linked by the proportion of lake chalk in the grave fill and the presence of flint artefacts in the case of graves 78 and 360. These artefacts were made from the same local raw material and produced using the flake method and bipolar splintering technique. The latter is not typical of the local NCS and is also rare in CWC and BB production (*Furestier 2004.84; 2008; Januszek 2020.11–16, 18–19, 162*).

The significant quantities of syncretic pottery with a BB component may indicate the longevity and intensity of the impact and dominance of this phenomenon over the local population and earlier CWC arrivals. At the site, in addition to the BB and BB-hybrid pottery, remains associated with this phenomenon may also include flint inserts for cutting tools and flat bipolar-splintered pieces (*Manasterski* et al. *2022a.Fig. 10.1–4*) and a stone shaft straightener, as well as fragments of diabase axes (*Manasterski 2009.Tabs. 70.1, 3–6*). One such axe, preserved in its entirety, was located in the burial of a male BB individual (Fig. 5.c3). Similar remains cannot be found for the CWC, which seems to indicate the lesser role of this culture in influencing the local community. This is all the more so because in the Early Bronze Age material classified as early TCS, any contribution from the CWC is absent. This cultural unit only initiated cultural changes that resulted in relatively few syncretic forms of pottery vessels, attributable to the beginning of the Ząbie-Szestno group. The transformations in material culture were continued by the BB community until the Early Bronze Age. Their expression at this time comprises early TCS pottery still containing a BB stylistic component (*e.g., Manasterski 2009.Tabs. 2.7, 9.3, 11.7, 24.13, 35.6, 43.2*). In addition to its representation in the cultural layer of the site, it was discovered both in a collective grave (120a) and in funerary ritual fea-

tures with skeletal parts of anonymous dead (features 522 and 192). The presence of lake chalk (white pigment) in the backfill of graves and ritual features can be considered reminiscent of the older Yamnaya cultural tradition that arrived with the CWC. In the Yamnaya culture, socially distinguished adult males were backfilled with chalk (*Häusler 1976.146–147; Woźny 2011.67*). At the Ząbie 10 site, it was symbolically present in the CWC grave fills. Probably as a result of contact between BB representatives and the CWC community, this foreign custom was adopted for the burials of BB individuals. An extreme example of the use of chalk is the complete filling of the burial cavity of burial 120b. Reception of white chalk symbolism is also evident at the Supraśl 3 site in two BB ritual features in the North Podlasie Lowland (*Manasterski* et al. *2020.378–380*). Therefore, at the Ząbie 10 site, the presence of chalk in the backfill of collective grave 120a and features 522 and 192 from the early TCS can be regarded as an expression of its acquisition from the BB as well as elements of vessel styling. This was a continuation of the white dye symbolism in funerary rituals derived from the Yamnaya culture, locally adopted by the BB through the CWC. However, this symbolism is only represented at the Ząbie 10 site. Within the Ząbie-Szestno group, which covers the Masurian Lake District, grave and ritual features from the CWC through the BB to the TCS have so far been identified for this island only. Other sites of this group located on islands in lakes in this lake district have only contained pottery and flint artefacts, indicating a similar process of initiation and development (*Manasterski 2009; Januszek 2020.74–84*).

Conclusions

With the emergence of farming and pastoral communities in the Masurian Lake District, a new phenomenon in the area was the appearance of archaeologically detectable graves, located on the mainland rather than on lake islands. Among the exceptions is the island in Łańskie Lake at Ząbie, where graves were only established by CWC ranked communities, who buried their dead of high social status there. The exceptionality of the site (both island and hill) was recognized by the BB community as well, who also buried representatives of their elite here, including a killed 'local leader' – a representative of the last Late Neolithic ranked communities in the Masurian Lake District. Up to this point, the island and its uppermost elevation had been a burial ground for elite newcomers who, by influencing local hunter-gatherer populations, initiated the formation of the syncretic Ząbie-Szestno group. The BB newcomers played the greatest role in its development. After the symbolic fall of their elites, no more individual graves of the ranked communities were located on the island. Within the further development of the Ząbie-Szestno group, in the Early Bronze Age, the influence of the BB phenomenon was still clear, especially in the pottery manufacture of the initial TCS phase. Other types of tools, especially flint artefacts, are mostly characterized by technological unification involving the bipolar splintering technique (*Manasterski 2009; Januszek 2020.86–103*). The island graves were replaced by funerary features containing the remains of anonymous dead – a unique and new aspect in funerary rituals, probably also having its roots in BB rituals. The puzzling question here is whether the partial burials are derived from an amputation or fragmented corpse at the time. These features were the final additions to a funerary-ritual complex, planned in relation to the cardinal directions and situated in a well-defined elevated area of an island. Thus, the Early Bronze Age saw the disappearance of individualism from funerary rituals, including indications of the social ranking of the deceased. The attempted formation of local elites at the end of the Neolithic under the influence of newcomers was short-lived and is not discernible in the Early Bronze Age, when there was arguably a return to social egalitarianism and unranked communities. This process did not take place equally across northeastern Poland, as graves of elites with gold equipment have been recorded in Warmia, west of and adjacent to the Masurian Lake District, dated to Bronze Age II, *i.e.* 1700 BC, according to the chronology for this region (*Dąbrowski 1997.88; Sobieraj, Hoffmann 2019*). Nevertheless, it was the newcomers associated with the BB phenomenon who had the greatest impact on the transformation of local hunter-gatherers into Early Bronze Age communities. Similarly, as in other areas of the phenomenon's range, its diverse impact contributed to the emergence of a wide variety of new communities (*Quiles 2019.287*).

The ability to recognize the impacts of allochthonous communities and their effects on the local population on the basis of the funerary and ceremonial complex at the Ząbie 10 site makes this place unique not only within the Mazury Lake District, but also within the entire border zone of the North and Eastern European Plains.

Authorship contribution
Dariusz Manasterski: *Conceptualization, Data curation, Formal analysis, Methodology, Investigation, Writing – original draft, Writing – review & editing, Supervision.* ***Katarzyna Januszek****: Conceptualization, Data curation, Formal analysis, Methodology, Investigation, Writing – original draft, Writing – review & editing.* ***Aleksandra Cetwińska****: Data curation, Investigation, Writing – original draft, Writing – review & editing.* ***Katarzyna Kwiatkowska****: Formal analysis, Writing – original draft.*

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Tab. 1. Funeral features from the Late Neolithic in Masurian Lake District.

Location	Feature	Deceased	Burial finds	Archaeological culture	Absolute dating	Sources availability	Reference
(1) Danowo (Siegenau before 1945), Pisz District	flat grave	individual	5 animal tooth hangers, bone awl, 2 flint flakes	Corded Ware culture	undated	lost during World War II	*Kilian 1955. 254-255*
(2) Dudka, Giżycko District	flat grave	individual	ceramic and stone beads	Corded Ware culture?	2340–2110 cal. BC	Institute of Archaeology and Ethnology, Polish Academy of Sciences	*Gumiński, Kowalski 2011.479-483*
(3) Koczek (Waldersee before 1945), Szczytno District	flat grave	individual	stone adze, pottery vessel, flint knife, 2 spearheads	Corded Ware culture	undated	lost during World War II	*Kilian 1955. 255*
(4) Nerwik (Nerwigk before 1945), Olsztyn District	flat grave	individual	fragments of pottery vessels, flint arrowhead, flint flakes	Corded Ware culture	undated	lost during World War II	*Kilian 1955.253*
(5) Rybitwy (Ribitten before 1945), Pisz Distr.	flat grave	individual	copper dagger, ring-shaped bone pendant	Corded Ware culture?	undated	lost during World War II	*Kilian 1955.45, 58, 66-67, 255*
(6) Bałdy (Balden before 1945), Olsztyn District	cist grave	no data	fragments of 2 pottery vessels, 2 flint axes, amber disc	Globular Amphora culture	undated	lost during World War II	*Klebs 1882. 43; Nosek 1967.50; Mazurowski 1983.115-116*
(7) Dąbrówno (Gilgenburg before 1945), Ostróda District	cist grave	2 individuals	fragments of 2 pottery vessels, flint knife	Globular Amphora culture	undated	lost during World War II	*La Baume 1943.48-49*
(8) Frygnowo (Frögenau before 1945), Ostróda District	cist grave	fragments of human bones	fragments of 2 pottery vessels, flint axe	Globular Amphora culture	undated	lost during World War II	*La Baume 1943.48*
(9) Grom (Grammen before 1945), Szczytno District	cist grave	neither human nor animal remains have survived	fragments of pottery vessels, stone grinder	Globular Amphora culture	undated	lost during World War II	*La Baume 1943.61; Nosek 1967.57*
(10)Januszkowo (Januschkau before 1945), Nidzica District	cist grave	neither human nor animal remains have survived	2 pottery vessels	Globular Amphora culture	undated	lost during World War II	*La Baume 1943.51*
(11) Małszewko (Malschöwen before 1945), Szczytno District	cist grave	neither human nor animal remains have survived	fragments of pottery vessels, flint axe, fragments of a few amber round buttons shaped with a V-shaped opening	Globular Amphora culture	undated	lost during World War II	*La Baume 1943.61; Nosek 1967.58; Mazurowski 1983.118*

Tab. 1. continued

(12) Miętkie (Mingfen before 1945), Szczytno District	2 cist graves	Grave 1: fragments of human bones; Grave 2: neither human nor animal remains have survived	Grave 1: fragments of pottery vessels, amber ornaments (6 buttons and 15 tubular beads). Grave 2: fragments of 3 vessels	Globular Amphora culture	undated	lost during World War II	*La Baume 1943.62*
(13) Naprom (Nappern before 1945),Ostróda District	cist grave	few human teeth preserved only	7 pottery vessels, amber ornaments: fragments of round button-shaped with a V-shaped opening (1) and tubular beads (7)	Globular Amphora culture	undated	lost during World War II	*La Baume & Jaentsch 1941*
(14) Rańsk (Rheinswein before 1945), Szczytno District	2 cist graves	Grave 1: neither human nor animal remains have survived; Grave 2: lack of human bones; a fragment of a pig bone	Grave 1: fragments of 4 pottery vessels, flint axe, amber ornaments (4 amber round button-shaped, few tubular amber beads, 1 amber disc). Grave 2: fragments of 7 pottery vessels	Globular Amphora culture	undated	lost during World War II	*La Baume 1943.64-67; Nosek 1967.58-61*
(15) Romany (Rohmanen before 1945), Szczytno District	cist grave	neither human nor animal remains have survived	9 pottery vessels, clay ball, 3 flint knives, and few flint flakes	Globular Amphora culture	undated	lost during World War II	*La Baume 1943.67-69; Nosek 1967.62*
(16) Rudno (Rauden before 1945), Ostróda District	cist grave	neither human nor animal remains have survived	fragments of pottery vessels, fragment of flint axe, flint blade tool	Globular Amphora culture	undated	lost during World War II	*La Baume 1943.52*
(17) Szczepankowo (Stauchwitz-Augusthof before 1945), Szczytno District	cist grave	neither human nor animal remains have survived	fragments of 3 pottery vessels, 2 flint axes, amber ornaments (1 disk, few tubular beads, 1 button-shaped with a V-shaped opening)	Globular Amphora culture	undated	lost during World War II	*La Baume 1943.69-70; Nosek 1967.62-63; Mazurowski 1983.120*
(18) Szczytno (Orteisburg before 1945), Szczytno District	cist grave	fragments of human bones	fragments of 3 pottery vessels, flint axe, 2 flint flakes,6 amber tubular beads	Globular Amphora culture	undated	lost during World War II	*La Baume 1943.63-64; Nosek 1967.63; Mazurowski 1983.120*

Tab. 1. continued

(19) Trelkowo (Gr. Schöndamerau before 1945), Olsztyn District	2 cist graves	Grave 1 and 2: neither human nor animal remains have survived	Grave 1: fragments of 9 pottery vessels, 2 flint axes, fragments of few amber tubular beads. Grave 2:fragments of 5 pottery vessels	Globular Amphora culture	undated	lost during World War II	*La Baume 1943.58-60; Nosek 1967.64-65*
(20) Wierzbowo (Wiesenfeld before 1945), Nidzica District	cist grave	3 individuals	5 pottery vessels, flint axe, 2 bone awls, pig jaw, 40 amber ornaments (31 tubular beads. 6 axe-shaped beads, 1ornament shaped as tetragonal with frontal openings, 1 disc, 1 separator)	Globular Amphora culture	undated	lost during World War II	*La Baume 1943.53-55*

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Plus ça change, plus c'est la même chose? Continuities and discontinuities in the funerary record of the northern half of Iberia

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ABSTRACT - *An evolutionary approach to the study of the funerary systems in Late Prehistory allows the recognition of diverse contexts of social crises in the north of Iberia. The analysis of the radio-chronological data that we have compiled indicates five phases of use – with the newness of identifying two different cycles during the Late Neolithic – and of subsequent 'abandonment' in the megaliths; this is reduced to two phases in the case of the sepulchral caves. We interpret the radio-chronological results through an examination of the material culture present in the graves and dynamics of the megalithic architecture. In addition, we contrast our results with different approaches, carrying out a complementary multidisciplinary approach. In this regard, we found that megalithism served as a vehicle for responding to the different crises and changes faced by increasingly complex and unequal human groups.*

KEY WORDS – *Neolithic; Chalcolithic; megalithism; chronology; social crises; Iberia*

Plus ça change, plus c'est la même chose?/Bolj ko se spreminja, bolj je enako? Kontinuitete in diskontinuitete v pogrebnih zapisih na severu Iberskega polotoka

IZVLEČEK – *Evolucijski pristop k preučevanju pogrebnih praks v pozni prazgodovini severne Iberije omogoča prepoznavanje različnih družbenih kriz. Analiza zbranih radio-kronoloških podatkov kaže na pet faz uporabe – z najnovejšo prepoznavo dveh različnih ciklov v poznem neolitiku – in kasnejših 'opustitev' v megalitih; to je v primeru sepulkralnih jam omejitev na dve fazi. Radio-kronološke rezultate interpretiramo s pomočjo pridatkov v grobovih in dinamiko megalitske arhitekture. Naše rezultate primerjamo z rezultati drugih pristopov, ki vključujejo primerljive multidisciplinarne analize. Ugotovili smo, da je megalitizem služil kot odziv na različne krize in spremembe, s katerimi so se soočale vse bolj kompleksne in neenakopravne skupine.*

KLJUČNE BESEDE – *neolitik; halkolitik; megalitizem; kronologija; družbena kriza; Iberski polotok*

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Introduction

Regardless of the paradigm under which we interpret the direct or indirect correspondence between the funerary archaeological record and the structure of the community *(Criado Boado 1989*), we will agree that social innovation will gain visibility (*Hodder 1990*). In this sense, the modification of the funerary expressions of prehistoric human groups represents a cultural and ideological change, although it is not easy to establish the difference between continuity and rupture when we analyse archaeological materiality. Cultures, like species (*Van Valen 1973*), show a strong trend, over time, to change by non-orthogenetic evolution, driven by internal and external factors, a dynamic that accelerates in contexts of competition. Therefore, change would not necessarily evidence a conflict. In contrast, ruptures occur in contexts of 'crises', a term that we reserve for the existence of systemic contradictions.

In the case of Late Prehistory in northern half of Iberia, the archaeological record provides a wide range of funerary items; in fact, for certain chronologies and regions, mortuary contexts contribute more to our knowledge than household contexts. In this regard, the rich megalithic funerary structures, and their equivalence in rock shelters and caves, contrast with the weakness of information about their contemporary settlements. This is a good example of the social and ideological representativeness of the funerary sphere: a monumental architecture faced with the ephemeral household constructions, and grave goods that suggest wealth opposite to 'anodyne' household goods. The idea needs to be qualified. Although there is a possible research bias, unlike southern Iberia, the early steps of megalithism in our study area are accompanied by a gap in the non-funerary data. Or, as a well-known saying among archaeologists puts it – 'people died but did not live'.

In this essay we reflect on the processes of change/rupture that occurred during Late Prehistory – from the Early Neolithic to Bronze Age – on the northern half of Iberia, through their funerary corollary. To this end, we draw upon radiocarbon dating series as well as architectural and material culture analysis.

The materiality of a specific tomb is an expression of the particular circumstances of the community linked to it. We wonder if, based on this materiality, we can identify long-term patterns. In other words, we propose to change the scale of interpretation of funeral behaviour to try to infer the presence of continuities and discontinuities (*Shanks, Tilley 1987*).

For our purpose, it is important to consider the dichotomy between natural and artificial funeral structures for two reasons. Firstly, the megalithic structures constitute an investment of energy (*Vicent 1995*) or a *"social work deposit"* (*Lull, Picazo 1989.17*) that has been mobilized during its erection. Secondly, the monumentality of megaliths, as opposed to collective graves in rock shelters and caves, could fulfil a function of territorial demarcation (*Renfrew 1976*), and would enter into a dialogue with the surrounding space. Those differentiating attributes of megalithism would be circumscribed to their phase of construction or first cycle of use, and not, most likely, to later reuse.

Study area and period

The archaeological record and the available ^{14}C data determinate the area of study (Fig. 1). In fact, although we intended an analysis of the funerary structures in the northern half of Iberia, the area was restricted to the east of the Cantabrian coast, the Ebro River basin, the Pyrenees and specific locations in the Duero River basin. The sites located in the central Cantabrian region, Galicia, and the northern half of Portugal, with a few exceptions, could not be included in our radio-chronological database: due to the kind of the dated samples or due to the results obtained. However, as our methodology also deals with the analysis of structures and grave goods, we incorporate many undated megaliths into our reflections.

The archaeological manifestation under study, megalithism, goes through several periods of Late Prehistory. The Late Neolithic in the northern half of Iberia, when collective funerary expressions began, is characterized by the proliferation of open-air settlements in whose structures pits are common. Understood as silos, they indicate storage practices and, therefore, surplus economies. In parallel, and particularly deep into the Chalcolithic period, the use of caves and rock shelters as pens became widespread (*Estremera 2003*; *Fernández-Eraso* et al. *2017*; *Francés-Negro* et al. *2021*; *Martín* et al. *2010*; *Pérez-Romero 2021*; *Straus, González 2012*), which suggests an efficient li-vestock management strategy with the use of meat, milk and, in general, 'secondary' products. According to the latest evidence, in the heart of our area of interest (Salinas de Añana), the first megalithic groups

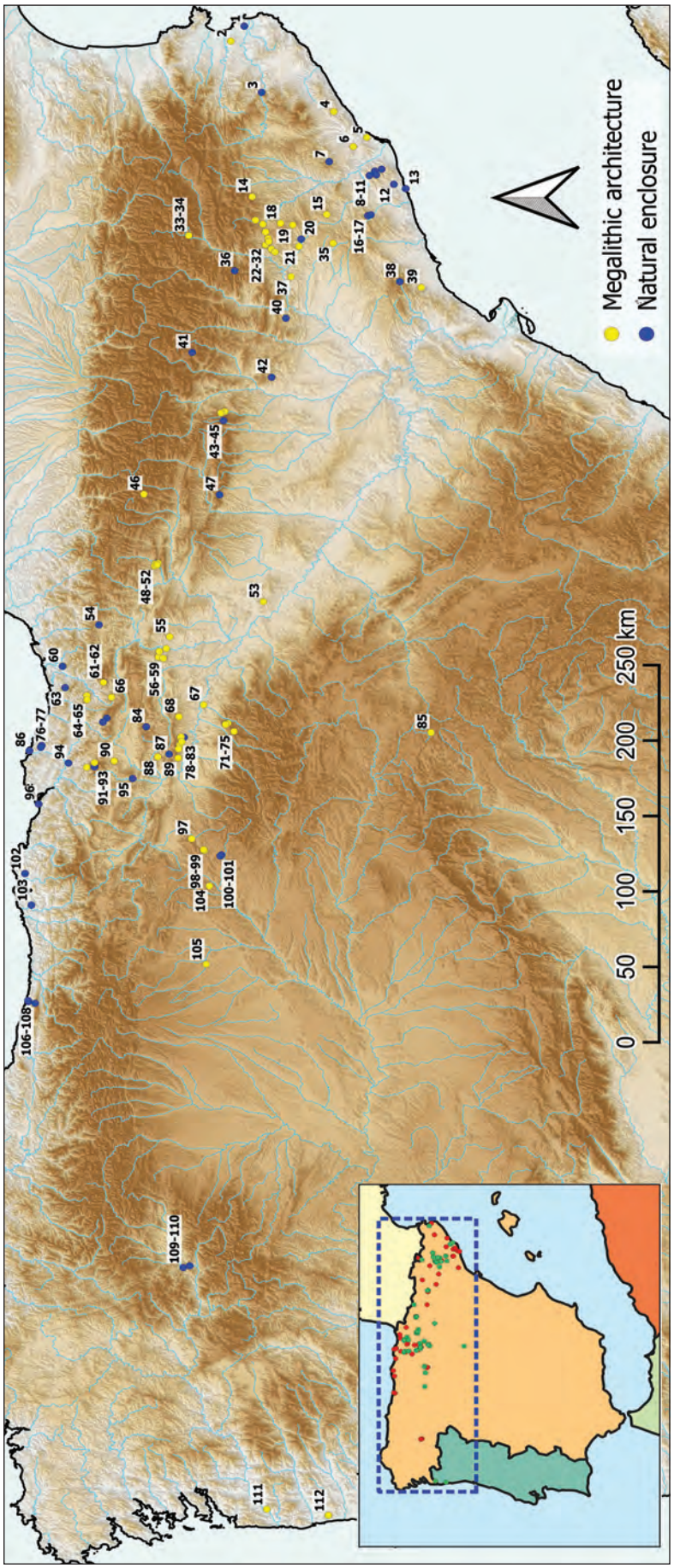

Fig. 1. Locations of the funerary sites used for this study. 1 *Cau d'en Calvet;* 2 *Tafania;* 3 *Pasteral;* 4 *Costa Can Martorell;* 5 *Sagrera;* 6 *Carrer París;* 7 *Frare;* 8 *Marge del Moro;* 9 *Cova Bonica;* 10 *Cova de l'Avi;* 11 *Cueva de Agulles;* 12 *Cova de Sant Llorenç;* 13 *Gegant;* 14 *Serrat de les Tombes;* 15 *Les Maioles;* 16 *Cova del Toixó;* 17 *Cova de la Guineu;* 18 *Solar III;* 19 *Pera d'Ardèvol;* 20 *Balma del Cal Porta;* 21 *Povia;* 22 *Tomba del Moro;* 23 *Vilar de Simosa;* 24 *Megàlit del Bisbe;* 25 *Clarà;* 26 *El Llord I;* 27 *El Llord V;* 28 *Ceuró I;* 29 *Costa dels Garrics del Caballol I;* 30 *Costa dels Garrics del Caballol II;* 31 *Santes Masses;* 32 *Ceuró II;* 33 *Feixa del Moro II;* 34 *Feixa del Moro III;* 35 *La Plana del Torrent;* 36 *Cova de Montanissell;* 37 *Reguers de Seró;* 38 *Galls Carboners;* 39 *Bòvila Casals;* 40 *Forat de Conqueta;* 41 *Trocs;* 42 *Moro de Alins del Monte;* 43 *Las Balanzas;* 44 *La Capilleta;* 45 *Cristales;* 46 *Cubilar del Barranco I;* 47 *San Juan de Loarre;* 48 *Corona de Hualde;* 49 *Padre Areso;* 50 *Faulo;* 51 *Pieza de Luis;* 52 *Puente de Bigüezal;* 53 *Tres Montes;* 54 *Abauntz;* 55 *Mina de Farangortea;* 56 *Sotoaldea;* 57 *Morea 1;* 58 *Aizibita;* 59 *Charracadía;* 60 *Martzulo;* 61 *Jentillarri;* 62 *Arraztarangaña;* 63 *Karea;* 64 *Larrarte;* 65 *Mandubi Zelaia;* 66 *Etxegarate;* 67 *La Atalayuela;* 68 *Longar;* 69 *Arantzazu;* 70 *Nardakoste;* 71 *Collado del Mallo;* 72 *Peña Guerra II;* 73 *Peña Guerra I;* 74 *Collado Palomero I;* 75 *Collado Palomero II;* 76 *Kobaederra;* 77 *Santimamiñe;* 78 *La Chabola de la Hechicera;* 79 *San Juan ante Portam Latinam;* 80 *Alto de la Huesera;* 81 *Layaza;* 82 *El Sotillo;* 83 *San Martín;* 84 *Atxoste;* 85 *Túmulo de la Sima;* 86 *Guerrandijo;* 87 *Las Yurdinas II;* 88 *San Quílez;* 89 *La Cascaja;* 90 *Kurtzebide;* 91 *Errekatxuetako Atxa;* 92 *Urratxa III;* 93 *Mendigana;* 94 *Arlampe;* 95 *Gobaederra;* 96 *Covachón III;* 97 *El Pendón;* 98 *El Hundido;* 99 *Alto de Reinoso;* 100 *El Mirador;* 101 *El Portalón;* 102 *Peredo;* 103 *Portillo del Arenal;* 104 *Arroyal I;* 105 *La Velilla;* 106 *La Llana;* 107 *El Toral III;* 108 *Fuentenegroso;* 109 *Cova do Santo;* 110 *Pala da Vella;* 111 *Quinta Água Branca;* 112 *Agra de Antas.*

worked a new resource, namely salt (*Plata Montero 2020*). Shortly afterwards, the case of Lagunas de Villafáfila points the massive exploitation of salt (*Ayarzagüena* et al. *2017*), and it seems clear that the related activity went beyond self-supply and trading networks had to be established. To this new source of wealth the beginnings of metallurgy were added. The emergence of a new economic order brought with it social innovations such as Bell Beaker pottery or ornamentation on exotic materials, entailing mining practices. This new material culture is almost exclusively visible in the funerary sphere. In fact, in the northern half of Iberia, apart from the funerary structures themselves, the typological and material distance between the grave goods of the first megalithic phases and following ones is the clearest testimony to the changes experienced by progressively more complex societies (*Parcero-Oubiña, Criado-Boado 2013*).

Chronometry

Given the continuous deposition of bodies in the enclosures, it is very difficult to determine the beginnings and phases of collective funeral systems. In recent years, the reiteration of dates on human bones has made it clear that megalithic burials did not constitute a homogeneous process; on the contrary, different phases of use have been identified, separated by hiatus. The same dynamic is repeated in natural enclosures. Being able to place these dynamics into defined periods gives us the opportunity to relate them to the cultural changes that we already know and to reflect on the processes of continuity and change.

In this paper, we collected 389 radiocarbon dates from 112 funerary sites in caves, rock shelters and built architecture in the north of Iberia from the period 5315–2550 ^{14}C BP. A total of 154 come from 46 natural enclosures and 235 come from 66 megaliths (simple dolmens, passage graves, hypogea and burial mounds) (see Supplement). We only take into account the results obtained on human bones with standard deviations of equal or less than 100 years.

As far as we are concerned, the number of dates that constitute the sample and its quality give robustness to the exercise. Despite the geographical dispersion, the bibliography shows the existence of a cultural relationship between the different records in the catalogue, represented initially by the San Martin-El Miradero cultural facies and, later, by the development of the Bell Beaker complex *(Delibes* et al. *2012; García-Martínez de Lagrán* et al. *2005*). The discovery of spatula-idols (Fig. 7.c) first in the dolmen of San Martín (La Rioja), and later in the collective burial site of El Miradero (Valladolid), was the reason to culturally connect both geographies. Currently, we know of around 100 pieces distributed by graves in the basins of the rivers Ebro and Duero. At a later date, the Bell Beaker culture was also expressed in a singular way in the same region, with the development of the Ciempozuelos beaker variety, as well as in international and mixed decorations, which are elements that can be used to trace exchange networks (*Alday 2001*). In the same way, although in a different geographical direction, the raw materials of siliceous manufactures link sites that are very far apart from each other (*Tarriño, Mujika-Alustiza 2004*). In short, the region shares not only a common desire to erect dolmen structures, but also assumes common models and interests in habitat types, economy or material culture.

From the available dates for collective burials, we selected those obtained from samples coming from human bones, discarding, among others, the values on charcoal samples. Consequently, we eliminate the disparities caused by the 'old wood effect' (*Bowman 1990*). It should also be considered that the dates of human remains provide us with the moment of burial, while charcoal may have different origins – it may come from land clearing, natural fires prior to the construction of the dolmens, earth moving, and so on.

Before discussing the methodology implemented and its results, we should stop for a moment to consider the nature of the events that are dating our ^{14}C series. When we work with samples from human bones, we place in time the moment of death of a given subject. In this way, the radio-chronological phases are constructed from a unique meaning of the concept 'use of the tomb': that concerning the act of burial of an individual in the grave – always under the assumption of synchrony between death and burial. Therefore, exclusively radio-chronological approaches to the identification and determination of the duration of use cycles must be properly weighed. As opposed to the short life cycles to which the ^{14}C dates point, we cannot discard the idea that the use was extended in time through recurrent rituals of the human group linked to the tombs, despite not receiving new burials.

Methodology

For the analysis of the probability distribution of the data set we use the Kernel Density Estimation (KDE) proposed by Christopher Bronk Ramsey (*2017*), which is an alternative to the sum of the probability distribution that combines the use of Kernel density with a Bayesian model. The method assumes that the events we are analysing are not completely independent. Among the advantages of the implemented procedure we would like to highlight: the reduction in the noise inherent to the sum of the probability distribution that, sometimes, makes it difficult to observe the underlying distribution; the decrease in the uncertainty associated with the sample bias; a lesser effect of the uncertainties of each of the dates; and its good performance in multinomial distributions (*Bronk Ramsey 2017*; *McLaughlin 2019*). However, this approach has some limitations when it comes to identifying the abrupt end of a phase, an issue we will return to later (for a general critique of Bayesian dominant paradigm, see *Weninger, Edinborough 2020*).

On the procedure and its limits let us simply recall the reflection of Bernhardt Weninger *et al.* (*2011.17*) here: *"Most importantly, however, perhaps we should not overlook the simple fact that it has never been claimed that Bayesian analysis can provide a closed solution to all archaeological applications, under all circumstances."* Certainly, it is necessary to have good control over each sample, its context and meaning in order to clarify the conclusions of this type of exercise, otherwise we sum up things that we do not understand. This is, moreover, fundamental because sometimes the trends that are marked by statistical modelling are opposed to the particular results of some samples: this is because statistical 'outliers' may not be sampling errors, reporting, on the contrary, concrete human actions that impede the standardization of historical processes.

Results

Figures 2 and 3 show the modelling resulting from the KDE method and the sum of probabilities of burials in rock shelters/caves and constructed structures, respectively (the attribution of each radiocarbon date to each specific moment based on the standard deviation and median of the marginal posterior distribution can be found in the Supplement. The incorporation of the results of the latter method is done in response to the fact that the algorithm implemented in the KDE blurs the abrupt phase endings (*Bronk Ramsey 2017*). Our knowledge of the archaeological record leads us to think that many of the observed funerary cycles had an abrupt end and, sometimes, their origins were also sudden. Therefore, the distribution of the sum of probabilities is a complementary approach in order to better define them.

From a radio-chronological point of view, we can observe that the practice of using natural structures such as collective graves begins in the second half of the fourth millennium BC (*c.* 3500 cal BC). Although, in fact, during the Mesolithic and Early Neolithic periods, individual burials were occasionally practiced between levels of occupation – Aizpea, La Braña, Los Canes or J3 are some examples of this (*Barandiarán, Cava 2001*; *Vidal* et al. *2008*; *Iriarte* et al. *2010*; *Arias 2012*). Their meaning and rituality, however, had no connection with what we are dealing with now. The beginning of this practice is abrupt, configuring a

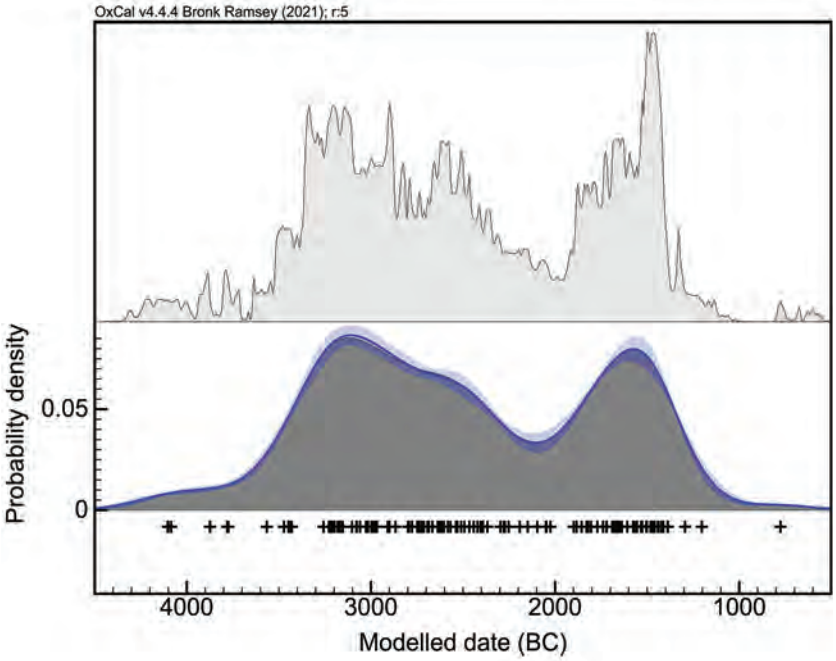

Fig. 2. KDE for the ^{14}C dating set from the inhumations in natural enclosures, performed with OxCal v4.4.4 (*Bronk Ramsey 2017; Reimer *et al.* 2020*). In dark grey the KDE estimated distribution; blue line for the mean value; blue band for the standard deviation (±1σ); light grey for the sum of the probability distributions; black crosses for the medians of the marginal posterior distributions for the events from the KDE.

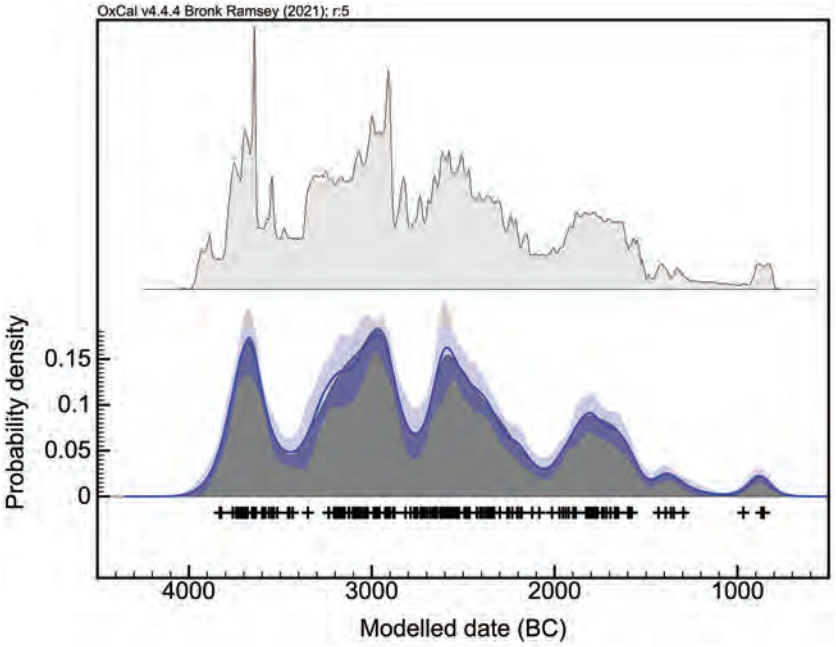

Fig. 3. KDE for the ^{14}C dating set from the inhumation in megalithic architectures, performed with OxCal v4.4.4 (*Bronk Ramsey 2017; Reimer *et al.* 2020*). In dark grey the KDE estimated distribution; blue line for the mean value; blue band for the standard deviation (±1σ); light grey for the sum of the probability distributions; black crosses for the medians of the marginal posterior distributions for the events from the KDE.

first phase of great vitality until *c.* 2350 cal BC. Afterwards, the use of caves as burial sites is sporadic for 600 years (*c.* 2350–1900 cal BC), at the end of which a new cycle began, from *c.* 1900 to 1400 cal BC.

The constructed structures, instead, are spread in five phases. The tradition is inaugurated *c.* 3800 cal BC and went on for almost three centuries. A second phase, of as much importance as the previous one, is found in the area of study from *c.* 3250–2900 cal BC. A third one takes up the short but active time span *c.* 2750–2200 cal BC. The fourth one is developed by the first half of the second millennium, with an epilogue of later punctual reuses. The pattern is thus of relatively short cycles with parentheses of several generations with very few burials.

It is easy to observe discrepancies and coincidences in the funeral dynamics between both types of burials. Firstly, the phase of origin of the constructed pantheons is not reflected in the burial caves. Secondly, the first cycle observed in the caves covers the second and third cycles of the constructed structures. Finally, the last phases of both types of pantheons are simultaneous. If it is not a problem of method, the parallelisms cannot be independent, nor their concurrence due to randomness: they would correspond, therefore, to concrete social and ideological situations, about which we will say more later.

In summary, the dynamics of collective tombs distinguish five phases and three hiatuses – where the case of collective burial caves must be matched, as we have pointed out.

Origins (c. 3800–3550 cal BC)
The construction of the first megaliths was set in place by communities that carried out a stable production economy in valleys and mountains. These are simple structures, such as those of the Catalan pre-Pyrenees (*Castany i Llussà 2009*) – perhaps not megalithic and with more individual than collective development (*Molist, Clop 2010*) – or of marked monumentality such as those of La Rioja (*Galilea 2011*). They are represented by the San Martín-El Miradero funerary facies (*Delibes* et al. *2012*), at least in the northern half of the region, and what was once called the 'Pyrenean culture' (*Pericot 1950*). Probably in the pre-Pyrenean area some monuments were closed after the end of this phase – at least, they have neither more advanced dates nor grave goods. However, it will be necessary to discuss the significance of some dates which, due to their antiquity, fall outside this chronological framework.

First hiatus (c. 3550–3250 cal BC)
This period was two and a half centuries in which, in general, the graves ceased to receive new burials.

Generalization (c. 3250–2900 cal BC)
Together with the erection of new structures, several of the preceding ones underwent a new cycle of use. In the course of this phase, various signs of violence have been observed, as well as, at the end of the cycle or perhaps in the hiatus that followed it, actions of destruction, closure and 'appropriation' of some monuments. It is noticeable that in several inhumations (Aizibita, Charracadía, La Chabola de la Hechicera, Larrarte) most of the dated individuals belong to this phase, but there is little or no evidence of representative archaeological material assigned to these

chronologies, and what has been recovered belongs to more advanced phases. It is also interesting to note that the end of this phase coincides with the presence of the first flat-retouched arrowheads, which replace the earlier projectiles (microliths chipped tools). Should the profusion of these objects in many of the funerary enclosures be read in conjunction with the signs of violence?

Second hiatus (c. 2900–2750 cal BC)
This was an interlude of 200–300 years in the early stages of the Chalcolithic, often referred to as 'Pre-Bell Beaker', and where acts that could be described as punitive were continued, or even increased, from the previous phase.

Third phase of activity (c. 2750–2200 cal BC)
Related to the 'Bell Beaker impact', this phase manifested in the megaliths but not in caves. It is remarkable that this 'impact' materializes in the international maritime and mixed versions, as well as in the classic decorative patterns and syntax of the Ciempozuelos beaker variety, offering homogeneous features in the collections of the western part of the region, since they do not appear in the pre-Pyrenean dolmens. Elements of personal ornamentation on exotic materials, probably for the display of wealth, also make their appearance, as well as the first manifestations of metal (*Alday 1992*; *Soriano Llopis* et al. *2012*). We observed once again architectural remodelling of the monuments.

Third hiatus (c. 2200–1950 cal BC)
This corresponds to the development of regional household Bell Beaker pottery of the second half of the Chalcolithic period. It is characteristic of dwelling locations, but not from the burial ones.

Fourth phase of activity (c. 1950–1500 cal BC)
This phase comprises the first half of the Bronze Age, as it is reflected in radio-chronological data and the presence of metallic remains. The more communitarian nature of the grave goods of the first stages would be surpassed, given the sumptuary and personal characteristics of these new items. An example of the relationship between prehistoric materiality and social relevance may be Gobaederra cave (*Apellániz* et al. *1967*), which has a set of metallic daggers and punches, perhaps associated with one of the around 100 buried individuals (see below).

Late uses (c. 1450–1250 / 1000–800 cal BC)
Rare burials in caves and dolmens
The proposal of cycles in the use of collective burials is based on the combination of radio-chronological values, and confirmed by analysing the particular biographies of dolmens with a sufficient number of ^{14}C dates to cover all or part of the time span of their use. Unfortunately, caves cannot be part of this exercise since a limited number of individuals per grave have been dated.

Thus, for example, in the dolmen of La Chabola de la Hechicera, each and every one of the above-described phases of use and hiatus are documented. Radio-chronology concentrates most of the inhumations in the first two phases (Fig. 4), and the material culture – incised-impressed Bell Baker pottery, necklace beads on exotic materials, and flat-retouched arrowheads *(Apellániz, Fernández Medrano 1978*) – attested the mortuary rites of the dolmen during the third phase. The first megalithic phase is represented in San Martín, and, even if the radio-chronology does not suggest it, the material culture gives a clear indication of the presence of the rest of the phases *(Barandiarán, Fernández Medrano 1964*). A similar circumstance occurs at Alto de Reinoso, despite the destruction of the upper levels of the tomb (*Rojo-Guerra* et al. *2015*). The radio-chronological biography of the Mandubi Zelaia dolmen runs through three of the proposed phases, to which a late burial can be added (*Mujika-Alustiza, Edeso 2011*) (Fig. 4). At Sotillo, although there is no radiometric evidence, the grave goods suggest that it was built in earlier phases (*Barandiarán* et al. *1971*), thus completing a biography in accordance with the described phases (Fig. 4). At Collado del Mallo radio-chronology draws three of the cycles – the first of which comes from infratumular deposits (Fig. 4) – the Bronze Age cycle not being present. Its closest neighbours Collado Palomero I and Peña Guerra II follow approximately the same pattern. The first two phases are also present at La Velilla, but neither the chronology nor the materials recovered attest to a later use (*Zapatero 1991*) (Fig. 4). As a final example, several funerary phases have been described in the dolmen of Arroyal I (*Carmona* et al. *2014*) (Fig. 4). In short, the recognition of phases and hiatuses in the particular biographies of the dolmens vindicate general trends, while they tell particular stories. Several studies on the biographies of European megaliths stress this idea (*Bayliss, Whittle 2007*; *Schulting* et al. *2012*; *Sévin-Allouet 2013*; *Marçais* et al. *2016*).

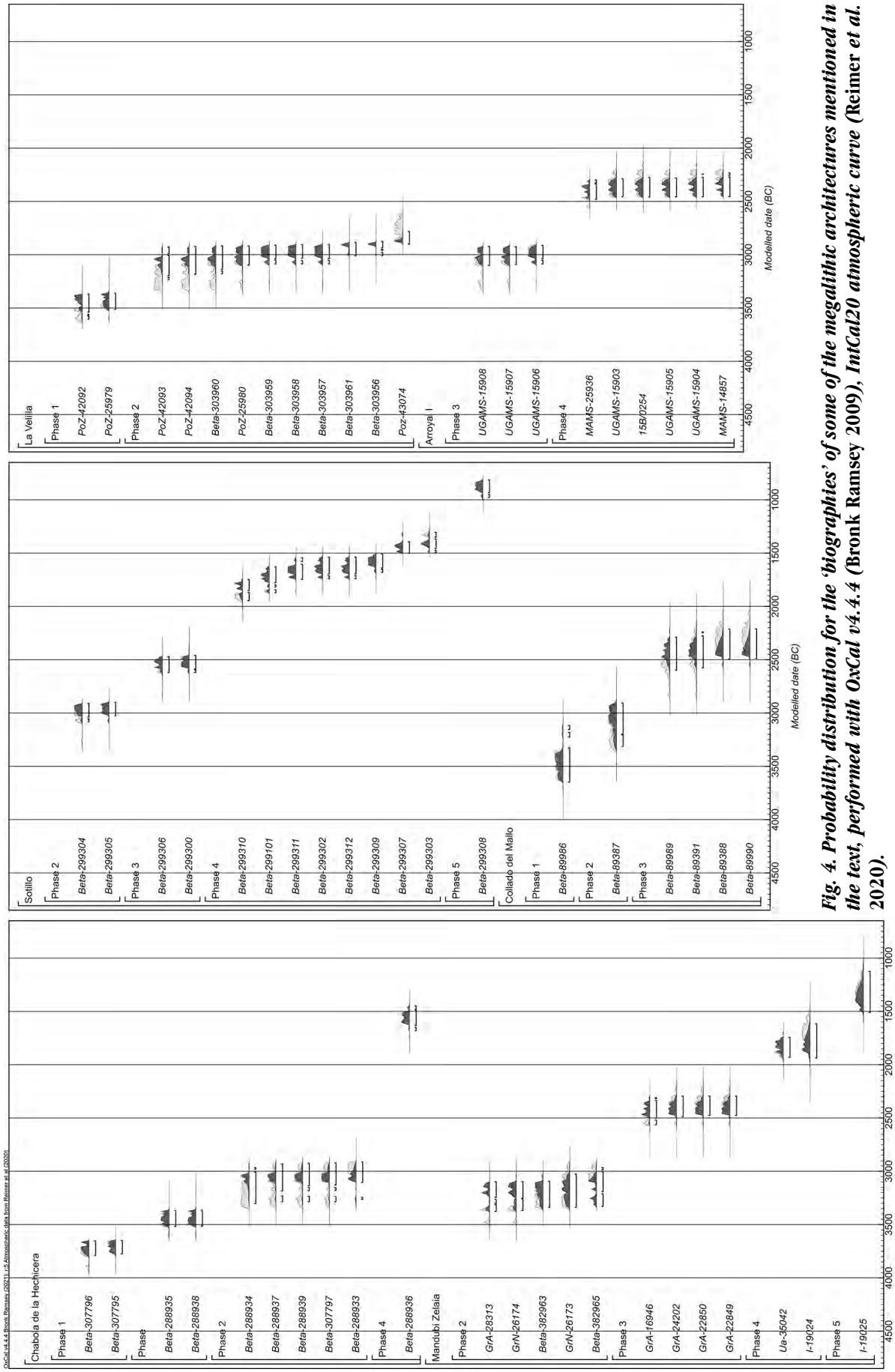

Fig. 4. Probability distribution for the 'biographies' of some of the megalithic architectures mentioned in the text, performed with OxCal v4.4.4 (*Bronk Ramsey 2009*), IntCal20 atmospheric curve (*Reimer *et al.* 2020*).

Structures

When we are in front of a dolmen, we should be aware that the legacy is the result of its construction, cycles of use and abandonment, closures, additions, rites, the vicissitudes of time, the actions of thieves and scavengers and other possible circumstances over which we have no control (*Álvarez 2003*). This means that each monument had its own 'non-innocent' history. It is thus not easy for an archaeologist to identify the processes that have taken place in each case; nor even, sometimes, to distinguish what corresponds to human intervention and what to collapse due to the course of time.

In the Iberian context, several researchers have documented the possible use of materials from previous structures in the construction of new monuments: flagstones at Azután, Gorriquía, Navalcán, Pedra Escorregadia, Puerto de los Huertos, Reguers de Seró or Soto (*Villoch 1998*; *Gavilán, Vera 2005*; *López* et al. *2009*; *Linares, García-Sanjuán 2010*), and wood at El Barranquete. Such dismantling of pre-existing architecture or the subsequent 'repair' of dolmen structures must be read in a social key: it is not a question of shoring up deteriorated monuments, or enlarging them to make place for new burials, as most likely the purposes of such actions were of a different nature, and only the society that carried out these works has the real key to their meaning.

We can observe the magnitude of this phenomenon by focusing on one of the regions in our study area: the upper Ebro basin, to which we will add the cases of some dolmens that are nearby. It is easy to increase the evidence, but we believe that the information we are going to relate is sufficient to support an underlying hypothesis: given the coincidence of these 'arrangements' in the pantheons with the first phases of use and hiatus reported by the ^{14}C, the actions must be considered as intentional and premeditated, not random at all.

At the sepulchre of La Mina, a cist-like enclosure was added to the original space of the chamber to give access to a burial, probably Bell Beaker (*Narvarte 2007*).

In San Martín, the archaeological excavation certified the fall, probably intentional, of the biggest flagstone of the chamber, occupying most of its surface and separating an ancient phase of burials from a more modern one; each one with its corresponding clearly differentiated grave goods (*Barandiarán, Fernández Medrano 1964*). The precinct of the lower level of the dolmen occurred in a *terminus post quem* date of 3643–3518 cal BC.

The neighbouring dolmen of El Sotillo reproduces the same situation, although the size of the flagstone was smaller and the separation of the levels was not so clear (*Barandiarán, Fernández Medrano 1958*).

The tumulus of the great pantheon of Aizkomendi was expanded in a second construction operation (*Barandiarán 1964*).

A series of excavations recently undertaken on one of the most impressive dolmens in the Basque Country, San Sebastián Sur, have allowed us to verify that its original chamber was blocked by one of the large flagstones of the corridor, which was adapted as a second adjacent chamber (Fig. 5). These changes made it necessary to reform a large part of the tumulus, on which there are also visible fires for its probable closure.

The recent excavation of the megalithic structure of Pariburu has revealed a first and singular construction which, in a second phase, was partially dismantled in order to build a new one based on the previous one (Fig. 6).

In Kurtzebide, fieldwork revealed the presence of ditches that must have supported several orthostats that were removed in a dismantling operation (*Vegas 1981*).

Excavations at the dolmens of La Cotorrita and Ciella revealed, as in the case of the other mentioned monuments, the collapse of some flagstones (*Narvarte 2005*), which can be understood as part of these actions of architectural remodelling.

The meticulous excavations in the sepulchre of Arroyal I have determined different phases of use and remodelling, in accordance with the radio-chronological information available (*Carmona* et al. *2014*). Here too, as in the case of San Sebastián Sur, a flagstone closed off the original chamber, separating it from the access corridor.

In the pantheon of Mandubi Zelaia, the burials and grave goods from the first half of the fourth millennium were covered by a flagstone over which evidence

Fig. 5. Left, general view of San Sebastián dolmen; right, northern cut:* a *earth tumulus from the second construction phase, actual filling;* b *stone tumulus from the second construction phase;* c *earth tumulus from the first construction phase;* d *stone tumulus from the first construction phase.

from the second half of the third millennium was recovered (*Mujika-Alustiza, Edeso 2011*). The closure occurred around 3201–2410 cal BC (x̃: 2893 cal BC). The roof of the hypogeum of Longar was fractured and caved in, sealing their contents in a *terminus post quem date* of 3341–2924 cal BC (*Armendáriz, Irigaray 1994*). In this case, we do not really know to what extent a natural accident or anthropic causation is involved.

The 'biography' of the sepulchre of Collado del Mallo had at least three stages of remodelling and use that changed the original design (*López de Calle* et al. *2001*).

In the construction of La Atalayuela, the first structure conceived as a 'house for the dead' was transformed into a classic tumulus of Bell Beaker typology. A remodelling that also affected the funerary rites – from

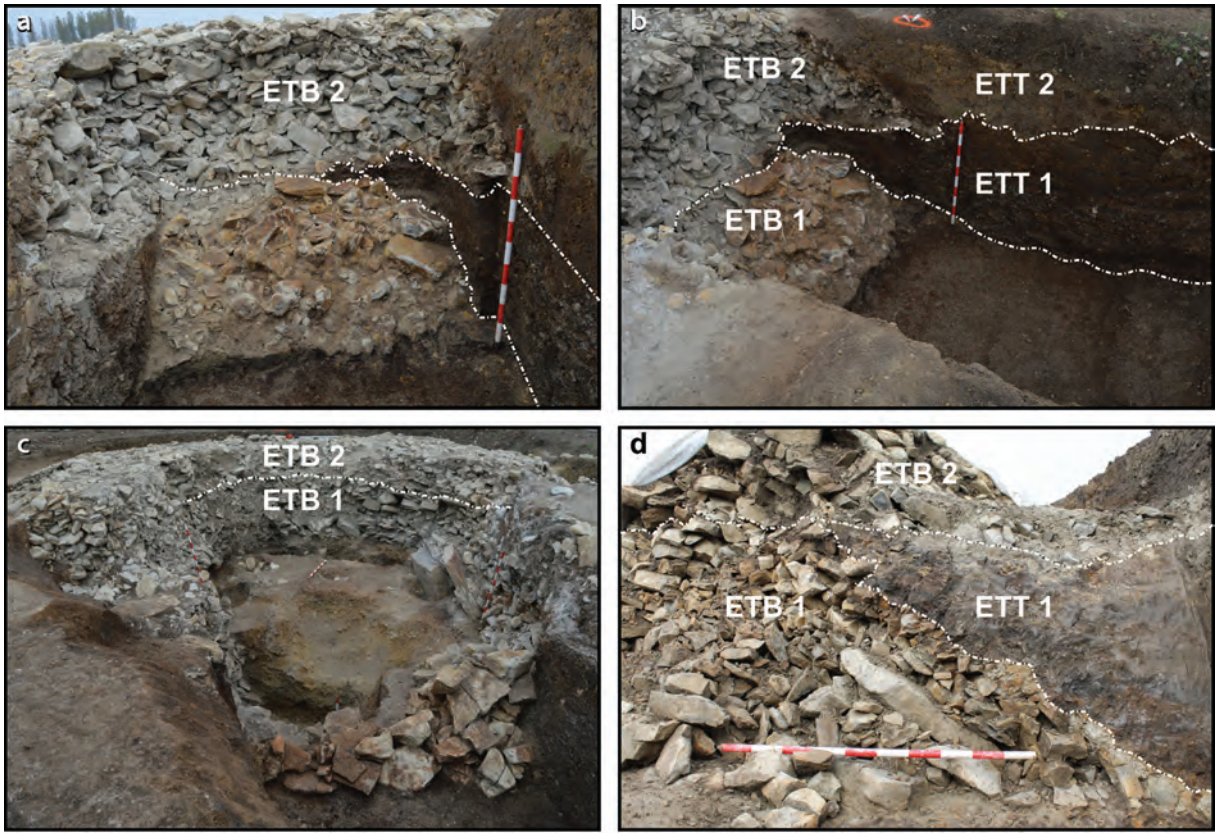

Fig. 6. Excavation process of the Pariburu dolmen:* a, b *western cut;* c *general view once the orthoses are lifted from the chamber;* d *eastern cut.* ETB 1 *is the stone tumulus structure of the old phase, covered by* ETT 1 *or earth tumulus structure of the same phase; at a second stage, the building was levelled to construct a new one where* ETB 2 *is a new stone tumulus structure,* ETT 2 *the earth tumulus structure that ends up covering the entire assembly.

individual collective to simultaneous collective – (*Andrés*, *Barandiarán 2004*), in the 'appropriation' sense, without discarding the idea of 'continuity'.

The dolmen of Peña Guerra II includes two chambers, an eccentric one that preserved the corpses of a previous tomb and a central one, more typical of a normalised sepulchre (*López de Calle, Ilarraza 1997*).

Collado Palomero I shows three funerary phases that include notable architectural and ritual changes (*López de Calle, Ilarraza 1997*).

The Tres Montes tomb is of a very original conception (*Andrés* et al. *2002*), with bone packages in secondary position and individuals in anatomical connection, the result of actions that included the closure, redesign and reuse of the monument.

The tumulus of La Mina revealed that the primitive passage grave was completely dismantled and its ossuary was covered with a tumulus so that it would not be completely destroyed. A second grave was built with the elements of the original monument (*Rojo-Guerra* et al. *2015*).

These examples suggest that – especially in our study region – the megalithic monuments were live buildings (see *Abad 1996*), which were architecturally updated in accordance with the changing social interests. Sometimes this occurred by closing the structures and their contents – in the case of Soria, the spectacular lime-kiln tombs attest to these actions (*Rojo-Guerra* et al. *2004*). In others, by altering their nature with additions that required significant investment of labour, in some cases, by individualizing chambers and corridors and in the most remarkable cases by building new monuments with materials from older ones.

It would be an error to consider each of the cycles of use of a given funerary structure as a rupture – in a cultural, not stratigraphic sense – with the preceding tradition. Some reuses could well represent a renewal of the community's ritual towards a space that continues to be considered sacred (*Sévin-Allouet 2016*). Others, instead, would respond to a desire to break with the past. It has long been rightly argued that the act of closing an inhumation may respond to a dual and opposing intentionality: preservation *versus* punitive destruction (*Andrés 2000*).

In the light of such dynamics, questions pile up, especially in order to infer the social impulse behind them. For example, are lineages within the same community responsible for the closures and reoccupations, which take over from the previous social order and probably imply a change in the mechanisms of power? Should the structural modifications of the architecture be interpreted as indicating the arrival of new groups or individuals who infiltrate, taking social command, subduing the buried ancestors to new ritual norms? These two questions are integrated in a common dynamic that reinforces the social crises, which we believe to be present in the record of the end of the Neolithic and the early metal ages.

In the case of natural enclosures, it is not easy to observe whether they were affected by changes in conception. Except in singular cases – El Portalón de Cueva Mayor de Atapuerca (*Pérez-Romero* et al. *2017*) – the absence of artificial structures in them reduces the possibilities of analysis. However, what has been documented on some occasions is the transformation of the function of the speleological space, superimposing another of an economic nature on the former vocation of sanctuary. A good example is Peña Larga rock shelter. The collective burial phase is stratigraphically inserted between an Early Neolithic past of habitation and another of use as a sheepfold for livestock management, after burning the human remains that were buried (*Fernández-Eraso 2008*), but we cannot say if this should be integrated into the social changes that we attribute to dolmen dynamics. At San Juan Ante Portam Latinam, not long after the burials were made, the roof of the rock shelter fractured and collapsed, closing and preserving a large part of the remains (*Vegas* et al. *2012*). This event, whose punitive nature we can speculate on, occurred in a *terminus post quem date* 3328–2701 cal BC.

Grave goods

In the chaos of bones and materials typical of megaliths and burial caves, it is not easy to sequentially order the materials left as relics, offerings or grave goods. Even the distinction of what are truly grave goods and what are integrated as part of other actions – for example, weapons placed in the body of the deceased – is a matter of discussion. Certain stratigraphies have made it possible to distinguish material lots ascribed to more or less defined cultural/chronological phases. The clearest case, which has served as a guide when interpreting the material inventories of the

dolmens of the northern half of Iberia, is that of San Martín (*Barandiarán, Fernández Medrano 1964*). Two questions are of particular interest to us in this regard.

(1) That the material lots serve as a complement to the chronological information provided by the ^{14}C. It should be noted that while only a small part of the human remains of a pantheon is dated by the ^{14}C, the grave goods represent, in principle, the entire time in which the tomb was in use.

(2) That while chronologically we observe five funerary phases, we only venture to make two 'packages' with the set of the usual material inventories of the tombs, to which we can occasionally make some warnings due to the specificity of very representative objects – for example, those metallic ones that identify advanced burials. Logically, in these circumstances, it is not easy to fit the temporal quadripartite division with the dual material division. In fact, the flat-retouched arrowheads belong to the second grave goods 'package' (Fig. 7.b), being present both at the end of the second funerary phase – from a chronological perspective – and in the subsequent ones. In contrast, the classic Bell Beaker pottery, also included in the second 'package', makes its presence felt in the third chronological cycle.

It is clear that there is not always concordance between the radio-chronology and the information from the grave goods. For example, in the monument of La Chabola de la Hechicera most of the dated burials belong to the first phases of megalithism, but most of the archaeological materials recovered are from more advanced phases – in particular, those associated with the Bell Beaker ritual were recovered outside the burial chamber, in the tumulus. The suggestion would be that, in this case, the first burials were deposited without any personal or communal grave goods, which socially converts these burials, assuming we understand that there is a direct correspondence, as figuratively 'democratic'. The phenomenon would go unrecognized were it not for the fact that it is repeated in other funerary contexts. Clearly in the dolmens of Aizibita and Charracadía, and probably – although with less certainty as fewer remains have been dated – in the Larrarte burial site. In all of them, the third phase corresponds to a smaller number of burials, but to more numerous, varied and personal material depositions. Therefore, in contrast to the previous idea, we would be dealing with less 'democratic' and more segregated rites.

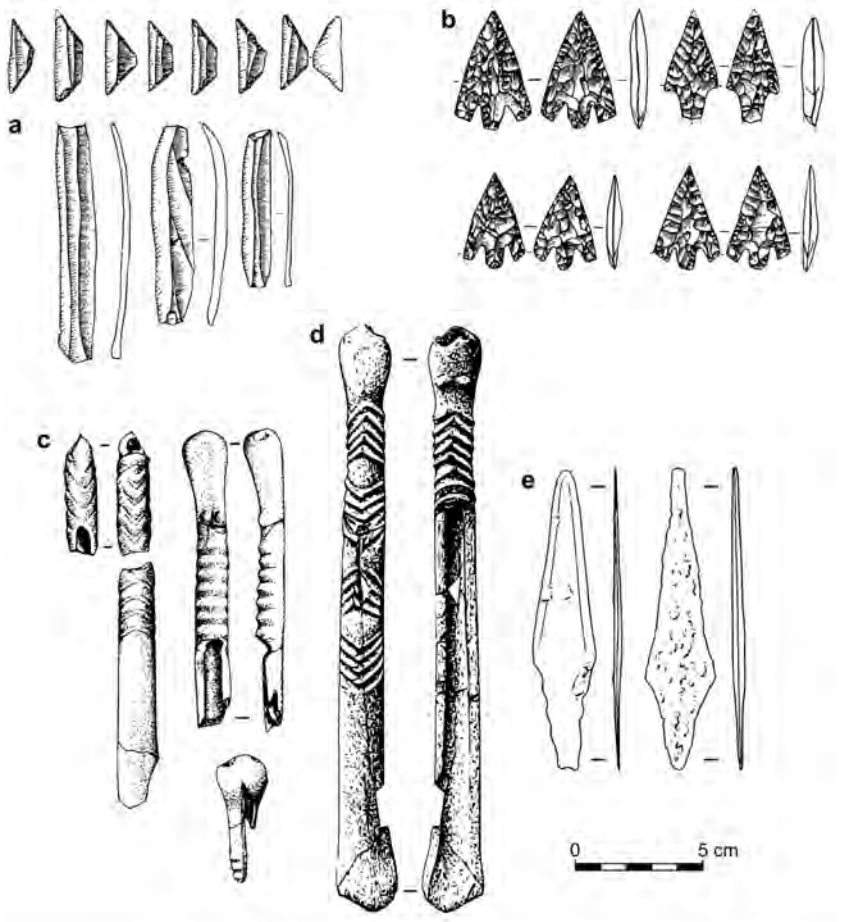

Fig. 7. **a** ***Lithic industry from San Martín (geometric microliths, lithic blades), ancient phase of megalithism (adapted from*** **Cava 1984*);*** **b** ***Lithic industry from El Sotillo (arrowheads), advanced phase of megalithism (adapted from*** **Cava 1984*);*** **c** ***Spatula-idols from San Martín, ancient phase of megalithism (adapted from*** **Andrés 1981*);*** **d** ***Spatula-idol from La Velilla, ancient phase of megalithism (adapted from*** **Zapatero 1991*);*** **e** ***Daggers from Gobaederra, advanced phase of megalithism (adapted from*** **Apellániz *et al.* 1967*).***

In accordance with what we have pointed out concerning the remodelling of the structures, as an alternative, it could also be speculated that some burials

were emptied and reused by a community that was different to the one that built them. Perhaps two representative cases would be the megalithic structures of El Sotillo, where the geometric microliths so characteristic of the early grave goods do not correspond with their radio-chronological information; and Pariburu, where there is no concordance between the size of the pantheon and the volume of their contents, neither between their microliths and the date of the only individual who was saved from the 'cleaning'. In this second example, what is evident is that the structure had a greater social significance than the buried and their grave goods.

On the other hand, the dolmen of San Martín reveals a different situation, since the excavations have identified two funerary phases in its chamber – immediately below and above the large flagstone that interrupted the practice of burial. Both have an acceptable number of individuals associated at each phase with rich and varied grave goods, Pre-Bell Beaker in the earlier phase (Fig. 7.a,c) and Bell Beaker in the more modern one. This means that either the practice of no or few grave goods in the first phase is not uniformly applicable for all the megalithic period – which turns the social interpretations upside down – or the shortest route was chosen here: instead of emptying the pantheon, it was decided to invalidate it and hide its contents by breaking down the flagstone of the chamber.

However, the presence and chronology of the so-called 'spatula-idols' is very remarkable in San Martín: objects commonly made on ovicaprid tibia that could well be abstractions of female bodies (Fig. 7.c,d). Discovered for the first time in pantheons in Araba, today we know of around 100 such objects distributed in about twenty tombs in the northern plateau of Iberia – plus some cases from outside this region (*Delibes* et al. *2012*; *Bellido 2015*). Very interesting are the radio-chronological values given by the dating of the two spatula-idols from San Martín (*Fernández-Eraso* et al. *2015*). The dates of 4335–4060 cal BC (Beta-339342) and 4904–4709 cal BC (Beta-317865) turn out to be from 500 to 1000 years earlier with respect to the first individuals buried in the dolmens, and it is evident that we need to consider this issue in more detail.

There is one more element of the funerary grave goods that deserves attention: the flat-retouched arrowheads that are found at the end of the second funerary phase, just before the following generations decided not to bury their dead in the megalithic tombs and proceeded to ruin them – at least partially. First of all, we must ask ourselves about their origin in these Chalcolithic times. It is true that, at first look, they do not seem to be an evolution, from the technological point of view, of the Neolithic projectiles, so it is understandable that an allochthonous origin or inspiration has been suggested (*Andrés 1998*). However, some levels of habitation sites do seem to show the reduction of some early prototypes of these points *(Alday 1998*), which over time will evolve into the usual forms found in dolmens and burial caves. In any case, we suggest that there must have been a more or less direct relationship between the presence of these new projectiles at the end of the second funerary phase, the abandonment for a couple of centuries of the practice of burying in communal pantheons, and the evidence of violence in several burials. However, it is not easy for the archaeologist to define the degree of generalization of this violence, how many people were involved and whether it was intergroup, intragroup or a combination of both. To get an idea of the situation, in the nearby sites of San Juan Ante Portam Latinam, Longar and Las Yurdinas, traces of violence – very striking in the first two cases and less so in the last one – have been detected that deserve an explanation (*Armendáriz, Irigaray 1994*; *Rivera 2011*; *Fernández-Crespo, De-la-Rúa 2015*; *Fernández-Crespo* et al. *2018*). The most classical explanation is that of a competition for territories and their resources, but other alternatives should not be excluded (*Esparza* et al. *2008*). Moreover, in funerary deposits from the east of the region violent actions are also alluded to as a cause of death of some of the inhumed (*Daví i Salvanyà 2019*).

There are several lessons to be learned from these brief reflections on the grave goods of collective burials.

(1) That the nature of the grave goods and their distribution inside the tombs would define two funerary phases: there were probably more, but the jumbled arrangement of the materials in the ossuaries does not allow us to detail them.

(2) That, with a few exceptions, the grave goods of the first two chronological phases are discrete – or simply did not exist – giving a more 'democratic' character to the burials. This idea of egalitarianism in the face of death does not exclude the possibility that society

established minimum rules, or biases, about who should rest, and who should not, in these funerary monuments (*Fernández-Crespo, De-la-Rúa 2015*).

(3) That, in what is a clear ideological evolution, in the third funerary phase some of the deceased are buried with objects that identify personal prestige – whether related to power, wealth or for other reasons. An example of a relationship between prehistoric material and a relevant social individual is the Gobaederra cave (*Apellániz* et al. *1967*), with a set of daggers and metal awls probably associated with one of the around 100 people buried in the cave (Fig. 7.e).

(4) That, therefore, the symbolic value that the grave goods of the first 'package' – evident in the spatula-idols – seems to transmute to a more individual value in the second 'package', such as the necklace beads on exotic materials (*Alday 1987*; *Borrell, Bosch 2012*; *Odriozola* et al. *2016*).

(5) That the presence of projectiles in some cases may have originated in violent deaths, while in others they may be funerary depositions.

(6) That, in general, it can be deduced that the sense, volume and nature of the grave goods of each funerary phase varied considerably, as has been previously documented, for instance, on collective graves in the Paris Basin (*Sohn 2002*).

Discussion

Previous radio-chronological approaches

This is not the first time that analysis of funerary practices has been approached from the perspective of ^{14}C. It is, however, one that deals with it from a greater number of radio-chronological references, which we also compare with those of other regions and non-funerary sets. In Iberia interest has focused mainly on the megalithic phenomenon in southern Spain and Portugal (*Boaventura 2011*; *García-Sanjuán* et al. *2011*; *Lozano and Aranda* 2017; *Carvalho, Cardoso 2015*). The proposals contained in these works have certain similarities with our numerical evolutionary modelling of funerary practices for the northern half of Iberia – with the exception of our identification of two phases for the Neolithic. However, if we take into account the large number of dates that integrate our study, the exclusive selection of human bone samples – as opposed to those evaluations that mix them with charcoal samples – and the use of advanced statistical techniques, we believe that the proposal presented here is more robust.

Among the exclusively radio-chronological approaches to the megalithic phenomenon, the recent work of Schulz (*2017*; *2019*) stands out; among other reasons, because his conclusions have crossed over the walls of academia. Without diminishing the relevance of the enormous effort of working with 2401 dates from pre-megalithic, megalithic and non-megalithic contexts on the European continent, nor the general validity of his conclusions, the chronology that he establishes for our study region differs from the one that we use. Thus, Schulz places the expansion and rise of dolmenism *c.* 4000–3500 cal BC on the Atlantic slope of the northern Iberia – with even earlier dates for the northwest. We, instead, believe that this chronology should be delayed – which is mainly based on chronological values obtained from charcoal samples, whose direct relationship with the process of erection of the architectures is highly debatable.

The 'outliers'

Before rejecting certain dates as erroneous – considering that they do not conform to a pre-established cultural model – the singularity of some dates must be understood and interpreted in the cultural context in which the funerary dynamic takes place. This is the case, for example, of some dates of human remains from Iberian dolmens – not necessarily from the region under study, but which warn us of the problem – which seem to precede the time of their construction. The most plausible explanation is the transfer of ancient burials to the new structures that are now beginning to be erected for the first time. Alternatively, it could be argued that we are dealing with the first cases of built monuments. We are not convinced by this last possibility: neither do the grave goods suggest this, nor is there a territorial logic in which these cases appear, nor would the typology of the monuments support such a hypothesis.

Other dates, however, do not seem to fit the proposed model by placing some inhumation events between phases of use (see Fig. 4.). Nevertheless, perhaps these 'outliers' may be simple sampling errors, they may in fact refer to specific human actions that prevent the normativization of historical processes. Alternatively, they may also alert us to more local singularities that may define nuances in the different patterns of funerary development, thus preventing the deterministic application of general rules at small-scales. In any

case, this fact does not detract from the validity of the proposed model, as evidenced by the law of large numbers (*Bernoulli 1713*): even though a value of a variable may deviate from the expected value, repetition will enable us to approach the expected value.

The two phases

From the perspective of the definition of cycles of use, one of the novelties introduced by our work is the identification of two different phases in the so far considered first period of megalithism. Nevertheless, is this division real? Alternatively, is it merely a statistical 'artefact'? We believe that there are sufficient elements in the archaeological record to support the existence of two funerary phases, beyond the numerical control of the dating and their concentration in two time-steps.

The most eloquent is represented by the San Martín-El Miradero funerary facies and its characteristic spatula-idols. Their presence in the funerary record seems closely linked to the oldest inhumations of the earliest architectures of the western half of the study region, and their absence is very significant both in later inhumations and in the tombs of what we could call 'second generation'. Thus, these objects seem to be exclusive to the funerary rituals developed in the first half of the fourth millennium. They are, if we may use the expression, the 'index fossil' of the first phase.

This is not the only evidence that we have. The funerary activity of some of the artificial structures erected in the Catalan pre-Pyrenees area is, if this is not a research bias, limited to the first phase, after which they did not recover their activity (Ceuró II, El Llord I, El Vilar de Simosa, Feixa del Moro, Garrics de Caballol, Povia, Solar III, Tomba del Moro). They have the particularity of being simple semi-buried structures, of small sizes compared to those of the San Martín-El Miradero facies, which mostly contain dual burials – either individual or cumulative burials of up to a maximum of seven corpses (*Castany i Llussà 2009*).

As a third argument, already pointed out in previous sections, the particular radio-chronological biographies of those dolmens with extensive radio-chronological series clearly show two phases for the Early Neolithic. This last point leads us to reject the idea that the binomial drawing of the curve is the result of an overlapping of the same dynamics with different chronologies for the territories.

There is one last aspect that allows us to distinguish between the phases. If during the first phase burial in artificial enclosures is practically testimonial, it is during the second phase that the generalization or 'democratization' of burials in caves of a collective nature begins.

'Index fossil' issue

Some doubts arise when it is necessary to interpret the meaning and, especially, the management that the groups made of such characteristic objects as the spatula-idols. Their analysis is of special interest because their presence in the archaeological record suggests a community of interests in the territory under study, giving more certainty to the generalizing aspect of our reflections. It should be noted that the 100 or so documented artefacts have been recovered from pantheons built in very different ways: burials in pit graves (El Miradero), in roundels (La Velilla), in lime-kiln tombs (Túmulo de la Sima) or in passage graves (San Martín) (*Delibes, De Paz 2000*; *Delibes* et al. *2012*; *Bellido 2015*). In addition, two convergent facts should be highlighted: the first is that, overall, the spatula-idols belong to chronologies much earlier than those considered for megalithism; the second is that their only known extra-Iberian parallels refer us to the eastern Mediterranean (*Molist 1996*; *Mujika-Alustiza 1998*; *Taha* et al. *2017*).

At present, the three specimens that have been directly dated come from the tombs of San Martín and Kurtzebide (*Fernández-Eraso, Mujika-Alustiza 2021*). As we mentioned earlier, the dates give an antiquity for their base materials of between 500 and 1000 years before the first burials in Iberian megaliths. Given the temporal distance, we handle the hypothesis that the spatula-idols constitute relic goods that circulated in terms of generations before their definitive amortization at the time of the coming of the new funerary-ideological cycle, reflected on the megalithic architectures. However, are we faced with a break in funerary practices or, in contrast, perhaps we should interpret these secondary depositions as a kind of 'ancestral rites' (*Kinnes 1975*; *Barrett 1988*) and, therefore, of a certain continuity? Probably, in this case, the spatula-idols would play the role of a conduit of memories between a past and new rites. However, on other occasions the answers to these questions will depend on how we interpret the funerary record. In this sense, we turn our eyes once again to the dolmen of San Martín, but focusing on another moment in its biography, the episode of the col-

lapse of the great chambered flagstone, which must have occurred between the second and third of the chronological phases we have described. What was the intention behind the architectural readjustment of the monument? Was it an act of 'appropriation' of the previous ideological world in order to give continuity to a new funerary-ideological code? Or was it an act of destruction and, therefore, of rupture with the previous symbolism, since the enclosure housing the new burials is still the same? In short, San Martín can exemplify the development of different social behaviours in the face of death and what it represents in the life of the communities: (1) of paradoxical continuity – even though the construction of megaliths represents an unprecedented social challenge – with the amortization of the spatula-idols; (2) of continuity *versus* rupture, depending on how we interpret the voluntary readjustment of the original architecture by the demolition of one of its flagstones.

From a similar perspective, we should discuss whether other characteristic objects of the first two funerary phases also represented a role in the amortization of previous rites/ideologies: is this perhaps the case of the geometric microliths which, absent in contemporary settlements, are reminiscent of materials from the Mesolithic and early Neolithic periods? According to what has been documented in the tomb of San Quílez (*Alday* et al. *2008*), the scarce material that accompanied the buried would have an eminently symbolic character. The pantheon is located next to one of the most intensely exploited siliceous outcrops in regional prehistory (*Tarriño 2001*) and, nevertheless, the microliths and flint blades that were deposited as offered goods were made in a siliceous variety at least 100 linear kilometres away. It is not a better-quality material than that available at such a short distance away, but it is different from it because of its striking whitish colour, which is frequent in these objects that are so common in ancient dolmens (*Cava 1984*). In the case of San Quílez the burials are secondary, with a selection of what has been moved to the funerary enclosure. Perhaps this is a new case in which ideological changes require the ancient burials to be redirected towards the new ritual.

It is tempting to correlate these hypotheses with the certainty that orthostats from earlier structures were used in the construction of the new ones, with the limits imposed by the chronological certification of these recycled building materials – in other words, whether they took place during the first construction of the necropolis or in a second phase of its use. In this sense, both at Pedra Escorregadia and Azután – two of those cases with bone dates of ancient results – it is suspected that flagstones from earlier structures were brought in for the construction of the monuments (*Villoch 1998*; *Gavilán, Vera 2005*; *López* et al. *2009*; *Linares, García-Sanjuán 2010*). A similar idea was put forward by Rui J. N. Boaventura (*2011*) with regard to the pantheons of Monte do Castelo and São Pedro do Estoril (Portugal).

An agitated Neolithic

One issue that cannot be avoided in the analysis of social crises in the Early Neolithic to the Metal Ages is the aggressiveness or violence between groups. Interpersonal, intergroup or intragroup violence corresponded to instability situations. Paleoanthropological studies have identified episodes of violence in the referred territory. An exceptional case is that of San Juan Ante Portam Latinam, a burial site with more than 300 individuals, some cases showing arrow impacts, Monteggia fractures and several traumas (*Etxeberria, Herrasti 2007*). Fourteen kilometres from this rock shelter, the hypogeum of Longar holds more than 100 burials (*Rivera 2011*), some of which were injured by arrowheads (*Etxeberria* et al. *2005*). Although in both cases the discussion on the simultaneity of these mass funerary episodes – understood as a 'mass grave/war layer' – is still under consideration (*Fernández-Crespo* et al. *2018*), the extensive radiocarbon information available allows us to delimit the cycle of use of the ossuaries and, therefore, to ponder the possibility of regional instabilities (Fig. 8). Taking into account the combination of San Juan Ante Portam Latinam dating, we obtained a chronological frame of 3339–3101 cal BC 95.4% (x̃: 3211 cal BC) (χ^2-Test: df=15 T=25.0 (5% 25.0)). We obtained similar results for Longar: 3360–3102 cal BC 95.4% (x̃: 3217 cal BC) (χ^2-Test: df=6 T=3.5 (5% 12.6)).

Even if the two cases mentioned above are undoubtedly the most remarkable, others can be added in the region. In the Las Yurdinas II rock shelter (*Fernández-Crespo 2017*), two arrowhead wounds fit chronologically around 3016–2895 cal BC 95.4% (x̃: 2952 cal BC) (χ^2-Test: X2-Test: df=2 T=2.1 (5% 6.0)). In the dolmen of Aizibita *(Beguiristain, Etxeberria 1994*), aggression with survival has been documented around 3361–3022 cal BC at 95.4% (x̃: 3196 cal BC). In the funerary sites of La Peña de Marañón (*Fernández-Crespo 2017*) and Alto de la Huesera (*Fernández-Crespo* et al. *2018*), we have not been able to establish with

sufficient reliability the chronology of the episodes, although several of the dates available for the second of these would be congruent with the previous ones. We found indirect evidence of aggressive – skeletal trauma with signs of healing, arrowheads with impact fracture – at, for example, La Atalayuela or Charracadía (*Laborda 2016*). Other regional cases can be identified by consulting Ángel Esparza *et al.* (*2008*) and Daniel Daví i Salvanyà (*2019*), noting that these actions are prolonged in time and affect both 'ordinary people' and what are assumed to be social elites. We are convinced that a thorough review of anthropological collections would return a larger number of cases.

Different approaches

The work of Antonio Blanco-González *et al.* (*2018*) is noteworthy as among the most interesting approaches to peninsular prehistoric dynamics, although focused on the transition between the Chalcolithic and the Bronze Age. In contrast with the static 'picture' that they draw for the north of Iberia, the considerable evidence collected in our work reveals a horizon of profound changes that had their correspondence in the funerary record. Taking into account the reservations about the validity of the sum of probabilities procedure (SCDPD or SCDRD) as a demographic proxy – for the Iberian case, with references to the problems of the method: Alfonso Alday and Adriana Soto (*2018*) – the work of Blanco-González *et al.* (*2018*) shows a retraction of prehistoric settlement *c.* 2200 cal BC, which would not recover until *c.* 1600 cal BC. We would agree with the probable existence of cycles of demographic expansion and contraction during the recent prehistory of our region, but not in the sense described by these authors. In fact, the exercise of compiling the dating of habitation contexts from the same geographical area and chronological range – once the research bias has been corrected according to the methodology presented in Alday and Soto (*2018*) – reports a relative stability of regional settlement, with a loss of data *c.* 1600 cal BC, perhaps more justified by changes in settlement strategies than by demographic deficits (Fig. 8).

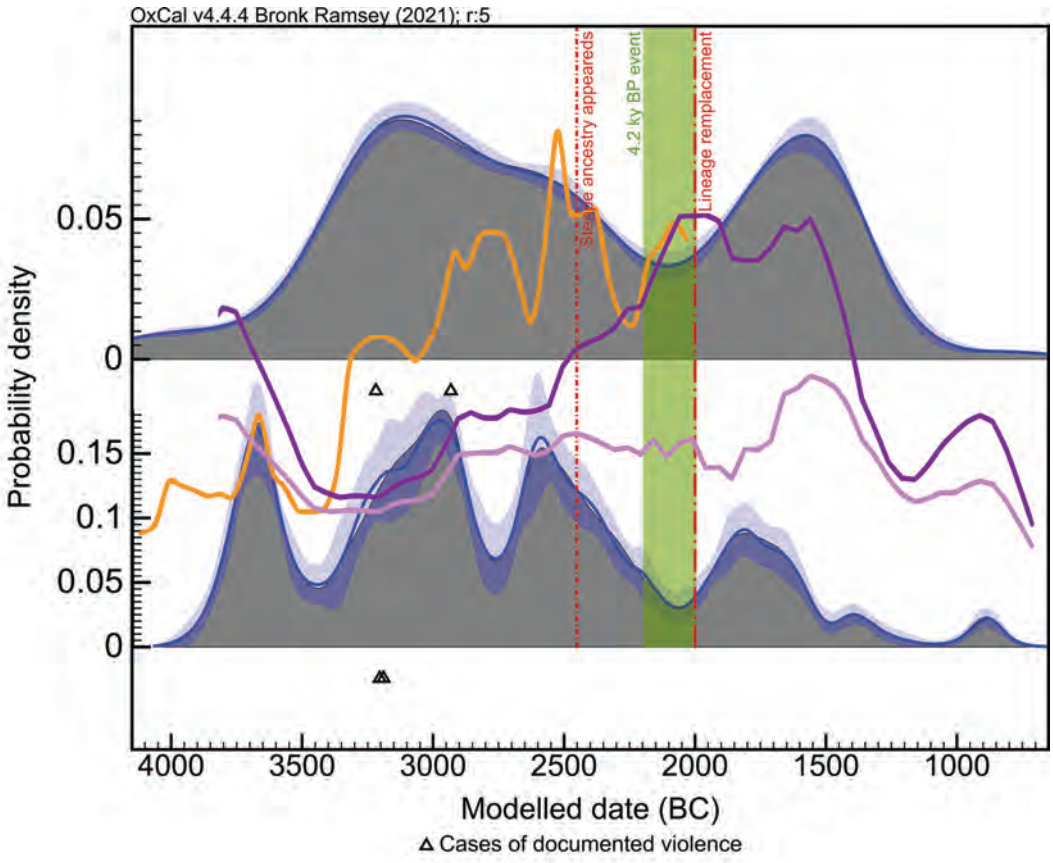

Fig. 8. Above, KDE for natural enclosures; below, KDE for the megalithic architectures. In purple SCDPD for our area of study; in light purple SCDPD corrected for research, taphonomic bias; in orange SCDPD for Iberia (*Balsera *et al.* 2015*); in green 4.2 ky BP climate change event (*Blanco-González *et al.* 2018*); in red population movements (*Olalde *et al.* 2019*). Performed with OxCal v4.4.4 (*Bronk Ramsey 2017*;* Reimer *et al.* 2020*).

This chronology would put in to one side those hypotheses that emphasise the abrupt 'climatic event of 4.2 ky BP' as the driving force behind the transformations observed in the archaeological record. This event has been linked to the collapse of well-organized societies in Mesopotamia or Egypt, as a consequence of climatic aridity processes (*Gibbons 1993*; *Weiss* et al. *1993*; *Fagan 2007*). The influence of this episode is discussed globally, on a Mediterranean scale – emphasizing the local heterogeneity of its effects (*Bini* et al. *2019*; *Di Rita, Magri 2019*) – and also at Iberia. Lillios *et al.* (*2016*) analyse the case in three peninsular areas, observing signs of aridity as well as local anthropic impacts of different signs in the southeast and southwest of the peninsula. However, this would not be evident in the northern half of Portugal, the Cantabrian and the upper Ebro River valley (see *Blanco-González* et al. *2018*; *Julià* et al. *2001*; *Roland* et al. *2014*). We do not have detailed studies for the territory under analysis, but, in any case, varied natural responses are to be expected here too, given that the region includes coastal, inland – between 500 and 1000 metres above sea level – and high-altitude areas. In the upper Ebro River valley interruptions in tufa edifices have been demonstrated (*González-Amuchastegui 2000*; *González-Amuchastegui, Serrano 2015*), in the Iberian system relatively intense erosional series (*Peña-Monné* et al. *2011*; *Peña-Monné 2018*), and in the Chalcolithic site of Torrentejo (Araba) a gypsisol resulting from aridity conditions possibly related to the 4.2 ky BP event (*Narbarte-Hernández* et al. *2019*). In any case, the radio-chronological values related to habitats suggest continuity without interruptions, and there are no data to estimate changes in social response or settlement strategies to these events. Whether this should be reflected in the funerary phases is a highly suggestive hypothesis yet to be explored, for which more evidence will have to be gathered.

Between the demographic dynamics and the funerary perspective of our work, we do observe coincidences during the episode of contraction or 'crisis' *c.* 3500 cal BC: this circumstance was documented by Verónica Balsera *et al.* (*2015*) and Blanco-González *et al.* (*2018*), and confirmed by our own data. Balsera and colleagues warn about its significance, and we add that, once the taphonomic bias (light purple line of Figure 8) is corrected, the contraction is more relative than the one implied by the raw data that, not in our case, include habitation and funerary deposits. In any case, the coincidence of this episode with the hiatus that separates the two funerary phases proposed for the Neolithic is relevant. We must also draw attention to the sharp retraction of activity observed around 1500 cal BC, in accordance with the definitive loss of interest in the built structures.

New genomic revelations relating to Iberia have brought back into focus the probable demic population movements as a factor or catalyst for social crises. The genomic history of Iberia over the last 8000 years, as formulated by Olalde *et al.* (*2019*), establishes a replacement of 40% of the population with Iberian ancestry *c.* 2000 cal BC by a population with Pontic steppe ancestry. Interestingly, this population burst onto the scene *c.* 2500 cal BC, coinciding with the rise of the third dolmen phase (Fig. 9). The coexistence between autochthonous and allochthonous groups would have extended throughout the third hiatus, suggesting that the replacement – especially of the male population – would have occurred in synchrony with the renewed interest in dolmens. As a counterpoint, it should be noted that the study by Iñigo Olalde *et al.* minimizes the nature of the process for the area under study in terms of extra-Iberian genetic contribution, in line with what has been observed in other works (*Valdiosera* et al. *2018*).

Conclusions

The Holocene funerary record of Iberia is extraordinarily rich, although with an unequal geographical and chronological distribution. In the Mesolithic, in shell middens and rock shelters, individual burials were common, which in some cases generated necropolises (*Bicho* et al. *2017*; *Gibaja* et al. *2017*; *Gonçalves* et al. *2014*). During the Early Neolithic this custom remained, in conjunction with burials in negative structures in the settlements (*Rojo-Guerra* et al. *2016*). In the fourth millennium we witnessed a major renovation of the funerary systems, through the construction of megalithic structures, to which collective burials inside the caves and rock shelters would be added very shortly afterwards. These were parallel phenomena, but with evident asymmetries in their cycles of use. Thus, accentuating the distances that ideologically and visually separate them: some structures for the memory in landscapes and societies, others for concealment, whose visibility and access are not always evident. Both structures are also instruments of cohesion for groups who, through them, reaffirm their belonging to certain spaces and socio-economic commitments. The wide extension of

the megalithic phenomenon is a symptom of a community of interests that, among other things, is also manifested in the dense networks of exchange. A new 'imagined order' (*Harari 2014*) embedded in the material world shared by hundreds of groups in the recent Prehistory of Western Europe.

Based on chronology, architecture and grave goods, we argue that during the long period of collective burials, nearly two and a half millennia, the meanings, orientations and cycles of use of funerary monuments mutated: the apparent stability that one believes seen in front of the powerful megalithic architectures changes into a polymorphous reality when observing their details. However, we believe that it is an inaccuracy to identify each of the observed phases of the funeral behaviour (peaks and valleys) as a rupture, in cultural terms, with the preceding tradition. It is true that around 3800 cal BC we witness a profound change in funerary practices with the recourse to the construction of structures. However, does this innovation constitute a break with the preceding tradition? If we look at the material links with the immediate past – spatula-idols and occasionally secondary burials – it seems that this is not the case, at least, as we have seen, during the first phases. The emergence of collective burials is followed by a hiatus of three centuries, in synchrony with a possible demographic retraction – if we interpret the proxies correctly, which new studies will have to evaluate in detail. Does the emergence of collective burials constitute, therefore, the epilogue of a crisis? Are we facing the last effort of some societies to guarantee their permanence? (*Criado Boado 1989*) *Plus ça change, plus c'est la męme chose?* (*Karr 1849*).

Whether or not it was a demographic crisis, the evidence shows there was a reduction in social work, at least with regard to funerary investment (*Lull, Picazo 1989*). Thus, the very active second phase of these sepulchres would be a reflection of communities that were once again in surplus and which, through the construction of some new architectures, would give continuity to the preceding tradition, while also burying collectively in the caves. Although we are faced with what appears to be the same practice, the role played by megaliths during a large part of the second phase changes: they are a vehicle for conflict. During what some authors have described as a 'conflictive demographic increase', the groups of the Late Neolithic/Early Chalcolithic seemed to adopt more violent behaviours (*Guilaine, Zammit 2002*), and punitive actions against megaliths – memory and legitimacy deposits over the territory – followed one another, something also observed in other European areas (*Masset 2010; Jagu, Masset 2010*). It is highly significant that the episodes of violence and the abnormal use of the enclosures (mass graves/war layers) in the region correlate with the climax of this phase, even though they are not exclusive to it.

The investment of social work in monumental tombs has been linked to a strong hierarchization in European Late Prehistory, and vice versa (*Ruby 1999*). As matter of fact, the organization of the human groups that managed to overcome this crisis does not seem to be the same from now on. Collective burial in artificial or natural structures seems to 'democratize' the world of the dead, but perhaps not in exact correspondence with the world of the living. In the region under analysis, dietary differences have been documented between individuals resting in dolmens and those resting in rock shelters and caves (*Fernández-Crespo, Schulting 2017*). If we may be self-critical, we believe that this idea should find more cases and a better foundation. We must dispel the doubt as to whether the differences in diet respond more to particular ways of life – family units that exploited the mountains with their cattle *versus* those who cultivated fields in the plains, neither of which are exclusive practices – than to social causes.

More doubtful is the interpretation of the subsequent hiatus. The structures considered in this article seem to show no funerary activity or architectural reformulations. Have the groups lost interest in them, or, having overcome the crisis, have they ceased to be a vehicle for conflict and become the object of conservation and periodic rituals that leave no evidence in the archaeological record? The answer may lie in how we interpret the third phase of reuse of the tombs. Thus, after a few generations, they are revitalized: the more abundant grave goods, which involve the circulation of exotic materials, are linked to important figures; the result of a social reformulation, and new ceremonies that would include libations and banquets. We can formulate this another way: perhaps social inequalities are being normalized, which does not exclude cohesive activities through the funerary image. At this point, it is easy to fall into the temptation of bringing into the scene allochthonous populations that have been integrating into the local communities for some time. However, the documented cases are not only heterogeneous, as several of them also

allow for different readings, and thus the danger of excessive generalizations. In this regard, a relevant example is that of the tumulus of El Virgazal (*Delibes* et al. *2019*): it tells the story of an individual with recent allochthonous ancestors, although perhaps he himself was not. He was buried with high-value jewellery and accompanied by, among others buried there, an individual transferred from a previous grave. In this case, are we dealing with an 'ancestral rite' in which a new hierarchy legitimizes its position of pre-eminence over the indigenous population? If so, it is clear that during the preceding hiatus the groups must have preserved and passed on their interest in these memory deposits. In other words, there was no *"abandonment or rupture of the social and cultural relationship"* (*Andrés 2005*), although there was in its archaeological expression. This situation could well have been reproduced during the interlude that separates the phases corresponding to the different metal ages.

In a fourth phase, during the Early Bronze Age, collective burials were reactivated: perhaps this was related to the spread of metallurgy and its relationship with individuals of prestige, as well as the new opportunities that arose and the consequent socio-cultural changes that they brought about (*Costa-Caramé, García-Sanjuán 2009*). It is also true that, at this point, there is a striking increase in the number of habitation sites reported by their dating, and the process of population replacement occurring at the end of the period may not be completely unrelated to the explanation for this renewed interest.

It is evident that behind the interruptions of funerary depositions and later reuse of the graves there must have been major social intentions, although they are not easy to identify. The very fact that the trend is reproduced over such a wide area, regardless of the type of tombs, suggest that we are dealing with a first-order social, economic and/or political dynamic. With the aim of outlining areas for future research, it would be interesting to explore to what extent between the first the second phases, and even more in the third, individual rather than collective burials were becoming the norm. If that were the case, given the relationship of the Bell Beaker and the emergence of metallurgy with the rise of personal leadership, we would be witnessing a phenomenon of appropriation of the previous memories by individuals looking for legitimacy. In this regard, we believe that it would be of interest to replicate our approach in other regions, particularly in those where complex social processes are well documented – such as southern Iberia (*Soares, Gomes 2021)*.

From the perspective of the *longue durée*, it is in the meaning that communities give to the graves where we believe we can find the ruptures. That is, the ruptures have more to do with the significance of megalithism than with the signifier. As Ian Hodder stated (*1990*): *"New usage within an existing context may have implications that lead to more radical change"*. In this respect, we find more relevant the changes observed in the patterns of access to the pantheons (more or less restrictive), the beginning and the end of funerary collectivism, some documented intentional destructions or the emergence of the Bell Beaker as 'iconography of power'. It is true that we are still far from establishing at what moments ruptures occurred in the communities of recent prehistory in the north of Iberia, although we suspect that the answers lie more in the interior of the phases than in the transition between them.

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Megalithic tradition associated with agricultural ritual: a study of the Chongkhong Phuja among the Hill Tiwas of Umswai Valley in Assam, India

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ABSTRACT - *The Tiwa community is one of the autochthonous communities of Northeast India. An important aspect of Tiwa culture is the erection of stone monuments during the celebration of Chongkhong Phuja. This ceremony is performed before the commencement of their yearly agricultural cycle which falls in late April and continues to early May. On this occasion, a menhir and table stone are erected by the head priest of the Tiwa village, who then invokes their village guardian deity to call for a better harvest as well as for the wellbeing of the villagers. This elaborate ceremony marks the beginning of the agricultural season for the year, following which the villagers commence their agricultural activities. This paper deals with the performance of Chongkhong Phuja and the associated living megalithic tradition among the Hill Tiwas residing in the Umswai Valley. It also documents the oral traditions associated with the origin of the megalithic tradition in the community. As most of the living megalithic traditions among the ethnic communities of Northeast India are either related to burial practices or commemorating the death of a person or an event, this Chongkhong Phuja represents a unique example of a megalithic tradition related to agricultural practice. Indirect evidence suggests the megalithic structures present at the ceremonial place of the Chongkhong Phuja in the Amsai village of the Umswai Valley have been continuously erected for the last thousand years. The paper also hypothesizes the shifting cultivation in the area to be as old as the practice of the megalithic tradition.*

KEY WORDS – *megaliths; living tradition; oral tradition; menhirs; animal sacrifice; jhum cultivation*

Megalitska tradicija, povezana s poljedelskim ritualom: študija obreda Chongkhong Phuja med ljudstvom Hill Tiwas v dolini Umswai v Assamu v Indiji

IZVLEČEK – *Tiwa je ena izmed avtohtonih skupnosti v severovzhodni Indiji. Pomemben vidik njihove kulture je postavljanje kamnitih spomenikov med praznovanjem Chongkhong Phuja. Obred se izvaja pred začetkom letnega poljedelskega cikla na koncu aprila in začetku maja. Glavni duhovnik vasi Tiwa postavi menhir in kamnito mizo ter prikliče božanstvo – varuha vasi ter prosi za dobro letino in blaginjo vaščanov. Slovesnost označuje začetek kmetijske sezone. V članku predstavljamo obred Chongkhong Phuja in z njim povezano megalitsko tradicijo med ljudstvom Hill Tiwas, ki prebiva v dolini Umswai. Predstavljamo tudi ustna izročila, povezana z izvorom megalitske tradicije v skupnosti. Večina megalitskih tradicij med etničnimi skupnostmi v severovzhodni Indiji je povezanih s pogrebnimi običaji in s spominom na umrlega, zato Chongkhong Phu predstavlja edinstven primer megalitske tradicije, povezane s kmetijsko prakso. Posredni dokazi kažejo, da so megalitske strukture na obrednem mestu Chongkhong Phuja v vasi Amsai v dolini Umswai kontinuirano postavljali zadnjih tisoč let. Domnevamo, da je selilno poljedelstvo na tem področju staro toliko kot megalitska tradicija.*

KLJUČNE BESEDE – *megaliti; živa dediščina; ustno izročilo; menhirji; žrtvovanje živali; selilno poljedelstvo*

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Introduction

In archaeological and prehistoric research, megalithic monuments have drawn considerable attention since the 19th century (*Herbert 1849; de Malahide 1866; du Noyer 1866; Lewis 1871; Godwin-Austen 1872*). These monuments, known by different names such as monoliths, menhirs, cromlechs, orthostats, dolmens, cists and so on, have been recorded in a wide region of the Old World, from the shores of England to those of Japan (*Moorti 2008*). These were often seen as linked with burials, tombs and sacred places. However, with prolonged research in various cultural contexts, geographies and chronologies, it is widely accepted that the function and significance of these monuments are far wider than previously thought. With the discovery of the megalithic monumental complex at the Neolithic site of Göbekli Tepe (*Schmidt 2010*) in southeastern Anatolia, Turkey, the antiquity of megalithic monuments has been even pushed back to *c.* 10th to 9th millennia BCE. Since megaliths are a prehistoric tradition that is found in the Neolithic, Chalcolithic, Bronze and Iron Ages, and even historical periods in most nations, archaeologists and anthropologists have often tried to look at the ethnographic practices persevered among various communities (*Bloch 1971; Basa* et al. *2015; Adams 2019*) to develop analogies for interpreting the social and cultural nuances from ethno-archaeological points of view. However, in recent years many of these archaic traditions are facing serious challenges with regard to constant change and eventual extinction, which is why the study of the ethnic communities that still maintain megalithic practices is now extremely important, before they have completely altered or vanished.

Northeast India is one such region, which is well known for the presence of a variety of megalithic monuments and structures, of ancient as well as recent origin. One of the first written accounts of the megalithic tradition in Northeast India was published in 1832. It was Lieutenant Murphy who wrote about the Khasi megaliths in his '*Account of the Cossyahs, and of a Convalescent Depot established in their Country, 280 miles N.E. from Calcutta'* (*Murphy 1832*). He stated that during funeral ceremonies the Khasi people marked the cremation spot with a stone enclosure; the ashes were collected, put into earthen jars or pots, and then deposited in a regular square stone box with a small door to it, over which they erected immense slabs of stone, varying in number from three to seven, according to the wealth (not rank) of the deceased. Godwin-Austen (*1872*) also reported on the megalithic remains and associated rituals performed throughout the Khasi Hills. Subsequently, several colonial administrators took a keen interest in the stone monuments scattered around this region (*Clarke 1874; Gurdon 1914; Hutton 1922a; 1922b; 1925; Mills, Hutton 1929*).

These megalithic monuments and structures of different shapes and sizes are recorded in a belt extending from the Khasi and Jaintia Hills through Karbi Anglong up to the Naga Hills besides Manipur, Mizoram and certain areas of Arunachal Pradesh. One of the major concentrations of megaliths is observed in the Khasi-Jaintia Hills of Meghalaya, where large clusters occur at Cherrapunjee, Mawphlang, Laitlyngkot, Laitkor, Jowai and Nartiang (also spelled Nartiyang) (*Bareh 1981; Rao 1991; Sen 1991; Mawlong 1996; 2004; Mitri 2016; Marak 2012a; 2012b; 2019; Meitei 2019; Meitei, Marak 2015*). In Manipur, megaliths are found to be spread over the Naga-dominated areas of the districts of Chandel, Ukhrul, Tamenglong, Senapati, and Churachandpur (*Singh 1985; Binodini Devi 2011; 2019*). Megaliths are also found extensively in the Kohima and Phek districts populated by Angami and others in Nagaland (*Jamir 2004; 2005; 2019; Jamir 1997; 1998; 2019; Venuh 2005; Devi, Neog 2014*). Carved monolithic pillars are recorded at Dimapur in Nagaland and Kasomari in Assam (*Hutton 1922a; 1925; 1933; Sarma 2016*). A large number of megaliths with petroglyphs on some of them are also seen in Vangchhia, Ralven Puk Tlang, Lung Ropui, Sazep and the Maullum Hills in Mizoram (*Lalhminghlua, Sarkar 2017; Malsawmliama 2019; Singh 2019; Nayan 2021*). Only at a few sites in Arunachal Pradesh are megaliths reported, such as at Jamiri, Shergaon, and Songlong Thong (*Thakur 2004; Gogoi, Baruah 2021*). In Assam, megaliths are mostly concentrated in the Morigaon, Kamrup, Karbi Anglong and Dima Hasao districts (*Medhi 2000; Bezbaruah 2003; Choudhury 2004; 2019; Sarma 2014; Thakuria* et al. *2016; Devi Bora, Bezbaruah 2018; Roy 2019; Hazarika 2016; Hazarika* et al. *2020; Borgohain, Sarma 2021*).

Northeast India is one of the few areas of the world where the erection of megaliths persists as a living practice in the form of memorial stones commemorating important events or the disposal of the dead in accordance with old customs and beliefs (*Rao 1979*). After cremating the dead, the ashes and decalcified

bones are deposited in a stone chamber and a memorial stone is erected by several communities in Northeast India. This living practice is closely associated with the socio-cultural traditions, social merit and religious beliefs of the people associated with the dead (*Mawlong 2004*). David Roy (*1963*) described the funeral rites of erecting megaliths amongst the Khasis of Meghalaya. Dwipen Bezbaruah (*2003*) extensively studied the living practice of erecting megaliths among the Karbi community as a post-cremation rite and drew parallels for the prehistoric megalithic remains found in the Karbi Anglong in Assam. In some instances, menhirs also function as a boundary marker for an individual or a community.

As mentioned earlier, several British administrators and Indian scholars (for recent reviews see *Mitri 2016; Marak 2019*) contributed valuable writings in their observations on the rituals related to the megalithic structures. Nevertheless, due to factors such as cultural change and loss of traditional practices, besides the emergence of Christianity, this tradition has been lost among many tribes. However, while the tradition of erecting stone for commemorative, funerary and functional purposes is widely studied, the origin and chronology of this tradition is poorly understood in the region (*Sarma, Hazarika 2014; Marak 2019*). Moreover, there has been hardly any excavation conducted at megalithic sites in the region, nor have they been dated absolutely. The lack of datable materials associated with the megaliths is another limiting factor. The clusters of menhirs that can be seen are the results of the frequent use of same area for erecting menhirs by a village or clan.

Differentiating the recently constructed megaliths from the ancient ones is also difficult due to the fast weathering of the stones and overgrowth of vegetation in the area. This makes all the structures look alike and impossible to differentiate without the help of a local. People's memories and oral sources are thus extremely important in such investigations. As such, in-depth studies are required in order to establish a chronology of the living tradition among various groups, as well as of the megalithic structures made by the ancient communities with varied cultural backgrounds. In this regard, a study among the Tiwas has provided some interesting insights about the origin and association of megaliths with agricultural practices in Umswai Valley.

The Tiwas

The Tiwa (aka. Lalung) community is one of the autochthonous communities of Northeast India, with one group speaking a language that belongs to the Bodo-Garo family of the Tibeto-Burman language family (*van Driem 2001*). Settled in the Morigaon, Nagaon, Kamrup, Jorhat, Dhemaji and Karbi Anglong districts of Assam and Ri-Bhoi district of Meghalaya, the Tiwas have long been referred to as 'Lalung' or 'Laloo' by other neighbouring groups such as Khasi, Jaintia and Karbi. The *Buranji*s or the Ahom chronicles (*Bhuyan 2012*) used the terms like 'Lalung', 'Garo' and'Dantiyalias' interchangeably to denote the Tiwa people. The people in question, however, refer to themselves as Tiwa. The detailed ethnography of the Tiwas is recorded in several notable publications (*Barua 1989; Baruah 2015; Bordoloi 2002; Deka Patar 2007; Gogoi 1986; 1987; Gohain 1993; Patar 2021; 2004; Sarma Thakur 1985; Shyamchaudhury, Das 1973*).

The Tiwas are divided into two socio-cultural groups, those settled in the plains who speak Assamese and follow a patrilineal descent system bearing Assamese patronyms, and those residing in the hills, speaking a Tibeto-Burman language of the Bodo-Garo group, that follow a matrilineal descent system. The Tiwa thus follow a bilateral descent (*Williams 1990.267*) system which recognizes that descent may be traced from either the father or mother, depending on the decision taken at the time of marriage. Hence, they are divided into Hill Tiwas and Plain Tiwas.

The comparatively bigger villages of the Hill Tiwas are located in the Amri Development Block in the West Karbi Anglong district of Assam and the Ri-Bhoi district of Meghalaya. They are situated on elevations ranging between 600 to 900m. They practice both wetland paddy and upland shifting cultivation depending upon the physical features of the land. Shifting cultivation is practised on high slopes where irrigation is not possible. According to Chatrasing Darphang (58 years old), a resident of the Kromkhunji village in West Karbi Anglong, crops like cotton, sesame, castor oil, and chilli pepper have been cultivated along with their main crop, paddy. They would use a plot of land for three consecutive years to grow a great variety of crops. In the first year, the abovementioned crops were cultivated but from the second and third years onwards they would cultivate only paddy.

The Plain Tiwas are mainly settled in Nagaon, Morigaon, Kamrup and in some pockets of the Titabor subdivision of the Jorhat district of Assam. A few Tiwa villages are also located in the Dhemaji district on the north bank of the river Brahmaputra and the Sadiya sub-division of the Tinsukia district of Assam. While the Hill Tiwa professes their 'traditional' religion, the Plain Tiwas are by and large, Hindu. The process of Sanskritization of the Plain Tiwa began in the mid-17th century with the subjugation of Tiwa chiefs of Gobha, Nellie and Khola by the Ahoms (*Patar 2021*). Subsequently, the conversion of chiefs of the minor Tiwa principalities collectively known as *Sato-raja* (seven kings) and *Paso-raja* (five kings) to Neo-Vaishnavism led to the conversion of more Tiwas into the fold of the latter. However, a large section still follows the traditional religion. According to Allen (*1906.62*) "*... the Tiwa religion is based on the worship of natural forces and the ordinary animistic type and is chiefly concerned with the propitiation of the evil spirits and with sacrifices to ensure prosperity*". However, since the 1950s, there has been a growing number of converts to Christianity, especially among the Hill Tiwa population.

Megaliths are an important aspect of the Tiwa ethnohistory (*Patar 2016*). These have different terminologies in the Tiwa language according to their types and purpose. The megaliths (Figs. 1 and 2) among the Tiwas of the Amsai village of the Umswai Valley are found in different contexts such as (a) menhirs erected at the present-day cremation ground, (b) megaliths used as a modern Hindu shrine, (c) stone slabs at the old residences of the kings, (d) megaliths (in the form of a heap of stones) in front of the residence of the *Loro* (chief priest), (e) alignments erected as boundary walls of the youth dormitory, known as *Samadi*, and so on. The construction of the alignments as boundary walls of the *Samadi*, placing the stones in a row, is a recent phenomenon at the Amsai village.

Both the Hill and Plain Tiwas practise several traditional religious ceremonies. Among these, the Chongkhong Phuja is significant as far as the living megalithic tradition is concerned. The Chongkhong ceremony is performed in two stages, the first one is known as Bor Chongkhong Phuja and the second as Phidri Chongkhong Phuja. The construction of megaliths is done during the performance of the Phidri Chongkhong Phuja at the Chongkhong Sal of the respective village. The Chongkhong Sal is a sacred patch of forest adjacent to the Tiwa villages dedicated to the guardian deity of the village where, apart from the megaliths, the cremation ground (known as *Mangkhor*) and other localities for religious ceremonies are demarcated. While performing these rituals, the role of the council of village elders, known as the *Pisai* is extremely important (*Patar 2020*). The formation and role of the members in the *Pisai* are provided in the Table 1.

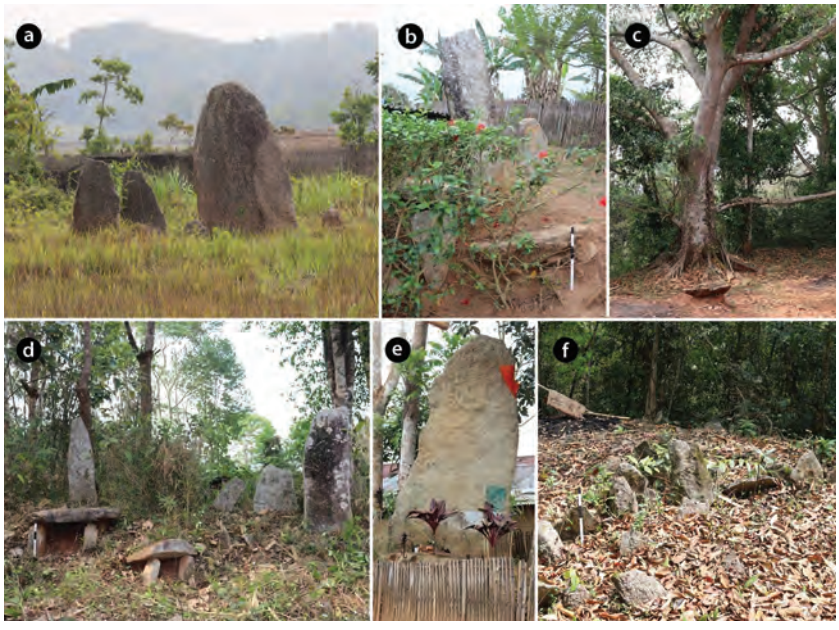

Fig. 1. Types of megalithic monuments in the Umswai Valley:* a *menhirs at Yangli Shal near Umswai market,* b *menhir with a table stone in front,* c *a stone slab at the old residence of the king,* d *dolmens,* e *menhir worshiped as Hindu shrine,* f *megaliths at a cremation ground.

Bor Chongkhong Ceremony

The Bor Chongkhong ceremony is held annually in the villages of Amsai, Marjong and Amkha clans (scattered in the west Karbi Anglong district of Assam) of the Tiwa community. In this ceremony, a pig is sacrificed in the name of Palakhongor, the presiding deity of the Amsai, Marjong and the Amkha clans and twelve fowls are sacrificed in the name of the *nima* or deities who protect the borders of Palakhongor's territory. In the Bor Chongkhong ceremony, the *Pisai* (the council of village elders) seek permission from their principal village deity to begin

the cultivation season. It is believed that they should not till the soil or clear the jungle for cultivation without performing the Bor Chongkhong ceremony, as it may bring a bad harvest. According to the Hill Tiwa belief, if anyone begins cultivation before performing the ceremony there will be bad omens for the village in the form of attacks by a tiger on humans and domestic animals, and the occurrence of an epidemic.

Fig. 2. **a** ***Megaliths in front of the residence of a Loro;*** **b, c, d** ***megaliths installed as a boundary wall of the youth dormitory.***

Phidri Chongkhong ceremony

This ceremony is performed three weeks after the conclusion of the Bor Chongkhong ceremony at the end of April or at the beginning of May, depending upon the decision taken by the council of village elders. This ritual takes place only on a Thursday. In this ceremony, the *Pisai* gets permission from the guardian deity of the village and the spirits of ancestors of the village, known as the *Phidri*, to dig canals to bring water from the streams to their paddy fields and to commence the sowing of seeds and saplings in their *jhum* (shifting cultivation) fields. On this occasion in Amsai village three pigs are sacrificed in the name of the principal deity – Palakhongor – and the spirits of the ancestors.

Ceremonies performed at the Chongkhong Sal

The erection of stones on the occasion of Phidri Chongkhong is an important ritual of the Tiwa society. During this ceremony two flat stones are erected;

Position	Responsibility
Loro	He is the head priest of Tiwa root villages. He leads in all the community-level religious ceremonies and presides over any socio-cultural functions and disputes in his village.
Toloi/Doloi	He supervises the overall preparation of religious ceremonies in his village.
Hadari/Hatari	He is the personal assistant to the *Loro* and provides all the necessary help while the *Loro* is performing religious ceremonies.
Maji	He is responsible for procuring animals and birds for the sacrifice at religious ceremonies.
Phador	He keeps records of the paraphernalia required for religious ceremonies and collects stones for the installation at the *Chongkhong Phuja.*
Shangot	He is responsible for procuring animals and birds for sacrifice at religious ceremonies and collecting stones for the installation at the *Chongkhong Phuja*.
Barika Baro	He is the head messenger of Tiwa village who has to convey important information about different religious events to the villagers.
Barika Pisa	He is the assistant messenger who helps the *Barika Baro* in disseminating information on different religious ceremonies.
Phayak Mul Kra	He is the head of the four *Phyakmul* who are responsible for cleaning, cooking and serving food at religious ceremonies.
Phayak Mul Majowa	He is the deputy to *Phayak Mul Kra*. He is responsible for cleaning, cooking and serving food at religious ceremonies.
Phayak Mul Jokha (two men)	They are responsible for cleaning, cooking and serving food at religious ceremonies. During the *Chongkhong Phuja*, they are to keep an eye on the observance of taboos and rules by the village households that are prescribed on the day of the ceremony.

Tab. 1. Role of different members of the Pisai, the council of village elders.

one vertically (upright stone) and another horizontally (table stone) at the Chongkhong Sal to mark the annual ceremony. The upright stone or menhir is known as *Orlong thuna* (*Orlong* means stone and *thuna* means sacred pillar) and the table stone or flat stone is known as *Phidri tongkhra* (*Phidri* means ancestor and *tongkhra* means flat seating place). The size of the menhirs found in the Chongkhong Sal of Amsai village ranges from 30 to 110cm while the table stones are generally 10 to 20cm wide. The menhir is buried 10 to 30cm deep depending upon the size of the stone.

Selection and installation of these stones are done by two village officials, namely the *Phador* and the *Sangot*. These stones must be installed at a location designated for these structures. As this is an annual activity among the Tiwas of Amsai, the same location is preferred for the ritual as well as the erection of these structures. These structures are erected as an alignment in the east-west direction. The Tiwas of Amsai believe that Palakhongor, the principal village deity visits and eats the offerings and sacrifice and takes rest at the stones placed there. Cotton threads are tied on the top of all these stones during the Chongkhong ceremony, signifying turbans.

The villagers also plant a flame tree (*Erythrina* sp.) or *mandarphang* close to the erected stones on the day of the ceremony. It is believed that if the flame tree survives then the person who planted it will die. However, if the tree does not survive then it signifies that the principal deity, as well as the ancestors of the village, is happy with the sacrifice and the entire village will have bumper crops for that year. According to Phulson Kholar (62 years old), the assistant priest of Amsai, a few years before, the *Sangot* of their village died of some unknown sickness after a few months of the Chongkhong Phuja. Interestingly they attribute his demise to the survival of the tree that he planted during the ceremony.

At the start of the Phidri Chongkhong ceremony, the location designated for these stones is cleared of the undergrowth and vegetation by the *Pisai*. As these stones are considered sacred, villagers or any other people, including visitors and tourists, are forbidden to disturb the structure in any manner. This provides us with some scope to assume these *in situ* structures are still in roughly their original locations, although they must have been disturbed by various natural forces over the years. Overall, however, and with some caution, these structures can be counted as evidence of the annual ceremony of the Phidri Chongkhong. During our fieldwork at Amsai, we counted 2048 menhirs and table stones, including those raised in 2017. These have been counted based on the intact nature of the standing stone as well as the flat table stone in front. The 1024 pairs of *Orlong thuna* and *Phidri tongkhra* thus indicate that this practice has been in existence for at least a thousand years. However, this hypothesis needs to be supported with absolute dates.

The day-long Phidri Chongkhong ceremony is an important religious event for the Tiwa people. In the early morning on the day of the ceremony three male pigs, one of which should be black, are sacrificed (Fig. 3) by the *Loro* of Amsai with the assistance of the *Hadari* and *Toloi* and other members of the *Pisai*. While chanting mantras outside the residence of the *Loro* the pigs are sacrificed by stabbing them with a pointed iron implement called a *pla* specifically reserved for this task. A pig is dedicated to Palakhongor, the principal deity of the village, and the other two are killed in the name of the dead ancestors. This part of the Phidri Chongkhong ceremony is called the *Phidri Chongkhone waphawa*.

After this ceremony, the *Phador* and *Sangot* of the village move to the Chongkhong Sal to erect the *Orlong thuna* and *Phidri tongkhra* (Fig. 7). They select a specific place in alignment with the previously erected stones and plant the flame tree (*Mandarphang*) behind the erected stone. This event is known as *mandar gaina simli gaina*. The size of the megaliths varies from 30 to 110cm in length depending on the availability of stones in the nearby area in the hills. These are mostly undressed stones. Every year, either of these two village elders find two pieces of suitable stone from the neighbouring hills.

Meanwhile, the *Loro* sacrifices a red fowl under an altar called the *Rongdo-Akur* specifically made for this ceremony. The *Rongdo-Akur* is a bamboo stand with four bamboo poles decorated with different designs where at the top two earthen pots called *thukli* are placed. In one pot, grains of rice are kept and the other one is filled with water. After the sacrifice of both pigs and the fowl, members of the *Pisai* clean their skins and intestines and rub them with rice powder.

At midday all the members except two *Phyakmul* (there are four *Phyakmul* in the *Pisai*) who are sent

to visit every house to check if the families are observing the taboos and rules that are prescribed for that auspicious day, go to the Chongkhong Sal. While going to the Chongkhong Sal, the *Pisai* take a specific route which goes through the Langkhon Sal via the Mangkhor Sal and the Sogra Sal. This trail enables the *Pisai* to enter the Chongkhong Sal from the western direction facing the east. According to the village elders, on the day of the Chongkhong Phuja it is forbidden to showtheir back towards the east where the sacred mountain *Makha Koja* (part of the Himalayan mountain range in Tibet) is situated. It is believed that their ancestors once lived in the *Makha Koja*. Before entering the Chongkhong Sal, the *Loro* and *Toloi* invoke their deities and inform them about their entry to the place. After arriving each member of the *Pisai* take up their assigned responsibilities for the ceremony.

Fig. 3. **a, b, c *Sacrifice of animals*; d, e *preparation for the offerings*.**

At the ceremonial location of the Chongkhong Sal, there is a designated open space with a few stone seats of flat stones. These stone seats are used for sitting by the members of the *Pisai* (Fig. 5). According to the *Pisai*, these stones arranged in a semi-circular fashion are of considerable antiquity. The members of this group can only take their designated seats when in their roles as Pisai (Fig. 4). The *Phyakmul* place wild *tara* leaves (*Alpinia* sp.) on the stone seats to facilitate the sitting. The *Loro* and the *Hatari* prepare offerings under the newly erected *Orlong thuna* and *Phidri tongkhra*. The *Loro* assisted by the *Hatari* offers chicken feathers smeared in blood, the bladder of a pig, and a bunch of *Tulsi* (basil) leaves on a wild banana leaf in front of the *Orlong thuna* (Fig. 8). While placing the items the *Loro* and *Hatari* chant a mantra and prays for the well-being of the village and the prosperity of everyone, including the animals. The offerings (Fig. 6) include twelve packets of rice collected from the twelve members of the *Pisai*. After this offering, the *Loro* tie cotton threads (Fig. 8) on the top of each *Orlong thuna* starting with the one erected in the current year. This symbolizes the offering of *Phaga* (turbans) to their ancestors. Each standing menhir is considered as an ancestor of Amsai village. These stones are also decorated with wildflowers, as well as leaves of *Alpinia* sp. and *Drynaria* sp. (Fig. 8) and orchid roots, which symbolize giving honour to their ancestors. The decoration of the stones can be attributed to the utmost concern for the dead ancestor spirits which are believed to have lived in the stones.

Fig. 4. **a *Arrival*; d *discussion*; c *offerings*; d *Phyakmul reporting to the Pisai at the Chongkhong Sal.***

Then similar offerings are made at the pair of stones called *Tana-*

Fig. 5. **a, b** ***Stone seats designated for the members of the Pisai;*** **c, d** ***members of the Pisai taking their respective seats at the Chongkhong Sal.***

ing the village to record violations of the taboos reach the Chongkhong Sal. One of the taboos is that it is forbidden to dry clothes in the sun on the day of the Phidri Chongkhong Phuja. Moreover, no ploughing, cutting of soil, or construction of any sort is allowed, while sun-drying vegetables such as bamboo shoots, mushrooms, yams, sesame, and chilies is also prohibited. These taboos are strictly maintained by the villagers and the *Phayakmul* watch for any violations.

rao and *Puwarao*. *Tanarao* is the god of storms and *Puwarao* is the god of rain. While making offerings to the principal deity of the village at the Chongkhong Phuja, the Tiwa of Amsai also offers sacrifices to these two important deities that have control over the weather. On this occasion, the priest sacrifices two fowl and a pig in the names *Tanarao* and *Puwarao*, and calls for the protection of the village's house, fruit trees, paddy and other crops.

Meanwhile, the members of the *Pisai* apart from the *Toloi* cut the sacrificed pigs into pieces. The *wa-lengjai* or the tail of the pig is given to the *Loro*, the *wa-khalao* or skull is given to the *Toloi* and *Sangot*, *wa-kunthri* (snout) is given to the Hatari and the *wa-ya-thong* (legs) are provided to the *Phyakmul* and *Barika*. These pieces of meat are tied to sliced bamboo and cooked separately, while the rest of the meat is boiled in a pot with rice powder. The intestines of the pigs are mixed with wild herbs and cooked in bamboo tubes. After the meat is cooked, the *Loro*, *Toloi* and *Hatari* make offerings to the deity and chant several rounds of a mantra and call for bumper crops in the village and seek protection from natural disasters and diseases.

Meanwhile, the two *Phayakmul* who were given the responsibility of touring the village to record violations of the taboos reach the Chongkhong Sal. One of the taboos is that it is forbidden to dry clothes in the sun on the day of the Phidri Chongkhong Phuja. Moreover, no ploughing, cutting of soil, or construction of any sort is allowed, while sun-drying vegetables such as bamboo shoots, mushrooms, yams, sesame, and chilies is also prohibited. These taboos are strictly maintained by the villagers and the *Phayakmul* watch for any violations.

With permission from the deity and the *Pisai*, the *Phayakmul* enter the ceremonial ground and report everything they have seen during their tour of the village. The reporting of the *Phaykmul* to the *Pisai* is detailed. After hearing the reports, the *Pisai* pray to the deity and their ancestor spirits and express anguish over the families who have not observed the taboos. After this ceremony, the *Phayakmul* serve the *Loro*, *Toloi*, *Hatari*, *Phador*, *Sangot*, and *Barika* with cooked meat, rice beer and other food and drink. All the members of the *Pisai* then leave the place of worship after performing another round of invocations to their deity and ancestor spirits.

Fig. 6. **a, b, c** ***Arrangements*****; b, e** ***cooking in bamboo tubes and metal vessels for the offerings.***

As we have seen, sacrificing animals is a common practice of the Hill Tiwas in their traditional rituals. In the pre-British period, there was also a tradition of offering human sacrifice each year at Chongkhong Sal at the bottom of Palakhongor Hill. The place is bounded by a sacred grove where of the four British officials abducted by the Gobha Raja's soldiers[1] three were sacrificed in1832. However, this was the last year with any human sacrifice.

Fig. 7.* a *Selection*; b *carrying of the stones;* c *erecting of Orlong thuna and Phidri tongkhra at the Chongkhong Sal.

Ceremonies performed at the village

In the evening after arriving from the Chongkhong Sal, the members of the *Pisai* gather at the residence of the *Loro* and perform some further rites and rituals (Fig. 9) associated with the Phidri Chongkhong. As part of this flutes and drums are played and three rounds of dance are performed by the *Phyakmul*, *Phador*, *Sangot*, and *Barika*. The *Loro*, as the chief priest, keeps a close watch on the entire ceremony. The first dance group is called *Orlong Gai*, the second group is called *Khum Duwa* and the third group is called *Di-Tha Rakha*. While dancing, the dancers with bamboo hoes made especially for the ceremony called *Pakhu* dig a pit almost 30cm in diameter in the floor of the *Nukthi* (the first room of the residence of Loro). Soon after the dancing, the Phaykmuls cover the pit with soil and once again level the ground with mud plaster. The symbolic use of digging tools, particularly the bamboo hoes in the ceremony at the *Loro*'s residence in the evening, along with the dancing, signify the *jhum* agricultural tradition in the hills.

After this the *Pisai* invites the *Panthai Khel*, the youth groups led by the *Changdoloi*, and the *Changmaji* and *Huruma*, to come inside the *Nukthi*. The *Panthai Khel* enters the residence of the *Loro* while singing traditional songs and after paying respect to the *Pisai*, then sits at the designated seat called a *tongkhra*. The *Loro* starts the invocation of the principal deity of the village and the ancestor spirits in the presence of the *Panthai Khel*. After the invocation, two rounds of rice beer are served to the members of the *Pisai* and the *Panthai Khel* in bamboo tubes. At the end of the drinking, the *Loro* and *Toloi* hand over the *Khram Panthai* (the drum) and *Pangsi* (the flute) to the *Panthai Khel* who is the custodian of these musical instruments. Soon the *Panthai Khel* leaves the *Loro*'s residence and deposits the musical instruments at the Shamadi, the bachelors' dormitory in the village. The Phidri Chongkhong ceremony ends with another invocation of the deities and ancestor spirits at the *Loro*'s residence. This Chongkhong Phuja is also performed by other villages of the Umswai Valley.

Agricultural practice among the Hill Tiwas

As mentioned above, the megalithic stones erected during the Chongkhong Phuja at Amsai village are related to agricultural practice. This can be considered unique to the Tiwas, as most of the living megalithic traditions among other communities of Northeast India are related to burial structures, commemorating the death of a person or an important event, apart from other functional purposes like establishing boundary demarcations, sitting stones and so on. As such, a discussion on the agricultural practices among the Hill Tiwas would be pertinent here to understand

1 According to the legend, on the occasion of Phidri Chongkhong a human was sacrificed each year by the priest of the Amsai village. This incident was documented by Pemberton (*1835.229*) in his "*Report on the Eastern Frontier of British India*". These sacrifices are believed to have brought prosperity and security to the village from the evil spirits.

Fig. 8.* a *Offering of sacrifices in front of newly erected Orlong thuna and Phidri tongkhra by the Loro and Hatari;* b *tying of cotton threads on the top of all the stones*; c *newly erected Orlong thuna and Phidri tongkhra;* d *decoration of the menhirs with wildflowers.

their relevance with the megalithic tradition. Agriculture has been the principal means of livelihood of the Tiwa community since the pre-colonial period. Paddy is the main crop of Tiwa agriculture, both in the hills and plains. The distinctive eco-cultural features of the Tiwa economic organization lie in its communal activities and inter-dependence among the families living within a village for the satisfaction of basic needs of with regard to food, clothing and housing.

In the hills, *jhum* – slash and burn or shifting cultivation (Fig. 10) – is practised by the Tiwas, which is woven into the fabric of their lifestyle and cultural milieu (*Gohain 1992.32*). The calendar for shifting cultivation starts with *Mahak* (January/February) when the plots are selected for cultivation by the households. The Tiwa refer to their *jhum* fields as *maiha* (*mai* meaning paddy, *ha* meaning field). The households have their own plots used with the consent of the *Pisai*, and the head of the family decides which plot is to be selected for that particular year. Selection depends on the *jhum* cycle, as abundant vegetation is necessary after a plot has been cultivated and left fallow for a period of four to six years. The land left fallow to regain its fertility is called *hagari* (*ha* meaning land, *gari* meaning leftover). At the end of the *jhum* cycle, the family returns to the same plot of land they had cultivated at the beginning of the cycle.

In the following months of *Phagun* (February/March) and *Chit* (March/April), parts of the jungle are cleared before the monsoon starts. The trees and shrubs are cut and the entire plot is allowed to dry for thirty to forty days. Just before the rains are expected the plot is set on fire on a day fixed by the common consent of the villagers, as they must see that the fire does not get out of control and spread to the plots of neighbouring villages because of dry weather and strong winds. After the fire, the burned soil is thoroughly hoed and mixed with the ashes so that it is not washed away by the first rains. In mid-April after the Phidri Chongkhong ceremony, the sowing of seeds takes place. Carefully preserved seeds (*khodya*) of other vegetables are selected for sowing. Several varieties of seeds may be sown in one plot, all mixed together. Usually, eight to ten grains of paddy

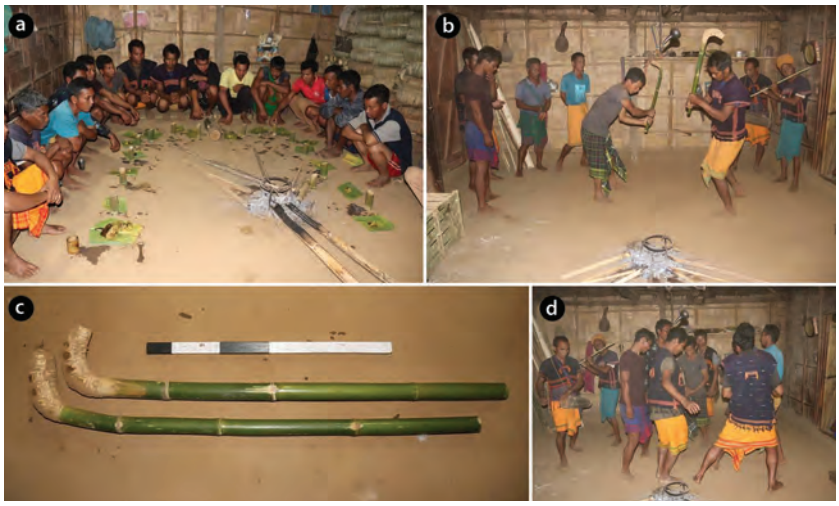

Fig. 9.* a *Performance of rituals*; b, d *dance at the residence of the Loro signifying the close association with shifting cultivation*; c *bamboo hoes.

are put in a hole made with a pointed stick (*khadi*). Both men and women work together while sowing the seeds. Men dig the holes starting from one end of the plot, followed by women who drop the seeds and cover them with soil.

The Hill Tiwa grow a number of crops simultaneously on a plot of land. Chilli, cucumber, gourd, egg-plant, sesame, arum, sweet potato and yam are grown in a common plot. Sowing activities take about a month to complete. Shoots of yam and arum are generally planted at the end of the sowing season (*Patar 2021*).

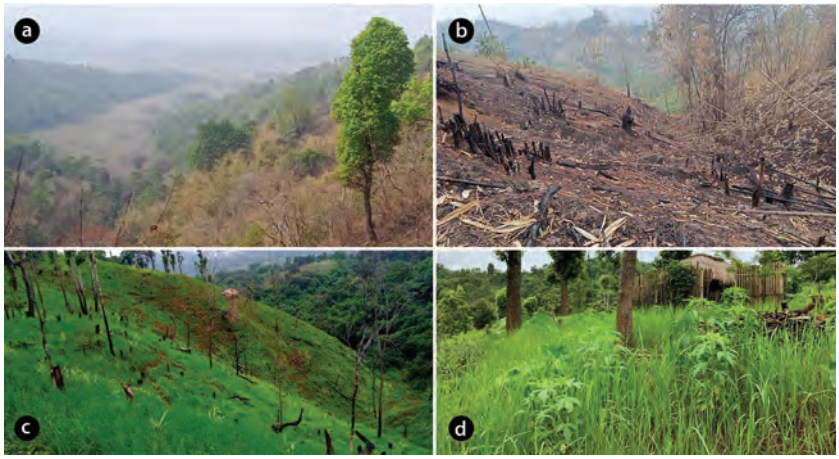

Fig. 10. **a** ***The hills surrounding the Umswai Valley*****; b** ***the clearing of the jungle by slashing and burning*****; c** ***jhum field with rice*****; d** ***small shed or house on the ground.***

Mixed cultivation requires more sustained and greater attention and care than the wet rice cultivation in the valleys. The crops are weeded twice, in July and late September. A watch has to be kept over the fields day and night. Two huts are built for this purpose; a bamboo hut in treetops (*thunggi*) and a small shed on the ground (*maru*), used for guarding in the day. At night a small fire is lit near this. The man who guards the plantation at night stays in the higher hut from where he can easily watch out for elephants, wild pigs, deer or porcupines.

The Hill Tiwa also practice wet paddy cultivation in the narrow valleys of Umswai, Morten, Bormarjong and Ulukhunji. They call their wet paddy fields *fadar*. Unlike their plain counterparts, the Hill Tiwas do not use ox-driven iron ploughs. Instead they use hoes to prepare the soil, a process which begins at the end of March and continues for about a month. After hoeing and irrigating the soil, water buffalo are allowed to tread on the soil to make it smooth. When there are no buffalo, loosening of the soil is done by hoeing only and the work is very strenuous. The process of wet paddy cultivation seems to be more labour-intensive than *jhum* cultivation, as both men and women need to hoe the field in the absence of a plough. Although the normal practice is to transplant seedlings from the seed-bed (*thuli*), which is prepared well ahead of transplantation, some varieties of seeds are planted directly in the irrigated fields. Direct sowing of seeds is undertaken at the onset of the monsoon in June.

The paddies are harvested in December. The Hill Tiwa do not use ox or human feet for separating the grains from the stalks of paddy, but rather they use three- to four-foot long wooden or bamboo sticks to separate the seeds by beating, which is known as *maipothala*. For this purpose, a small plot of land is selected in the paddy field. Men and women in separate groups of seven or nine takes turn separating the grains from the stalks by beating them with sticks. The process continues until the entire paddy has been threshed. The grains are then gathered in a heap and fanned with a winnow to blow away broken stalks. After this, they are collected in baskets of straw called *maipur*, each containing 30 to 35 kilograms of threshed unmilled rice. The hill Tiwas do not construct separate granaries to preserve their rice. Instead, they keep the *maipur* or the straw basket inside *nukthi* (part of the traditional house *nobaro*) along the walls.

Shifting cultivation is a common mode of subsistence among the population residing in the hilly areas. It is also considered as a continuation of the Neolithic tradition (*Sharma 1990*). Many times polished and chipped stone artefacts are found by the villagers while clearing the forest and tilling an area for shifting cultivation. These are believed to be thunder-axes by the villagers and occasionally collected and kept in their possession for various magical-religious practices. Interestingly, many of the stone artefacts resemble modern day axes and adzes made of iron used for various domestic and agricultural activities. A comparative study made by Roy (*1985*) on the Neolithic tools from Garo Hills and artefacts used in shifting cultivation reveals homogeneity in function of both these modern and ancient tools. The use-wear

patterns of the present day as well as prehistoric items suggest similar kinds of use have been maintained. The site of Bargaon, associated with the Hill Karbis in the Garbhanga Reserved Forest has also produced some iron implements which might have been used for shifting cultivation (*Hazarika 2016*). Similarly, Ajay Pratap (*2000*) has correlated the shifting cultivation system of the Paharias of Santal Paraganas with the archaeological record. Eleanor Kingwell-Banham and Dorian Fuller (*2012*) suggest that shifting cultivation may have been a widespread economic system during the Neolithic period, in both the Ganga Valley and the Deccan Plateau of South India. This might have been the case for certain areas of Northeast India, too, where the early settlers adopted the incipient mode of shifting cultivation and developed a strategic subsistence economy over time, exploiting the hilly terrain. The long association of the inhabitants of the hilly landscape with shifting cultivation is thus reflected in their tangible culture as well as intangible cultural practices.

Conclusions

Based on the above discussion, it can be surmised that the Chongkhong Phuja performed by the Hill Tiwas is a unique cultural tradition attached to their agricultural practices. The annual custom of erecting megaliths associated with the Phuja provides us with ample clues regarding the antiquity of the megalithic tradition, as well as the long history of *jhum* cultivation in the area. Moreover, the symbolic use of bamboo hoes in the dance associated with the Chongkhong Phuja ceremony highlights the central role of agriculture in the Tiwa way of life. This symbolism also suggests how the community has been practicing the *jhum* cultivation with simple implements such as digging tools over the years. Based on archaeological, historical and ethnographic evidence, shifting cultivation can be considered as a mode of subsistence supported by gathering, hunting and fishing that has existed since the Neolithic period in these areas of Northeast India (*Hazarika 2017*).

While there is lack of absolute dates for establishing the antiquity and chronology of shifting cultivation in the region, the intricate association of this farming practice with the Tiwa life-ways suggest its deep-rooted historicity. The findings of polished and chipped stone artefacts from the *jhum* fields in the Umswai Valley can be considered as evidence of incipient agricultural activities in the past. However, further systematic archaeological excavations are required in these areas to ascertain the absolute chronology of shifting cultivation as well as the Neolithic tradition in this area.

The megalithic tradition among the Tiwas has been practised for a long period of time. In the Tiwa dominated areas, a variety of megalithic structures are observed which can be categorized as both commemorative and utilitarian. The present study has shed light on the enduring living megalithic traditions among the Tiwas and revealed the close association of megaliths with their agricultural practices. This is perhaps the only example in an Indian context where the erection of megaliths is an annual activity associated with an agricultural ritual. This highlights the diversity of meaning, function and ideology within megalithic traditions and opens avenues for comparative studies with other megalithic cultures worldwide. This study also hints at the intangible cultures attached with early farming practices during remote prehistory.

Northeast India is a hub of various ethnic groups and traditional cultures. Many of the ethnic communities continue to practise some age-old traditions, which provides scope for archaeologists to draw parallels for generating insights for many archaeological problems. The Chongkhong Phuja is one such archaic tradition which leads us to rethink the association of megaliths beyond burial or commemoration.

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Early Neolithic imagery in flux. A case study on the reliefs of Building F at Göbekli Tepe, southeastern Turkey

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ABSTRACT - *Stone is often regarded as the ideal medium for the long-term preservation of knowledge, as it is resistant to change. Early to middle Pre-Pottery Neolithic Göbekli Tepe in southeastern Turkey has repeatedly been treated as a prime example for such external memorial storage in durable stone. The present paper challenges this view. A close examination of pillars and their reliefs in Building F reveals the fluid character of imagery with repeated and frequent phases of erasure and re-making. It is argued that it is not the durability of stone that made it suitable for the preservation of 'cultural memory', but the possibility to re-shape the image carriers continuously over a long period of time, which resulted in processes of transmission, learning and memorization.*

KEY WORDS – *Pre-Pottery Neolithic; Göbekli Tepe; pillars; reliefs*

Zgodnjeneolitske podobe v razvoju. Študija reliefov v stavbi F v Göbekli Tepeju v jugovzhodni Turčiji

IZVLEČEK – *Kamen velja pogosto za idealen medij dolgoročnega ohranjanja védenja, saj je odporen na spremembe. Göbekli Tepe je pogosto predstavljen kot odličen primer ohranjenega spomina v kamnu v zgodnjem do srednjem predkeramičnem neolitiku v jugovzhodni Turčiji. V članku zavračamo ta vidik. Natančen pregled stebrov in njihovih reliefov v stavbi F kaže na stalno spreminjanje značaja podob s pogosto ponavljajočimi se fazami brisanja ter ponovnega ustvarjanja. Trdimo, da ni obstojnost kamna tisto, kar ga je naredilo primernega za ohranjanje 'kulturnega spomina', ampak možnost kontinuranega preoblikovanja nosilcev podob v dolgem časovnem obdobju, ki je rezultiralo v procesih prenosa, učenja in pomnjenja.*

KLJUČNE BESEDE – *predkeramični neolitik; Göbekli Tepe; stebri; reliefi*

Introduction

Stone is often regarded as permanent, stable, immobile and resistant to change (*Robb 2009; Croucher 2012.139*). Monuments made of stone have therefore been identified as a prime medium for the preservation of long-term or 'cultural' memory as opposed to more unstable everyday or 'communicative' memory (*Assmann 1988*). It has been argued that their permanence and imposing presence make them ideal links between the living and the dead (*Parker-Pearson, Ramilisonina 1998*). Similar opinions have been

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voiced for the Early Neolithic of southwestern Asia. The increased use of stone has been described as a major difference between the Epipalaeolithic and the Pre-Pottery Neolithic (PPN), serving to preserve "*ideological concepts for future generations*" (*Benz, Bauer 2013.16–17*). However, the permanence of stone and images carved from or into stone has been called into question, and recent work stresses the temporality of the material not least based on the frequent changes made to monuments (*Díaz-Guardamino 2021 with references*). For Iberian stelae, Maria Díaz-Guardamino has argued that it is not the durability of the unchanged monument but the resilience of relationships, the constant preoccupation with stone images that underlies their function in stabilizing group identities (*Díaz-Guardamino 2021)*. Early to middle Pre-Pottery Neolithic Göbekli Tepe in southeastern Turkey has repeatedly been treated as a key site for early external memorial storage in stone (*Morenz, Schmidt 2009; Morenz 2014; Watkins 2004, with references*), with a focus on its richly decorated limestone pillars. Most interpretations so far describe a predominantly 'static' site with reliefs in a 'finished' state. In this article we want to challenge this view based on insights deriving from a recent in-depth study of the pillar reliefs (*Dietrich*, *Schmidt in print*). We choose one structure, Building F, and its pillars as a representative case study.

Fig. 1. Göbekli Tepe. The main excavation area in the southwestern depression, Building D in the foreground (© DAI, photo N. Becker).

Göbekli Tepe

Göbekli Tepe is located about 15km to the northeast of Şanlıurfa in south-eastern Turkey (*Schmidt 2012; Kurapkat 2015*). The mound rises up to 15m high on a drawn-out limestone plateau on the Germuş crest. The plateau's lateral outcrops once served as the quarries for the site's megalithic structures (*Schmidt 2009.23–33*). Göbekli Tepe was first recognized as an archaeological site in 1963 during a joint project by the University of Chicago and Istanbul University under the direction of Robert Braidwood and Halet Çambel. In his account of his visit at the site, Peter Benedict described its surface to be formed of elevations of red soil separated by depressions whose slopes were reported to be littered with flint artefacts (*Benedict 1980.179, Nr. V52/1, 181–182*). It was not until 1994 that Göbekli Tepe's true potential was recognized by Klaus Schmidt during a systematic survey of the region's Neolithic sites (*Beile-Bohn* et al. *1998*). His longstanding experience from fieldwork at Nevalı Çori under Harald Hauptmann helped him to recognize surface finds as fragments of T-shaped pillars from Neolithic buildings and large-format limestone sculptures, as just recently recorded at this site (*Hauptmann 1993; 1999; 2011*). Fieldwork at Göbekli Tepe began in 1995 under the direction of Adnan Mısır from the Şanlıurfa Museum and Harald Hauptmann from the DAI's Istanbul Department, with Klaus Schmidt as the field director. Schmidt continued to pursue annual systematic investigations until his untimely passing in 2014.

After an initial survey and prospective soundings at the site slopes as well as investigations of some features on the

plateaus (*Beile-Bohn* et al. *1998*), work soon began to concentrate within the south-eastern depression (Fig. 1–2; *Schmidt 2001; 2008a; 2009; 2011; 2012*). Here, four monumental stone buildings (Buildings A-D) of a type so far not known from contemporary sites were uncovered. The four buildings were found to be laid out according to a basic pattern comprising large T-shaped monoliths weighing several tons arranged in an approximate circle or ellipse while held in place by stone walls as well as so-called walled 'benches' in front of the walls (Fig. 1), although these 'benches' were not necessarily meant for seating. In Building C, for example, they seem far too tall (*Piesker 2014*). A pair of similar but much taller monoliths with heights of up to 5.5m stands freely in upright position roughly in the structures' centre. The inner diameter of the buildings varies between 10m and 20m. Seen from the side, Schmidt (*2012.69–72*) recognized the pillars' particular T-shape as a stylized reference to the human body, as also suggested by the occasional occurrence of low reliefs depicting arms, hands, as well as garments (*Köksal-Schmidt*, *Schmidt 2010*). Two parallel bands run down the frontside of many pillars, identified as a stole-like garment; 'V'-shapes in the neck area have been preliminarily identified as 'necklaces'. The circle pillars are always looking towards the central pair, and most of the numerous animal reliefs decorating them are oriented in the same direction (*Peters*, *Schmidt 2004*). A depleted structure discovered on the plateau was designated Building E; the discovery of Buildings G, H and F followed later.

During excavations, Schmidt preliminarily ascribed the large structures to an earlier layer III, which according to the finds and radiocarbon dates was thought to date to the PPNA and probably also to the early PPNB (*Kromer*, *Schmidt 1998; Pustovoytov 2002; 2006; Pustovoytov*, *Taubald 2003; Pustovoytov* et al. *2007; Dietrich*, *Schmidt 2010; Dietrich 2011; Dietrich* et al. *2013*). His layer II was considered to be more recent; it is characterized by smaller rectangular buildings (*Schmidt 2012.228–235; Kurapkat 2015.18–22*). Direct stratigraphic overlays between the architecture of layer III and that of layer II were observed in only few locations (*Schmidt 2000.18–19; 2012.128, 228; Kurapkat 2015.81–82*). In the main excavation area in the south-eastern depression, the space taken in by the monumental buildings had been deliberately spared from later overbuilding and delimited by the so-called terrace wall (Fig. 2; *Schmidt 2010a*).

Layer II after Schmidt is characterized by significantly smaller rectangular structures with lime plaster floors not unlike those observed at contemporary Neolithic sites (*Garfinkel 1987; Hauptmann*, *Yalcin 2000*). If at all present, the size and the number of pillars significantly decrease in this layer. In general, only the two central pillars were maintained, the largest ones reaching heights between 1.5m and 2m. The most impressive architectural representative of this layer contained numerous spoils and was initially referred to as the 'lion pillar building' after the large felines depicted on both its central pillars

Fig. 2. Göbekli Tepe. Plan of the main excavation area with pillar numbers (© DAI, drawing K. Schmidt, additions by O. Dietrich, J. Notroff).

(Fig. 3), although these animals have been identified as most likely being leopards (*Peters*, *Schmidt 2004.184*). This is the only rectangular building whose pillar images reveal more than the already mentioned anthropomorphic features. The structure was exhaustively discussed by Dietmar Kurapkat (*2015.30–38*).

The main criterion for the definition of the above-mentioned layers, which initially served as a rough reference for classifying finds and features during the excavations, was the change from round to rectangular buildings, analogous to architectural developments observed elsewhere in south-eastern Turkey at Early Neolithic sites presenting long occupation sequences (*Özdoğan 2017*), such as Çayönü (*Özdoğan 2010; Erim-Özdoğan 2011*). These 'architectural horizons' will require more scrutiny in the forthcoming study of the site's stratigraphy. It also became clear at an early stage that the radiocarbon data pointed to partial simultaneities between the buildings of layers II and III (*Dietrich 2011*). Numerous *in situ* finds of grinding stones and limestone basins set into floors would suggest food processing activities, contrary to earlier assumptions of the non-domestic character of the rectangular buildings (*Dietrich L.* et al. *2019; 2020; Dietrich L. 2021*). Several locations at the site were found to contain small, curvilinear features, especially in the deep soundings west and north of Building D, but also in the northeast of the main excavation area, and in deep soundings on the north-western elevation (*Schmidt 2011.47–48*). There is a strong possibility that they were dwellings associated with the monumental buildings' earlier phases (*Kinzel*, *Clare 2020*), although to what degree the site may have been permanently occupied still needs further study. The uppermost, disturbed horizon was designated layer I, consisting of the thick deposits which formed at the mound's foot through erosive processes, and the plough horizon.

To verify whether the high concentration of special architecture was a feature only of the south-eastern depression or characteristic of the whole site, comprehensive geophysical surveys were conducted in 2003, 2006, 2007 and 2012 (*Dietrich* et al. *2012. Fig. 3; 2016.56–57*). The investigations by ground penetrating radar in particular revealed evidence of monumental architecture over the entire mound. To test the results, the site's south-western summit was investigated in a large excavation trench in an east-west alignment of eight excavation squares measuring 9x9m and joining with the main excavation area (Fig. 2). The rectangular buildings were found to continue into this area. The test trench led also to the partial uncovering of another large circular structure (Building F) with an inner diameter of 10m (Fig. 4; *Schmidt 2008a.67–69, Fig. 10*). Owing to its location just below the surface, the building's date and stratigraphic position remained uncertain. The pillar dimensions were more reminiscent of those recorded inside the rectangular buildings, while the round outline and the diameter of 10m corresponded to the monumental buildings.

Building F has been described only preliminarily so far (*Schmidt 2008a.67–69*), the pillars and their images have never been fully published and discussed before. As the building is of special importance for the interpretation of the site, this will be done in the following sections.

Building F

Building F is located on the western slope of the south-western hilltop of Göbekli Tepe (excavation areas K9-87 and K9-77). About two-thirds of the almost oval building with two central pillars was explored between 2006 and 2008 (Figs. 2, 4–5). The

Fig. 3. Göbekli Tepe. The so-called leopard's pillar building (© DAI, photo M. Morsch).

inner diameter of the structure is about 10m. However, the pillars are much smaller than those in Buildings A-D and H. The central pillars are oriented in a south-eastern direction, as opposed to south-southeast in Buildings A-D. Since its northern part is outside the excavated area, the total number of pillars in the ring wall cannot be determined yet, although six have been identified so far. The ring wall of Building F consists of two mantles retaining a fill of relatively large rocks and smaller rubble. The outward facing sides of the stones had been processed evenly, the gaps between them were filled with smaller limestone chips. The wall is preserved to about 1.20m above the bench platforms (about 1.70-1.80m above ground level) and is 70-90cm wide. The lime plaster floor inside is even. Benches lean onto the ring wall, and end in coping platforms at about 70-85cm above floor level. In some cases, the platforms abut directly onto the ring wall, sometimes smaller stone slabs fill the gaps in-between. The quality of the bench masonry corresponds to that of the ring wall. The benches rise to between three to five stone courses above the lime plaster floor (height approximately 55cm). To the west a large slab in upright position replaces the bench wall. The pillars in this area are located behind the bench instead of being integrated into it, as observed in the rest of the building's excavated part. No traces of an access to the structure were found inside the excavated area.

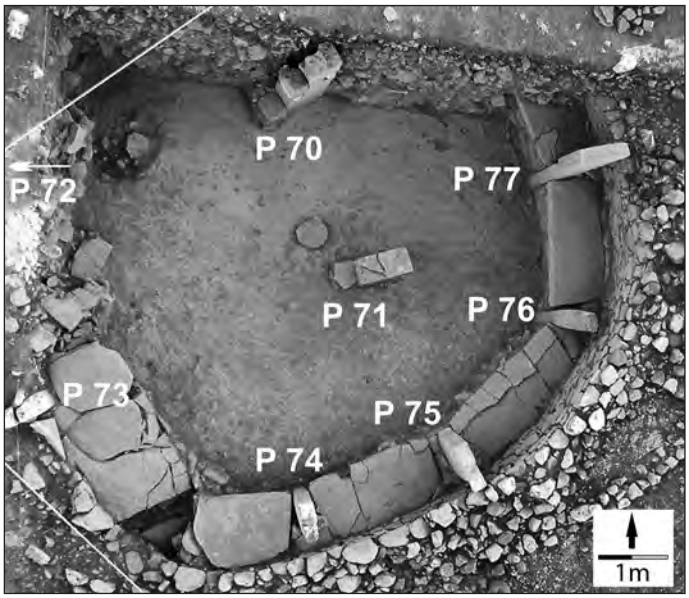

Fig. 4. Göbekli Tepe. Building F (© DAI, photo K. Schmidt).

Given its location directly below the surface, a stratigraphic linkage of the building to the rest of the site proved problematic. Although its contemporaneity with the other round buildings remains uncertain, the latter is nevertheless suggested by the structure's circular shape, its size, which corresponds to that of Building B, as well as by the wealth of ornaments appearing on the pillars as compared to the rarely reliefed ones in the rectangular buildings.

The northern section drawing of area K9-87 is informative for the reconstruction of the fill processes in Building F (Fig. 6). Noteworthy is a dark brown, sandy silt layer containing very few stones just above the lime plaster floor in the centre of the building (Fig. 6.1). It cuts a lighter layer (Fig. 6.3) to the east and therefore likely marks an intrusion, probably the base of a pit that was refilled with sediments mixed with humous topsoil. It is covered by a continuous layer of grey-brown soil with numerous large stones (Fig. 6.2). This is likely the upper part of the filling of the intrusive pit or the result of a second intrusion into the refilled building as the layer's upper limit matches with the preserved height of the central pillar stumps. Pottery sherds, partly from vessels with handles, distinctly post Pottery Neolithic, were found in this layer, they still await examination and final dating. One or multiple post-Neolithic destruction events directed at the central pillars similar to Buildings C and H (*Schmidt 2008b; Dietrich* et al. *2016*) are therefore likely.

Fig. 5. Göbekli Tepe. Building F, 2008 (© DAI, photo S. Matzerath).

The ring wall in the northeast exhibits a marked slant towards the inside, which led to speculation about the former existence of a corbelled roof vault. However, the stones are very irregular, partly unworked, and of different size, and thus this seems unlikely. Above this layer is a grey-brown deposit with many small pebbles and a few large stones (Fig. 6.4). Immediately next to the ring wall, several events of wall collapse are detectable (Fig. 6.5, 6). A thin humous layer follows on top (Fig. 6.7). As result of the post-Neolithic disturbances, Building F does not provide evidence for the discussion on intentional backfilling of buildings at Göbekli Tepe.

The pillars of Building F

The recorded measurements for the pillars are dependent on the state of excavation – at any rate, the visible height is always indicated. Cases in which measurements are missing signify that they were unfeasible. The naming of the pillars followed conventions originally established during excavations, closely connected to the layer III-I scheme. The attribution of Arabic numbers to the pillars in the monumental round buildings of the so-called layer III follows the order of their discovery, whereas Roman numbers refer to the pillars unearthed in the rectangular buildings of the so-called layer II. This distinction was reasonable as far as it concerned the main excavation area, where it referred to different building types with pillars of different sizes in at least partly consecutive stratifications. Building F – a large round construction with small pillars – calls this categorization into question. Therefore, Arabic numbers are now assigned to all pillars and the correspondences are given below.

Central Pillar 70 / formerly Pillar XXXVII

Relief bands, arms, hands, fox. Area: K9-87*; height: 1.57m; width (shaft): 0.62m; width (head): –; thickness: 0.31m (Fig. 7).*

Pillar 70 is the northern central pillar of Building F. It is severely damaged, but a partial reconstruction of the shaft was possible through assembling several of its fragments; the T-head is lost. The pillar stands in the building's lime plaster floor. A flat stone slab on a 45cm high earth mortar pedestal had been placed on the floor in front of the pillar. Arms rendered in relief are displayed along the shaft's broadsides, whilst the hands converge at the front. Vague fingers arranged as parallel bands join in a pointed triangle covering the relief bands. A fox whose head is no longer preserved appears in the arm bend on the shaft's left broadside. Remarkably, the animal's tail is missing as well, either because of the masking effect of the elbow, or due to the later execution of the latter. However, this second possibility seems less likely, as the depth of the reliefs is almost identical for both motifs.

Central Pillar 71 / formerly Pillar XXXVI

Arms/hands. Area: K9-87*; height: 0.83m; width (shaft): 0.65m; width (head): –; thickness: 0.38m (Fig. 8).*

The southern central pillar of Building F is also embedded in the floor and preserved as a stump. One of the fragments bears the remnants of a representation of fingers, thus also giving evidence to the former existence of arms and hands. As with Pillar 70, a small stone slab had been placed on an earth mortar pedestal in front of it. Its northern side has traces of plaster, which originally probably covered the whole pedestal.

Pillar 72 formerly Pillar XXIII

No reliefs so far. Area: K9-77; height: 0.50m; width (shaft): 0.77cm; width (head): –; thickness: 0.33m.

Pillar 72 in the west of Building F is a severely weathered pillar stump already visible at the surface prior to the excavations.

Fig. 6. Göbekli Tepe. Area K9-87, north section (© DAI, drawing O. Dietrich, based on drawings by S. Matzerath, Julia Wagner).

Pillar 73 / formerly Pillar XXIV

No reliefs so far. Area: K9-87*; height: 1.10m; width (shaft): 0.60m; width (head): –; thickness: 0.22m.*

Pillar 73, a severely weathered and fractured stump, stands in the west of Building F.

Pillar 74 / formerly Pillar XXV

Relief bands, 'V-shaped necklace', arms, hands, leopard(?), human. Area: K9-87*; height: 1.10m; width (shaft): 0.68m; width (head): –; thickness: 0.24m (Fig. 9).*

Pillar 74 stands in the south of Building F. Its shaft is broken, and the T-head is missing. A so-called V-shaped necklace as well as relief bands and hands are visible on the front side facing the building centre (Fig. 9.1, 3). Contrary to representations on other pillars, the hands appear like mere parallel strips converging in a triangle, but owing to the arms on the broadsides, the interpretation is safe. The hands cover the relief bands. The upper area of the pillar's rear side facing south shows an animal with an upward bent tail which during the excavations was identified as a dog, even though it may also be interpreted as a leopard according to other matching motifs (Fig. 9.2). Below appears a human figure in frontal view, whose body is supplanted by wide square shoulders. The figure has been unearthed down to the level of its knee. Faint lines visible below the chest may trace the outline of the ribs. Remnants of relief bands especially recognizable in the upper part of the current pillar rear side point to the pillar's relocation and reuse. Each broadside exhibits a distinct offset just above the bench platform. Below appear rough chisel marks pointing to transformation work after the pillar's repositioning inside the bench.

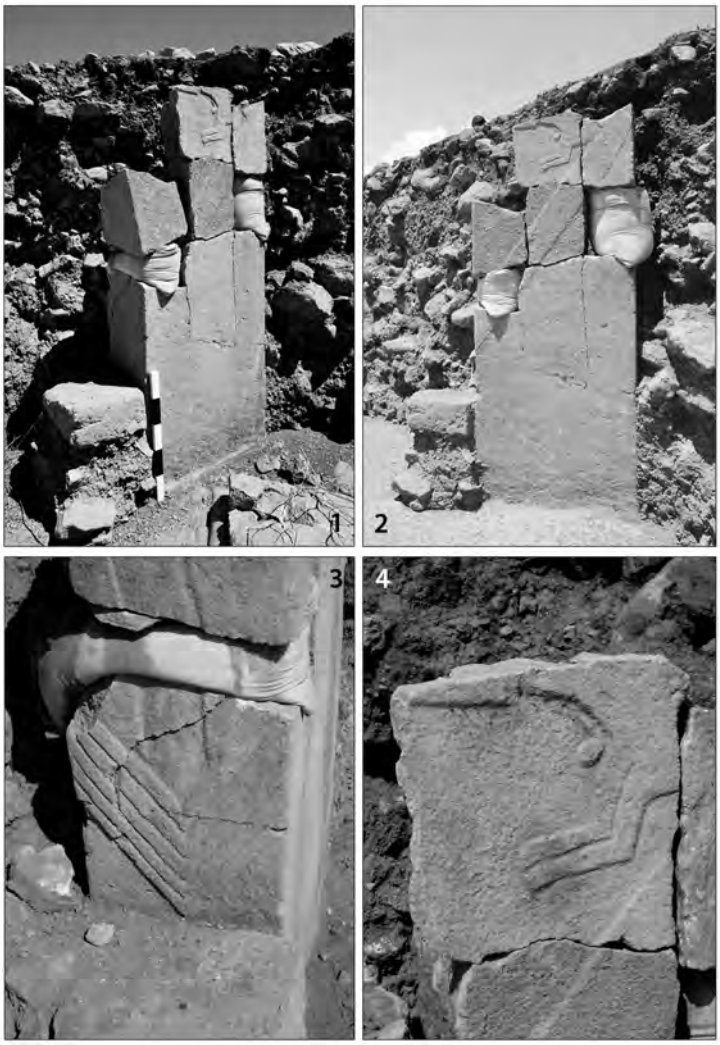

Fig. 7. Göbekli Tepe. Pillar 70 (© DAI, photos S. Matzerath).

Fig. 8. Göbekli Tepe. Pillar 71 (© DAI, 1-2 photos N. Becker; 3 photo Ç. Köksal-Schmidt).

Pillar 75 / formerly Pillar XXVI

Arms, hands, 'V-shaped necklace'. Area: K9-87*; height: 0,82 m; width (shaft): 0,52 m; width (head): –; thickness: 0,23 m (Fig. 10).*

Pillar 75 is located in the southeast of Building F. Its head is broken off, the offset marking the shaft-head-transition is still present. The pillar fragment had been walled into the bench masonry and fixed between the bench platforms by aid of wedge stones. Traces of a so-called V-shaped necklace are noticeable on the front side (Fig. 10.2), from whose broadside emanates the shallow relief of the left arm (Fig. 10.3), which reaches down to the barely visible hand at the front (Fig. 10.2). The relief supplants an earlier arm, which is also rendered as a shallow carving (Fig. 10.4). However, the arm is bent towards the actual rear side of the pillar. The remains of an even earlier, more pronounced arm relief likely pointing in the same direction have survived in the lower area. The pillar can therefore safely be attributed to a secondary context, and its carvings have been re-fashioned in (at least) three different stages. Though lacking relief decorations, the opposite side reveals an offset at the bench level, the pillar's wider part being concealed by the latter (Fig. 10.1). Possibly, an earlier relief had been erased here to also place an arm motif on this side. The last re-fashioning of the pillar was apparently not finished.

Pillar 76 / formerly Pillar XXXIV

Predator (leopard?), bird. Area: K9-87*; height: 1.13m; width (shaft): 0.55m; width (head): –; thickness: 0.24m (Fig. 11).*

Pillar 76 stands in the east of Building F. The T-head and a part of the shaft are missing. The left broadside bears the carved image of a predator (leopard?) and details of a significantly deeper relief of a bird displaying a markedly curved beak, perhaps that of a vulture, protruding from the level of the bench platform. Though it seems to be executed as an outline only, the body area of the predator relief shows numerous chisel marks, leading to the assumption that the outline represents the remnants of an earlier, erased relief. The opposite broadside is extremely uneven, suggesting that the pillar had weathered on this side lying at the surface for a longer period before being reused.

Fig. 9. Göbekli Tepe. Pillar 74 (© DAI,* 1,3-4 *photos N. Becker;* 2 *photo S. Matzerath).

Pillar 77 / formerly Pillar XXXV

Relief bands. Area: K9-87*; height/length: 2.15m; width (shaft): 0.45m; width (head): 0.62m; thickness: 0.22m (Fig. 12).*

Pillar 77 stands in the east of Building F. The head was found immediately next to the pillar stump and refitted. The pillar reveals relief bands on its rear narrow side, an indication of an (at least) secondary position. The rest of the surface shows chippings and flaws, but appears not to have any reliefs.

Building F. Installations and imagery

So far, no access is known for Building F. It is thus uncertain whether it was entered from the roof or from elsewhere in the yet unexcavated area. In the case of an entrance opposite the front side of the central pillars, as in Building C (*Schmidt 2008b*), it might still be found in the unexcavated area. Both central pillars are severely damaged, as shown above likely in the wake of a post-Neolithic intrusion event (Fig. 6).

For both central pillars, arms and hands can be reconstructed. Pillar 70, which was partly reassembled from fragments, has the motif

of a fox inside the arm bend. The motif is repeated only once at Göbekli Tepe so far, on Pillar 18, one of the central pillars of Building D (*Köksal-Schmidt*, *Schmidt 2010*). However, there may be a potential link to another group of images that consists of moving or leaping solitary predators. These individually depicted animals on armless pillars could be *pars pro toto* representations of the more complex scene. The motif of a leaping solitary predator on the shaft broadsides, whether in the arm bend or not, seems to be particularly prevalent on the central pillars. So far, in addition to Pillars 18 and 70, which include arms and animals, four pillars are known to match with this category: both central pillars in Building B (Pillar 9 and 10: *Schmidt 2012.124–128, Fig. 51–52*), the western, central Pillar (37) in Building C (*Schmidt 2008.28*), and the eastern central Pillar (51) in Building H (*Dietrich* et al. *2016.59, Fig. 7*). The question whether this similar characterization of the central pillars could hint at a depiction of the same entity is open to discussion (see *Becker* et al. *2012* on the possible character of the central pillars).

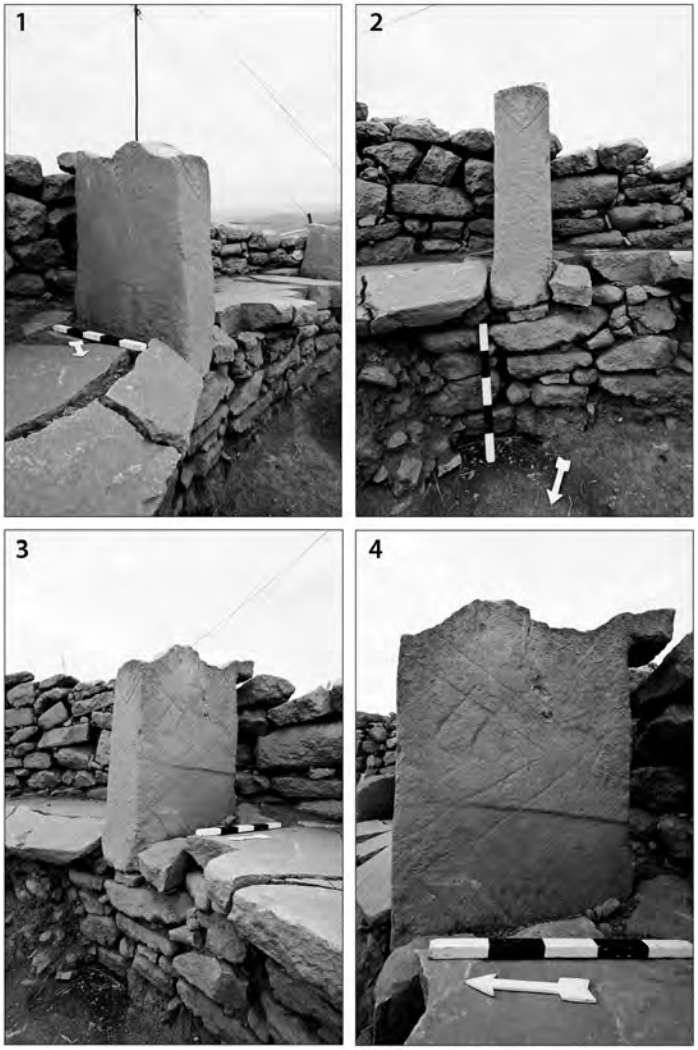

Fig. 10. Göbekli Tepe. Pillar 75 (© DAI, photos N. Becker).

Stone slabs had been placed on pedestals in front of both central pillars in Building F. As they are integrated into the floor plaster, they belonged to the original configuration of the building. Their function is unclear. One possibility is that they had been equipped with lighting facilities as tentatively observed in other buildings; another is that they were used to place other important items in front of the pillars. In Building D the remains of a foxtail in anatomical composition were found close to Pillar 18, in the lower area of the building's backfill (*Peters* et al. *2014.175*), and during excavations concentrations of finds like axes, decorated limestone balls or sculptures have regularly been recorded next to the pillars, particularly the central pillars (*Dietrich* et al. *2019a*). A large, now fragmented stone plate had been integrated into the lime plaster floor between both pillars (Figs. 8/3), and it is reminiscent of a stone bowl in the floor of Building B (*Schmidt 2012.128–129, Fig. 51*).

Some of the ring wall pillars have not been fully excavated yet. As one moves from west to east along the ring wall, the pillar stumps 72 and 73 so far reveal no reliefs. Pillar 74, whose head is missing, has relief bands, arms, and hands, as well as a small animal on its rear side, possibly a leopard, and a standing human figure in frontal view (Fig. 9.2). Representations of humans are very scarce on the pillar reliefs, which contrasts with a large repertoire of anthropomorphic sculpture (*Dietrich* et al. *2019a*). The reason behind the apparent hesitation to depict humans on reliefs remains elusive. There are two further cases in which humans are depicted with some security on pillars. The lower shaft of Pillar 43 in Building D has a damaged depiction of a headless human apparently riding a large bird (Fig. 13). This image has been interpreted as referring to a shamanic soul journey (*Borić 2013*), an interpretation that needs an in-depth discussion that goes well beyond the scope of the present paper. The second image was found on a large pillar fragment (Fig.14) discovered in 2010 just north of Pillar 18 in Building D (*Schmidt 2010b.245, Fig. 11).* A vulture with spread wings and a large quadruped predator, possibly a bear) dominate the

Fig. 11. Göbekli Tepe. Pillar 76 (© DAI, photos N. Becker).

fragment. Another quadruped relief above the bear is partly cut off. In front of this animal appears a human head. A bent human arm may signal a more complex and probably narrative scene. Whether the human figure is being attacked by the animals is not entirely clear. The human depicted on Pillar 74 on the other hand appears static in his frontality, and no action is indicated. This conforms to the standards of plastic anthropomorphic images, where a large group consists of standing humans with a clearly defined frontal viewing axis, the images often being stele-like and not going into depth (*Dietrich* et al. *2019a*). A prime and completely preserved example is the so-called Urfa man (*Hauptmann 2003*). Because of the conspicuously long and small neck and the narrow thorax as compared to the very broad shoulders the person on Pillar 74 evokes the impression of partial skeletonization. This would liken the depiction to a group of animal images with pronounced depictions of ribs, which could be seen as a reference to death (*Schmidt 2013b*) but also could have been meant to evoke slick dexterity, tension during the prowl prior to attack or increased ferocity from famishment. On the other hand, the peculiar anatomy of the human figure could be also explained by the depiction of a cape-like garment.

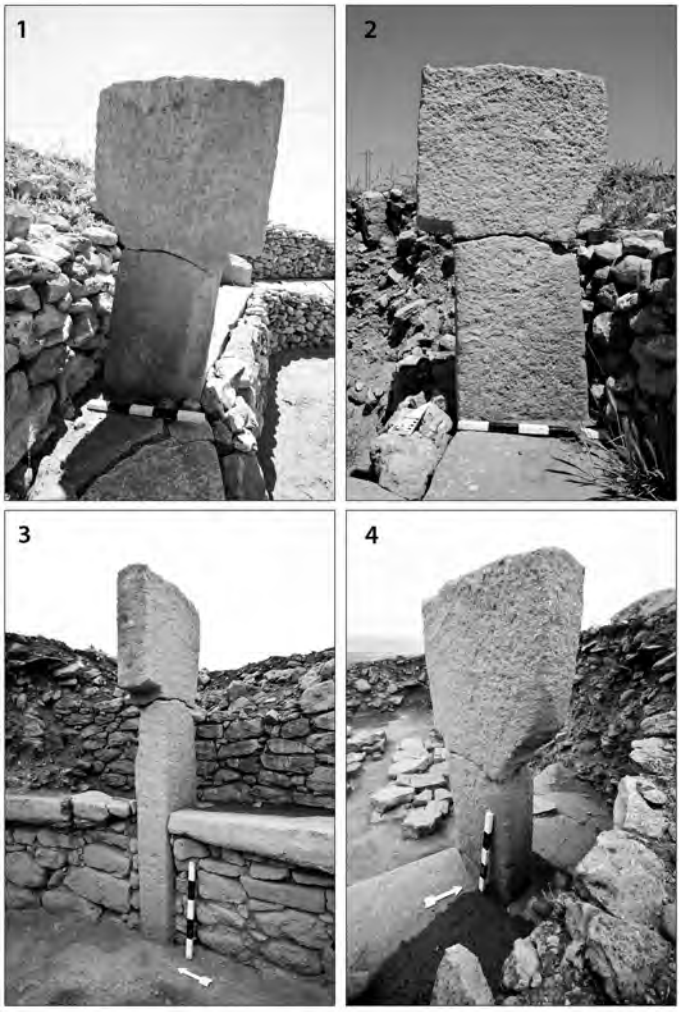

Fig. 12. Göbekli Tepe. Pillar 77 (© DAI, photos N. Becker).

Pillar 75 also has clear anthropomorphic traits as it displays a 'necklace' as well as arms and hands. Pillar 76 shows a predator (leopard?) and a bird, whilst Pillar 77 has relief bands. All well-investigated pillars are in (at least) secondary position and some were apparently being reworked still during the building's terminal phase. The functional period of this building can be suspected to have lasted for a considerable time, judging from the numerous conversions. With continuing work, the discovery of more ring walls, as documented in other buildings at Göbekli Tepe (*Piesker 2014*), would be no surprise.

Discussion. Building F and Early Neolithic imagery in flux

As stated in the introduction, Göbekli Tepe has mostly been seen as a static site with fixed image programs that convey cultural concepts closely related to its builders. Every monumental building so far excavated at Göbekli Tepe has a 'preferred' depiction, an image that occurs much more frequently than the rest (*Peters*, *Schmidt 2004.209–212*). This predominant depiction has been tentatively interpreted as having an emblematic or totemic role for a group of people using the respective building. In Buildings A-D and H a certain animal species dominates the iconographical range. Building F, on the other hand, has so far produced the largest assemblage of anthropomorphic features on pillars among all buildings at Göbekli Tepe, but few animal depictions.

This could contradict the former interpretation as emblematic images. However, an interpretation in the sense of a chronological development is possible, too. There is a general tendency of a reduction of the quantity and range of images between the monumental round and the small subrectangular or rectangular buildings (*Peters* et al. *2014.172*). The latter have nearly no zoomorphic reliefs but the anthropomorphic characterization of the pillars still exists in a few cases. This fits with observations from Nevalı Çori, where some of the pillars of the EPNNB-MPPNB 'cult building' also show arms, hands, V-shapes and stoles but not a single animal relief (*Hauptmann 1993*). Building F could be relatively late in the sequence of Göbekli Tepe's round buildings.

The more complex arrangements of animal reliefs, described by Schmidt as 'Großbilder' ('extended images'), have been interpreted as likely depicting mythological scenes (*Schmidt 2013a*). The canonical and repetitive character of the imagery that also includes 'abstract signs', has been taken as evidence for external memorial storage (*Watkins 2004*). In this line of thought, Göbekli Tepe's buildings could be seen as arenas for learning and the preservation of knowledge. The exact mode of the learning processes likely associated with the imagery have only partly been discussed so far. Unpleasant or even traumatic experiences during imagistic rituals (*Whitehouse 2000*), meant to produce lasting 'flashbulb' memories, have been proposed as one possible scenario of use for the subterranean monumental buildings with their intimidating imagery of snarling predators and

Fig. 13. Göbekli Tepe. Detail of Pillar 43 in Building D (© DAI, photo K. Schmidt).

powerful animals in aggressive postures (*Dietrich* et al. *2019b*). Another way to generate lasting effects of memorization of the stories behind the imagery is constant engagement with the buildings and images.

The data presented above speaks in favour of a transformative and processual attitude towards the rather soft and easily workable stone as an image carrier at Göbekli Tepe. Building research has also revealed that the buildings were subjected to frequent changes – de-constructed, re-constructed, and repaired (*Piesker 2014; Kurapkat 2015*). The same is true for the pillars and their reliefs. Pillar 75 is a prime example of a relief surface very much giving the impression of a palimpsest. Older images are (partially) erased by pecking and grinding, new ones are applied, the pillar turned around and the formerly undecorated spaces filled with images. The intensity of the changes becomes clear from the amount of material substance removed from the pillar surfaces. On Pillar 74, the offsets reach about 5cm; for several pillars surface reductions of more than 10cm are observable. This is significant regarding pillar size and another argument against the differentiation into larger (older) and smaller (younger) pillars. It would

Fig. 14. Göbekli Tepe. Decorated pillar fragment from Building D (© DAI, photo N. Becker).

not be surprising if at least some of the 'small' pillars were the result of constant re-shaping of originally much larger pillars. Although hypothetical at the moment, this certainly is a starting point for future research.

Karina Croucher (*2012.140–142*) had already considered that the process of making images might have been more important at Göbekli Tepe than the actual images. Indeed, many pillar reliefs were partly or completely hidden by walls. Drawing on ethnographical data, she proposes that the images and stone itself could have been perceived as animated: Stone absorbs and conducts temperature, and working soft stone may have echoed practices of body decoration. When viewed in flickering light, the images could have appeared animated. The knowledge of stone carving, of bringing the material to life, would not have resided with individuals in Croucher's view, but constituted the knowledge of a group, handed down by their ancestors. Even if not every detail of this interpretation can be proven and conclusions drawn from ethnography are fraught with doubts, Croucher's approach offers an interesting perspective on our findings from Building F and the other monumental enclosures at Göbekli Tepe: the transformative character of the imagery and the image carriers.

The intensity of activities inside the buildings clearly transcended functional purposes like maintenance or repair (*Clare* et al. *2018*) and seems ritualized. The constant engagement with the imagery implies processes of handing on and learning its meaning, which could have helped to actively preserve key concepts related to the identities of the builders. Drawing on Pierre Bourdieu's (*1977*) thoughts, what was at work at Göbekli Tepe could be understood as social practices in the form of ritualized work, serving to uphold group identities, knowledge, and the habitus of the hunter by constant occupation with important buildings and re-making of imagery. It is not the durability of stone that made it suitable for the preservation of 'cultural memory' at Göbekli Tepe, but the possibility to re-shape the image carriers continuously.

We have already referred to the chronological tendency towards fewer images on the pillars and the decline of imagery centring on wild animals. Radiocarbon data and material culture hint at a period of use between 9600–8000 BCE for Göbekli Tepe (*Schmidt 2001; Dietrich* et al. *2013*). The end of the site thus roughly coincides with the final establishment of plant cultivation (*Dietrich L. 2021*) and livestock husbandry (*Peters* et al. *2014.177*) in the region. Within this slow process, animal images seem to have lost their importance successively, while anthropomorphic elements lasted until the end of Göbekli Tepe. The advent of food production could well have made the knowledge and the acts of learning associated with the site obsolete, in a world that now was transformed irrevocably by human actors.

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Human and birds: avifauna at hunter-gatherer sites of the 6th to 3rd millennia BC (Western Dvina Lakeland)

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ABSTRACT - *The paper presents the study of avifauna from the hunter-gatherer sites at the Dnieper-Dvina basin spanning time period from the 6th to 3rd millennia BC. A total of 669 bird bones were identified and attributed to 46 different bird taxa, representing resident and migrant birds. They belong to four habitat groups: waterfowl, forest, woodside and meadow-steppe. The dominance of waterfowl birds follows the common strategy of aquatic resources exploitation. Changes in the procurement strategies, use and symbolic meanings of birds can be envisaged. Reconstructed regional mean temperature fluctuations suggest a particular influence on breeding biology and migration patterns of different species.*

KEY WORDS – *birds; Neolithic; Dnieper-Dvina basin; mean temperature fluctuations; items made from bird bones; hunter-gatherers*

Človek in ptice: avifavna z najdišč lovcev in nabiralcev od 6. do 3. tisočletja pr. n. št. (Pojezerje Zahodne Dvine)

IZVLEČEK – *V članku predstavljamo študijo avifavne z najdišč lovcev in nabiralcev v Dnjeprovsko-Dvinskem bazenu v času med 6. in 3. tisočletjem pr. n. št. Skupno je bilo identificiranih 669 ptičjih kosti, ki pripadajo 46 različnim ptičjim taksonom. Ti predstavljajo lokalne ptice in ptice selivke. Uvrščajo se v štiri habitatne skupine: vodne ptice, gozdne, ptice z roba gozda in travniško-stepske. Prevlada vodnih ptic kaže na strategijo izkoriščanja vodnih virov. Sklepamo lahko o strategijah lova, njihove uporabe in simbolnem pomenu. Rekonstruirana povprečja temperaturnih nihanj v regiji kažejo pri različnih vrstah na določen vpliv na njihovo gnezditveno biologijo in selitvene vzorce.*

KLJUČNE BESEDE – *ptice; neolitik; Dneper-Dvina bazen; povprečna temperaturna nihanja; predmeti iz ptičjih kosti; lovci in nabiralci*

Introduction

People have had diverse economic, symbolic, social and ecological relationships with birds, with the animals used as a food supply, materials for producing items, ritual features and burial gifts (*Gal* et al. *2021*; *Mannermaa* et al. *2008*; *Lozowski 1996*; *Mannermaa 2008; 2008a*; *Zhulnikov, Kashina 2010*; *Oshibkina 1996*). Among the bird species found at archaeological sites, waterfowl birds dominate within both hunter-

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gatherer societies and those with a productive economy (*Gal* et al. *2021*; *Mannermaa 2013*; *White* et al. *2021a*; *Russell 2019*). The high percentage of bones of bird species from other habitats may be due to several factors, *e.g.,* proximity of certain landscapes to the ancient site (*Vos, Russell 2021*), functional orientation and seasonality of habitation at the site, focus on a certain seasonally rich resource (*White* et al. *2021a*), as well as a cultural choice.

Bird bones along with other faunal remains were found on Neolithic wetland sites of the 6th to 3rd millennia BC in the Dnieper-Dvina region. The studied area lies in a recently glaciated zone of the Valdai ice sheet which is characterized by high geo- and biodiversity with well-developed land relief, reach lakes, swamps and mires of different sizes and shapes. An important axis of the Western Dvina River, the valley was used for migrations of animals as well as human groups and ideas. Climate change can be seen through increases in global temperatures (*Davis* et al. *2003*), and in the occurrence of extreme events caused hydrological changes and impacted on the breeding biology and migration patterns of different species. Regional or local climatic fluctuations might have been of particular importance in this context, too (*Mroczkowska* et al. *2021; Płóciennik* et al. *2022*).

This article aims to analyse the avifauna at the hunter-gatherer sites of the Dnieper-Dvina basin from a diachronic perspective from the 6th to the 3rd millennia BC, to reveal the peculiarities of hunting strategies, range of bird species and habitats, to what extent influence of paleoclimatic conditions is visible, and the role of birds in ancient societies.

Material and methods

The avian bone assemblage represented here came from Serteya II (pile-dwelling areas excavated in 1972-1974, 1980–1989, 1993-2023 and western shore zone – 2015-2023), Serteya I (2010-2011), Serteya X (1992-1997) (Serteysky microregion), Usviaty IV (1963-1966) (Usviaty microregion), Naumovo (1970-1975) (Zhizhitsky microregion), Dubokray V (1983-1991) and VII (1991) (Sennitsky microregion) (Fig. 1). The materials from excavations undertaken in the 1960-1990s were recorded within the squares and horizons, and no sieving was applied. The finds, including faunal assemblage, at the Serteya II and I sites were recorded in a three-dimensional coordinate system. The entire layer was washed through a 0.5cm sieve, the finds were labelled according to lithological layers and squares, and further attributed to the distinguished chronological horizons (*Mazurkevich* et al. *2020a*).

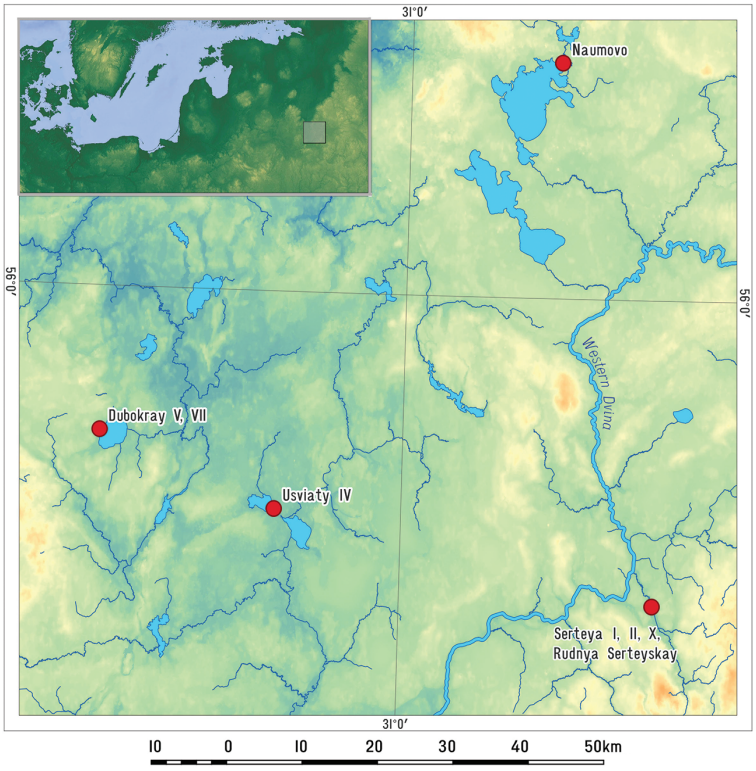

Fig. 1. Location of the Serteya I, II, X, Rudnya Serteya), Naumovo, Usviaty IV, and Dubokray V, VII sites.

Of the total 757 bird bones that were found, 669 were identified using the comparative bird collection housed in the Laboratory of Ornithology of the Zoological Institution of the RAS (Tab. 1). This makes up from 13.8 to 15.2% of the total animal bone material at different sites (fish assemblage not included).

The results of Chironomidae-inferred mean July air temperature from Serteya II (*Płóciennik* et al. *2022*; *Kittel* et al. *2021*; *Wieckowska-Lüth* et al. *2021*) were compared with alkenone-inferred temperature reconstruction from the western Mediterranean following Marta Rodrigo-Gámiz *et al.* (*2014*) and Darrell Kaufman *et al.* (*2020*).

Traceological analysis of bone items was applied with comparison to a reference collection, a surface study was made with a Leica EZ4 and Olympus BHMJ

with augmented LED lighting and lenses x10 / 0.30 UMPlanFI x20 / 0.40 LMPlanFI based on acetate prints taken from the artefacts.

Sites: chronological and functional context

The bird bone assemblage can be attributed to different time periods – 6th to early 5th millennia BC (Serteya II (western section), layer of coarse-grained grey sand, Rudnya Serteyskaya (*Sablin* et al. *2011)*), second half of the 5th millennium BC (Serteya II (western section), layer of black gyttja); 4th millennium BC (Serteya II (western section), upper part of black, olive gttja), Serteya I, X, Naumovo (layer B), Usviaty IV (layer B), Dubokray V, VII); middle of the 3rd millennium BC (Serteya II (western section, brown gyttja), Serteya II (eastern section, pile settlement)); and late 3rd millennium BC (Usviaty IV (layer A and α), Naumovo (layer A)) (Tab. 1).

The remains of bird bones are confined to different functional contexts at sites. Short-term usage of a shore line zone can be reconstructed for the 6th to early 5th millennia BC at the Serteya II and Rudnya Serteyskaya sites. Between 4150 and 3250 cal BC intense anthropogenic activity was observed at the Serteya II site, when the water level was relatively high and this was a place used for fishing, as testified by a number of different wooden fishing structures. The regressive-transgressive regimes of the ancient lake in the Serteya basin at the end of the 5th to 4th millennia BC coincided with the appearance in the region of various groups from the forest-steppe, steppe Don River and the left bank of the Dnieper River. The Serteya I site can be interpreted as a place used for a specialized fishing, synchronous to several phases of occupations of the Serteya II site (pile-dwelling section of the 3rd millennium BC, and western shore section of the 4th millennium BC) (*Mazurkevich* et al. *2020b*). Bird bones are mainly discrete finds from the archaeological layers of the sites, which complicates their precise dating. However, date modelling for the Serteya II site has made it possible to suggest shorter periods of occupation, which can also be extrapolated for dating birds (*Mazurkevich* et al. *2020a*). Given the small number of identified species, it can be assumed that these faunal remains were deposited just before site abandonment.

Narrow time periods of occupation can be suggested for the complexes uncovered in pile-dwelling sites Serteya II (eastern section), Usviaty IV and Naumovo sites (Tab. 1). At Naumovo (layer B) and Usviaty IV (layer B, 3 building horizons) remains of bird bones were found in the dwelling horizons of pile structures dated to the end of the 4th millennium BC. During this time period, around 3250 to 2500 cal BC, water level fluctuations and the possible disappearance of the lake basin in dry seasons are noted in the Serteya microregion (*Kittel* et al. *2020, 2021*), when only the western section of the Serteya II site was inhabited. Since *c.* 2750 cal BC a significant regression accompanied by seasonal fluctuations (*Wieckowska-Lüth* et al. *2021*) led to the formation of the Zhizhitsa culture pile-dwelling site, inhabited all year round with several dwellings (no. 1-6 with five construction phases distinguished within dwelling no. 1) in the eastern section of the Serteya II site and household areas, with zones of butchering on the shore line in the western section.

Bird assemblage: species, element representation and modifications

Species description. A total of 46 species of birds from 16 families were identified (Tab. 1). The difference in the number of bird remains at the sites can be due to the size of excavated areas, excavation techniques, but also to the specifics of the ancient societies' economies. The faunal collection is represented mainly by adults, the number of young birds is small – from 5 to 23%, and on average about 10% (Serteya II) or 6% (Usviaty IV layer B); one young bird was recorded at each of the Dubokray VII, Naumovo (layer B), and Usviaty IV (layer A) sites, and only adults were recorded at the other sites.

The largest collection of birds – 21 species from nine families – was recorded at the Serteya II site (Tab. 1). The dominance of aquatic bird species was noted for all chronological periods, with more than half (55.8%) represented by *Anas platyrhynchos*. Of particular importance could have been species of *Pelecanus crispus, Anser sp., Fulica atra, Gavia sp*., and *Podiceps sp.*, procured in part for their tough skins covered with dense plumage.

At Usviaty IV (layer B) 20 species from nine families were recorded, while at Naumovo settlement (layer B) six species from five families. In later layers a much smaller set was recorded – three (layer A) and one species (layer α) at Usviaty IV, four species at Naumovo (layer A).

Burned bones were recorded only at the Serteya II site, where they make up to 10% of all identifiable bones. They are mainly distributed within the sandy platform used for fire-places in pile-dwellings and on the household platform in the western section.

Element representation. At the Serteya II site almost all skeletal elements of *Anas platyrhynchos* are represented, with the humerus and coracoid predominating (Fig. 2.a,b). Cranial axes are rather rare, long bones are the most abundant, especially coracoids, ulnae and humeri. Other taxonomic groups are represented by a few or single fragments, or a slightly major presence of bones associated with meat-rich parts, such as humeri, coracoids and leg bones (tibiotarsi), can be noted. At other sites birds are divided within two groups – represented by almost complete skeletons and single bones. At Usviaty IV (layer B) site humerus (range between 28% and 36% (*Anas platyrhynchos),* coracoideum (14%), tibiotarsus (12%) and ulna (11%) made up to 65 % of all bones (Fig. 2.c).

Modifications. Anthropogenic marks are very rare, and include peeling and cutting marks related to the process of disarticulation. The cutting marks found on humerus and ulna (Fig. 3) are probably a consequence of the disarticulation of wings.

Bird assemblage: bones used for items and depictions of birds

All items come from the dwelling areas of pile settlements of the late 4th millennium BC (Usviaty culture, Dubokray V and Usviaty IV (layer B) sites) and mid-3rd millennium BC (Zhizhitsa culture, Serteya II site), except for one point found in the layer attributed to the second half of the 6th millennium BC (Serteya II site). This point was made of an ulna with a preserved proximal epiphysis (Fig. 4.17). The diaphysis was segmented and sharpened by longitudinal scraping. Such points are very rare, and only single items are known from the circum-Baltic area and Eastern Europe (*Lozowski 1996; Mannermaa 2013, 2008; Vankina 1999*).

At the Serteya II site 16 items are known, including three tools, six ornaments, seven production wastes and blanks; at the Usviaty IV site (layer B) there are two items with birds depictions, four tools, and one blank, and at the Dubokray V site there are two flutes. *Anatidae sp.* bones were mainly used, and single items were made from grey heron bones and the bones of large birds of prey. Only long bones were worked: humerus, radius, ulna and tarsometatarsus.

At the Serteya II site tools include two items with circular grooves. One piece was made from the radius (or humerus) of a large predator, the two epiphyses of which had been sawn and separated. The proximal part was sawed with a thin rope/tendon (U-shaped groove), and the distal part with a flint tool (V-shaped groove) (Fig. 4.16 A-E, H-D). The diaphysis shows a series of grooves perpendicular to the longitudinal axis, less often oblique, irregularly incised along the circumference, mostly U-shaped in cross-section, indicating repeated contact with a soft, thin material. At the bottom of the grooves traces of flint sawing can be seen (Fig. 4.16 B-F), which were mainly erased during further operations (Fig. 4.16 C-G). These tools may have been used to soften thin strips of skin, tendon fibres or plant fibres. The second was made from the humerus of a large waterfowl, and the epiphyses were preserved. The grooves on the diaphysis, U-shaped in profile, are more numerous, much shallower, and have a more regular organization. Similar items with grooved depressions with a 'U'-shaped profile were found at the Usviaty IV (Fig. 4.11,14,15,18) (*Miklyaev 1971; Malyutina, Sablin 2014*) and Dubokray VIII sites.

The most widespread category is pendants, all attributed to the Zhizhitsa culture. Five of them come from the pile-dwelling area of the Serteya II site (4 from dwelling no. 1, 1 from dwelling no. 3 (Fig. 4.1-4,6), one from the western shore part of the Serteya II site (Fig. 4.5). Pendants are short segments of the diaphysis of a long bird bone. Their cross-section (5 to 8mm) suggests the use of relatively thin bone. The edges of these pendants are so blunted by wear that the traces of manufacture are often completely obliterated. However, some have small transverse V-shaped incisions which suggest that they were made with a flint tool. Six items can be attributed as blanks/waste from the manufacture of such pendants (Fig. 4.7-13). These are fragments of diaphyses (mainly of the humerus or radius, and also of the tarsometatarsus), often epiphyseal, of rather thin long bones (cross-section 5-8mm), corresponding to the morphometric standards of the pendants described above. The diaphyses are segmented by sawing and breaking off. Two sawing techniques can be distinguished. The first, characterized by a V-shaped groove obtained by working with a flint tool (Figs. 4.7,8,10). These

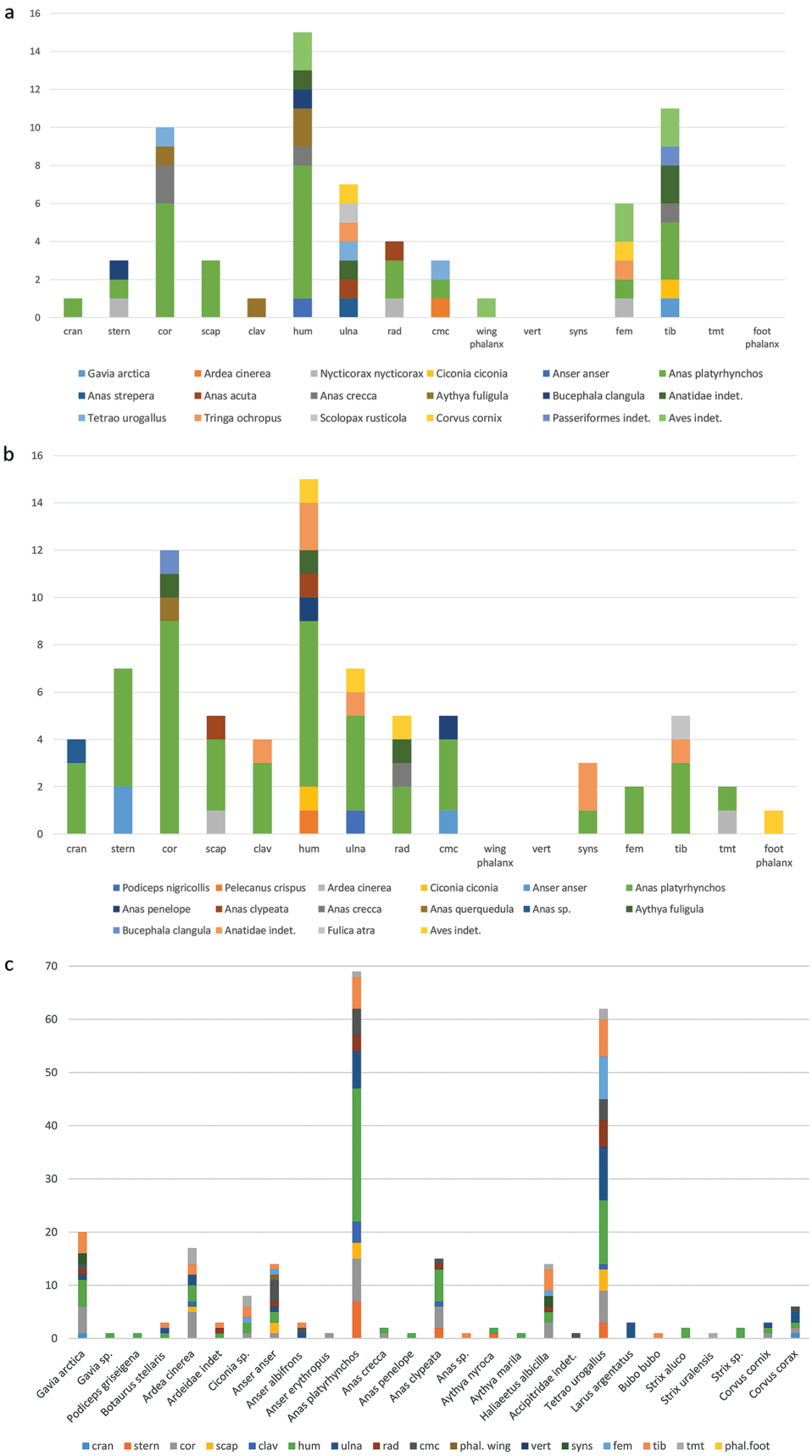

Fig. 2. Distribution of bird skeletal elements at Serteya II, western section, 4th millennium BC (a), eastern section, pile settlement (dwelling no. 3, second half of the 3rd millennium BC) (b); and Usviaty IV (layer B) site (c).

originate from dwelling no. 3 (Serteya II site). The second technique relates to rope/tendon sawing, as evidenced by the 'U' profile of the groove (Figs. 4.9,12,13). These production wastes may have other grooves, the distance between which is similar to the size of the pendants, which suggest that pendants were produced on site. All of them come from the western shore part of the Serteya II site, and can be attributed to the Usviaty culture. One possible similar item is also known at the Usviaty IV (layer B) site (Fig. 4.11), but no finished pendants were found for the Usviaty culture. Pendants made from bird bones are quite common both in the Mesolithic, Early Neolithic (Narva I site (*Gurina 1967*) and Late Neolithic (Abora I site (*Lose 1979*) and Asaviec 2, 7 sites (*Charniauski, Charniauski 2010*).

At Dubokray V site two flutes (Fig. 5.1,2) were found made from tubular bones of large swamp birds. They are straight and oblique open flutes with four side holes. The first one has worked playing holes and circular grooves left from secondary use (Fig. 5.1). The second is covered with geometric ornamentation (Fig. 5.2). They were made to the same musical standard, which might show the existence of an elaborate musical tradition. Dubokray flutes, according to Feliks Ravdonikas (*1997*) possess a sound order combining a very narrow and wide interval, which can be compared with ancient Greek enharmonic harmonics.

Several bird images are known: a pendant with a stylized image of a waterfowl (Fig. 6.2) (Serteya II site); a long spatula made of an elk rib with an image of a

Fig. 3. Cut marks on bird bones (*1, 2, 4, 5, 7, 8 *Serteya II;* 3, 6, 9 *Usviaty IV (layer B)):* 1 *Anas platyrhynchos, humerus;* 2 *Pandion haliaetus, ulna;* 3 *Haliaeetus albicilla, tarsometatarsus;* 4 *Anser anser, sternum;* 5 *femur;* 6 *Gavia arctica, tibiotarsus;* 7 *Anas platyrhynchos, coracoid;* 8 *Pelecanus crispus, humerus;* 9 *Haliaeetus albicilla, humerus (scale 1 cm).

bird's head (presumably a crow) (Fig. 6.1) (*Mazurkevich 2009*), a spatula with a bird's head (presumably a grouse) (Fig. 6.3), a wooden paddle with carved heads of birds (Fig. 7) (Usviaty IV, layer B). A pendant with a stylized image of a waterfowl was found in the pile-dwelling no. 3 of the Serteya II site. The blank of this pendant was made of a long bone of a large mammal. The entire contour was worked with flint to give it a serrated edge. The biconical perforation was made by rotary pressure with a flint cutter. Similar iconography can be found in the materials of Sakhtysh I sites in the Upper Volga region (*Kostyleva, Utkin 2009*) and sites of the Belarusian Dvina basin (*Charniauski, Charniauski 2010*).

Fig. 4. Pendants* (1-6)*, blanks for pendants* (7-13)*and tools* (14-18)*(*1-10, 12, 13, 16, 17 ***Serteya II site; 11, 14, 15, 18 ***Usviaty IV, layer B site:*** 17 ***Early Neolithic,*** 9, 11-16, 18 ***Usviaty culture;*** 1-8, 10 ***Zhizhitsa culture).***

Habitats and palaeoecological conditions

Birds identified in the Neolithic layers of wetland sites of the Dnieper-Dvina basin belong to four habitat groups: waterfowl, forest, woodside and meadow-steppe (Tab. 1), including nine sedentary species and others that are migratory.

The group of waterfowl birds (25 species at Serteya II site, 75.8%; 18 species at Usviaty IV (layer B) Fig. 8, Tab. 1) includes species that are not systematically related to each other, but are closely associated with water in their way of life, and these make up to 92.6% of the identifiable bones (at the Serteya II site). *Anas platyrhynchos* bones were particularly common at Serteya II (55.8%), and less common at other sites (Tab. 1). A set of waterfowl bird species testifies to the existence of open water bodies with abundant vegetation in the coastal zone and adjacent forest areas. In the 3rd millennium BC, species inhabited shallow water reservoirs (*Anas clypeata, Anas penelope*) can be documented; finds of *Anser anser* indicate hunting in marshes or reservoirs with standing water, *i.e.* outside these micro-regions or during the migration of these birds. At this time (2500-2100 cal BC) in the Serteya microregion a change in the water body regime can be traced, a lowering of the water level with seasonal fluctuations (*Kittel* et al. *2020*). The lake system may have been replaced by a river system. While birds with an aquatic habitat dominated at all pile-dwelling settlements, a different set of birds should be noted for the Usviaty IV and Serteya II sites (Fig. 8). At Usviaty IV (layer B) there is a smaller number of waterfowl species, and significantly higher number of subdominant species (*e.g., Gavia arctica, Ardea cinerea, Anser anser,* and *Haliaeetus albicilla* (Fig. 8) which settled near much larger water bodies than species at the Serteya II site. The latter (*Haliaeetus albicilla)* was also found at sites of Sennitsa and Zhizhitsa microregions.

The woodside group includes nine species (15.2% at Serteya II). Finds of *Scolopax rusticola* and *Tringa ochropus* are attributed to the 4th millennium BC, when climate warming and moistening were recorded (Fig. 9). They may point to the existence of dense deciduous or mixed forests with moist soil in the surroundings of the Serteya II site. Finds of bones of the *Columba palumbus* with a habitat area in floodplain deciduous forests with shrub undergrowth, and *Cerchneis tinnunculus* – in open dry spaces near forests, are dated to the 3rd millennium BC.

Fig. 5. Flutes (Dubokray V site).

The forest group includes nine species. Only two species were recorded on the Serteya II site: *Accipiter gentilis* and *Tetrao urogallus* (6.1%). The increase in the number of *Tetrao urogallus* in the pile-dwelling Serteya II site may be related to palaeoclimatic changes during 2550-2475 and 2150-2000 cal BC, which led to a change in forest composition: dominant *Alnus* species within wetland areas and mixed forest nearby were replaced by *Pinus* and *Picea* (*Kittel* et al. *2020; 2021*; *Wieckowska-Lüth* et al.

2021). This correlates with *Tetrao urogallus* habitat area – shrubby green-mossy pine, spruce-pine and other mixed forests with the participation of pine alternating with areas of upland bogs (*Piminov 2020*). A much more diverse set of birds of forest habitats can be noted for the Usviaty IV (layer B) site (seven species).

Within the meadow-steppe group only *Perdix perdix* was recorded at the Naumovo, Serteya I and Setreya X sites, where there were dry open habitats nearby inhabited by this species. The absence of *Perdix perdix* in the materials of other sites and only single bones may evidence occasional hunting.

Fig. 6. Bone spatula with an image of a raven's head (1) and grouse (3) (Usviaty IV, layer B site), an image of a waterfowl (2) (settlement Serteya II, dwelling no. 3).

Long- and short-term climatic changes and avian population dynamics

Climatic changes, both global and regional, strongly affected lake, mire as well as local fluvial environments. Generally shallow regimes were partly replaced by mires or fluvial system during water level lowering phases (*Kittel* et al. *2020; 2021*; *Wieckowska-Lüth* et al. *2021*; *Płóciennik* et al. *2022*). Species associated with different breeding habitats responded differently to changes in climate suitability and hydrological fluctuations. Species associated with inland wetlands may be more responsive to environmental changes than forest areas (*Mason* et al. *2019*). The proportion of a population that is migratory may be influenced annually by local conditions; adverse weather can encourage the movement of more birds to milder environments and *vice versa* (*Lehikoinen, Sparks 2010*). The population dynamics of water birds was suggested to be affected by the North Atlantic oscillation by impacting the availability and extent of the habitat and influencing dispersal decisions of individuals. It could have played an important role in the observed advance of arrival dates during the spring in Europe (*Gordo* et al. *2011*). Mean summer temperature reconstruction applied for Serteya microregion (Fig. 9) might explain records of southern birds which fall within warm periods during the 4th and 3rd millennia BC, which are currently absent in avifauna of the region.

A comparison with the modern ecology of bird species shows changes in their migration patterns and areas of distribution. *Gavia stellata, Pelecanus crispus, Nycticorax nycticorax, Ardeola ralloides* and *Oxyura leucocephala* are not nesting nowadays in this region. *Gavia stellata* tends to occupy northern areas, and the modern southern border

Fig. 7. Wooden paddle with the heads of ducks on the top of the handle (Usviaty IV site, layer B).

of its range runs through South Karelia (*Panteleev, Khrabry 2020*). In the 19th to early 20th century this bird was commonly nesting on the Karelian Isthmus, and in the 1960s it penetrated into Leningrad Oblast, Latvia and Estonia (*Malchevsky, Pukinsky 1983*). Certain climatic conditions might have influenced its southern boundary, resulting in possible stop-over in Dnieper-Dvina area in Neolithic during migrations. The modern distribution of the *Pelecanus crispus* is very fragmentary, with breeding areas scattered from Eastern Europe to Mongolia (*Matsyna, Matsyna 2011*). At present, in the European part of Russia the nesting area covers the Black Sea-Caspian region. Finds of subfossil bird bones at different sites in northwestern and central Europe shows that birds of the genus *Pelecanus (Pelecanus crispus*), occurred far out of their present range during mid-Holocene, which coincided with climate parameters (*Nikulina, Schmölcke 2015*). The nearest nesting sites of *Ardeola ralloides* are located in the Northern Black Sea coast, the Lower Don and the Volga Delta. There are vagrant birds documented in Europe, up to Finland (*Rusev 2011a*). *Nycticorax nycticorax* has a wider range, breeding in the Azov-Black Sea region, in the Lower Volga region, northwards to the Middle Don and Oka Rivers. Vagrants were documented in the Baltics and in central European Plain (*Rusev 2011b*). The main range of *Oxyura leucocephala* is in Lower Volga region, extending eastwards to Tuva, Kazakhstan and Central Asia (*Dementiev* et al. *1952*). Some time ago *Oxyura leucocephala* was breeding in Western Europe and the Azov-Black Sea region and had a vast unified habitat, which is now fragmented.

Discussion

Single finds and a small number of bones of waterfowl species can be attributed to the Early Neolithic (6th millennium BC). This may be explained both by the rate of preservation of materials from this time at Serteya II site, as some of them were apparently washed away during the subsequent rise in water level (*Mazurkevich* et al. *2020b*), and the short period of habitation at this site on the shore of shallow lake-type water bodies with seasonal floods which sustained for a long period (*c.* 5500–4150 cal BC) (*Kittel* et al. *2020*; *Mroczkowska* et al. *2021*). Finds of lost arrowheads along the shore zone may evidence bird hunting here (*Mazurkevich* et al. *2020b*). The small number of bird bones for the 4th millennium BC may be due to the specificity of the Serteya II site used mainly for fishing activity. The capture of birds in nets and fishing structures was most likely accidental or as a result of occasional bird hunting during fishing. Some of the birds, predominantly waterfowl species, were found at a household platform at the Serteya II site along with other faunal remains.

The greatest number of birds was recorded in the dwellings of the pile-settlements of the late 4th millennium (Usviaty IV (layer B)) and 3rd millennium BC (Serteya II site). At Serteya II site bird bones were found in dwellings no. 1 and 3. In dwelling no. 1, the avifauna was recorded in the lower horizons (4-5) (birds of aquatic and forest biotopes nesting in the region) and horizon 1 (birds of all biotopes nesting in the region, also migratory and passer-by birds). In dwelling no. 3 only the remains of birds of aquatic habitats nesting in the area and migratory birds were found. The absence of avifauna in the second and third building horizons of dwelling no. 1 may reflect the season of habitation and/or minimal number of birds during this period at this location due to high anthropogenic pressure and natural conditions (*Kittel* et al. *2020*).

The range of waterfowl species indicates the existence of open water bodies with abundant vegetation along the shore zone and adjacent forested areas over a long period of time for the Serteysky microregion, and large open water bodies for other microregions. For the 3rd millennium BC, palaeoecological changes and the appearance of species-inhabited shallow water bodies are noted. While birds of aquatic habitats are undoubtedly dominant, different sets of waterfowl species were recorded at different pile-dwelling settlements (Fig. 8). The number of birds from forest habitats is also significantly higher at Usviaty IV site (layer B), and only at the sites of the

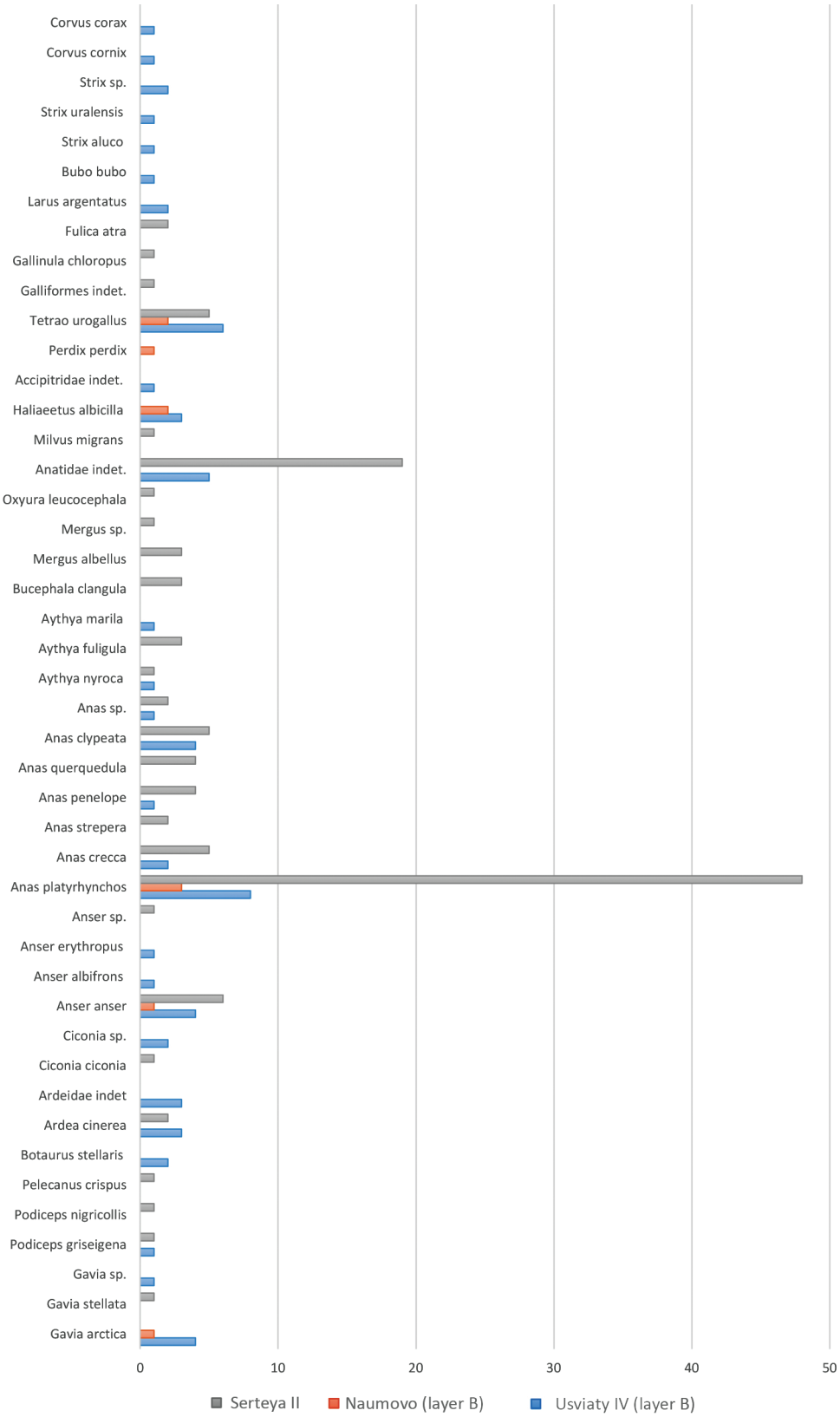

Fig. 8. Ratio of bird species and number of individuals from the dwelling horizons of the pile settlements Naumovo (layer B), Usviaty IV (layer B), and Serteya II (dwellings nos. 1 and 3).

Sennitsa, Usvyatsky and Zhizhitsa microregions *Haliaeetus albicilla* was recorded. Species from the forest habitat (Fig. 8; Tab. 1) at Usviaty IV suggest the presence of high-stemmed old mixed forests in the immediate vicinity. Records of a range of southern birds might fall within warm periods during the 4th and 3rd millennia BC reconstructed based on mean temperature modelling (*Mroczkowska* et al. *2021; Płóciennik* et al. *2022*).

The composition of bird bones indicates that many birds were brought entirely to the settlement and cut up on site. The minimal number of cutting traces (Fig. 3) can be noted, which is typical for many bird assemblages (*Mannermaa 2013*) and may be related to the preparation of whole birds or to the peculiarities of bird cutting, when traces remain only on a certain set of bones (*White* et al. *2021b*). Birds were mainly procured for meat, but particular types of birds, as well

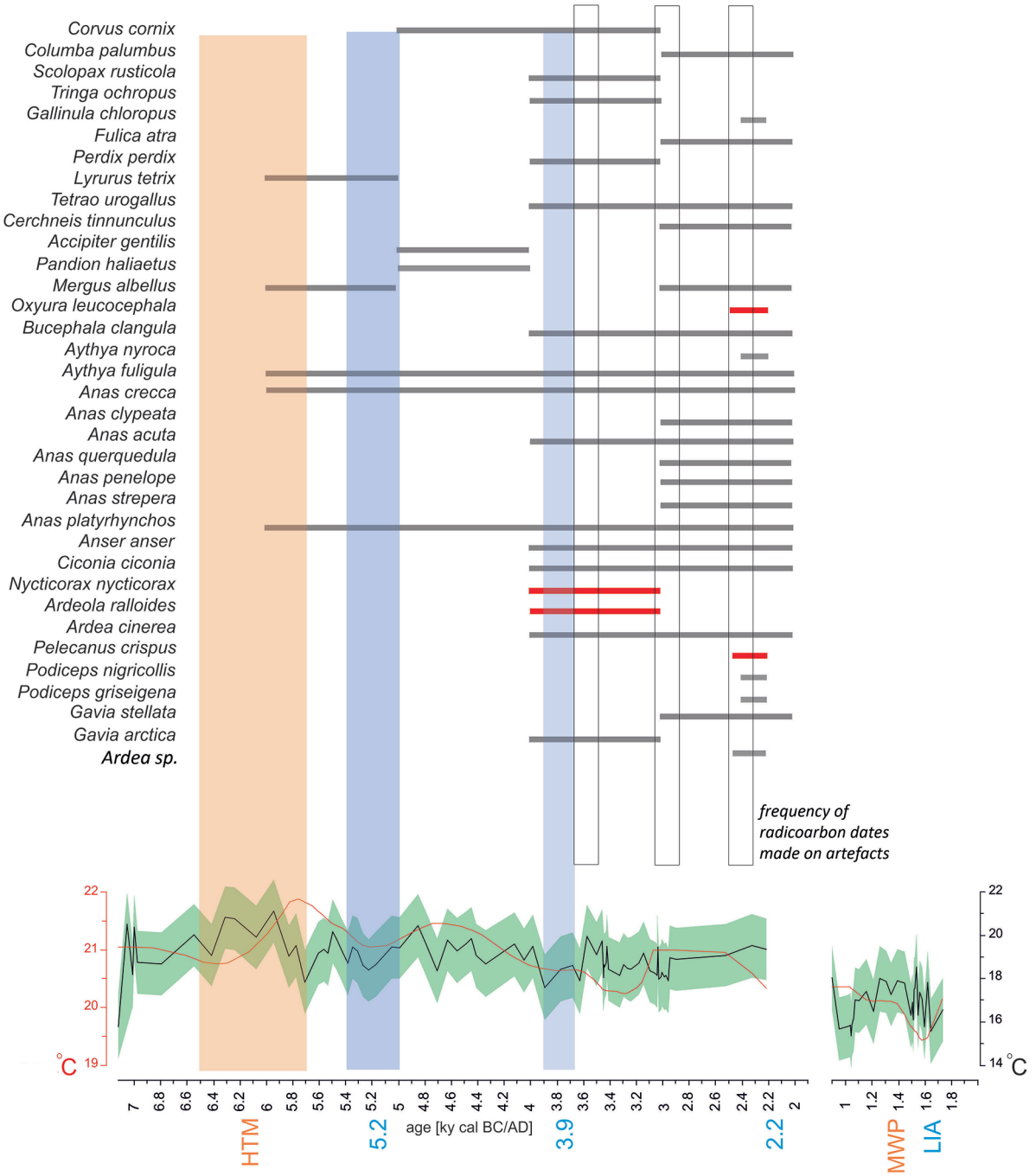

Fig. 9. Bird species and palaeoclimatic reconstructions of mean summer temperatures during the 6th to 3rd millennia BC for the Serteya II site (for Serteya microregion (black line) according to* Mateusz Płóciennik *et al.* 2022*, for the Mediterranean region (red line) according to* Rodrigo-Gamiz 2014*), (periods of frequency of radiocarbon dates were reconstructed based on* Andrey Mazurkevich *et al.* 2020a*).

as sets of bones and cutting marks, show evidence of also hunting for skins and plumage.

The dominance of bones of migratory birds and a small number of bones of juveniles may indicate spring and autumn as a potential hunting time. The latter could indicate that during the mass appearance of immature young birds (from July to early August) the hunting of birds was less common. Adult *Tetrao urogallus* could be hunted most likely either in late autumn or early spring, and young birds at the end of July-August (*German 1957*).

The peculiarity of the structure and morphology of bird bones determined the choice of this material for a certain set of items in different ancient cultures (points, beads, flutes) (*e.g., Scheinsohn 1997; Christensen 2016; Lozowski 1996*; *Mannermaa 2008*; *Gal* et al. *2021*). However, despite the widespread practice of making tools and ornaments from animal bones and teeth at Neolithic sites of the Dnieper-Dvina basin (*Mazurkevich* et al. *2020b*), bird bones were used rather rarely, and mainly for beads or tools for softening fibres. Bird images can testify to the special place of certain bird species in the culture of ancient societies of this region in the late 4th and 3rd millennia BC.

Conclusion

Hunter-gatherer strategies would have implied the procurement of a range of natural resources, highly dependent on their accessibility and variety, also influenced by climatic fluctuations, creating a particular system both economic and symbolic where they could have been incorporated. This could be envisaged through depictions of birds, strategies of their procurement, and a range of birds recorded at sites. Similar landscapes and habitats could determine similar hunting strategies and bird species in different cultures (*Zhilin, Karhu 2002*; *Mannermaa 2008; 2013; Tomek, Gumiński 2003*; *Kuzmina, Kasparov 1987; Skorobogatov* et al. *2016*). Specialization on a particular abundant seasonal resource may be part of the economic model of a number of ancient communities, both hunter-gatherers and communities oriented towards a productive economy, such as hunting migratory birds, fishing during the spawning of particularly valuable fish species (*Bondetti* et al. *2021*; *Cramp* et al. *2019*).

The focus on a single habitat resulted in the overwhelming dominance of waterfowl birds at the Serteya II site (mainly nesting) as well as Usviaty IV (layer B) and Naumovo (layer B) (nesting and migratory birds). A high variety of waterfowl species can be attributed to hunting along the shore zone for any incidentally caught birds and net fishing with incidental catches of diving species. The most birds were apparently captured on migration during the warm season, spring or autumn. Birds of some other habitat groups (*e.g., Perdix perdix*) may have resulted from occasional hunting.

A change in water body types and the climatic fluctuations of the 6th to 3rd millennia BC in the Dnieper-Dvina basin (*Kittel* et al. *2020, 2021*; *Wieckowska-Lüth* et al. *2021*; *Mroczkowska* et al. *2021*; *Płóciennik* et al. *2022*; Fig. 9) could lead to a change in bird species, caused by the formation of new habitats and bird migration routes. The differences in bird species and their number found on the sites of the Dnieper-Dvina basin may be due to micro-regional paleoclimatic and habitat variations, various forms of specialization of the sites (specialized fishing sites, household areas, zones of shore activity, dwelling structures of the pile settlement), the food preferences of ancient communities, and the role which birds played in different groups of hunter-gatherers.

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Figurative representations of the Pali Aike volcanic field (Santa Cruz, Argentina - Magallanes, Chile) in comparative perspective with the southern extreme of Patagonia

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ABSTRACT – *This paper aims to make a comparison of the figurative representations of the Pali Aike volcanic field (province of Santa Cruz, Argentina – province of Magallanes, Chile) with those registered in other sectors of southern Patagonia, such as the southern shore margin of Lake Argentino (Argentina), the Morros area and the Cerro Benítez-Lago Sofía locality (Chile) during the middle and late Holocene. This analysis was based on integrating background and new information related to different areas. The goal is to evaluate the existence of diverse patterns of representation, considering the morphologies, technical treatment, frequencies, relative abundance of types of motifs in each area, distribution within the space, and temporality of figurative motifs. From this, it is expected to advance the discussion of information exchange among hunter-gatherer groups through figurative representations on a macroregional scale.*

KEY WORDS – *rock art; information circulation; hunter-gatherers; Holocene*

Figurativne upodobitve na vulkanskem polju Pali Aike (Santa Cruz, Argentina - Magallanes, Čile) v primerjavi s skrajnim jugom Patagonije

IZVLEČEK – *Cilj članka je primerjava figurativnih upodobitev na vulkanskem polju Pali Aike (pokrajina Santa Cruz, Argentina – pokrajina Magallanes, Čile) z upodobitvami, ki so zabeležene na drugih območjih južne Patagonije, kot so južno obrežje jezera Argentino (Argentina), območje Morros in območje Cerro Benítez-Lago Sofía (Čile) v srednjem in poznem holocenu. Analiza temelji na integraciji obstoječih in novih informacij, ki so povezane z različnimi območji. Cilj je oceniti obstoj različnih vzorcev upodobitve, pri čemer upoštevamo morfologije, tehnično obdelavo, pogostost, relativne zgostitve vrst motivov na posameznem območju, razporeditev v prostoru in časovnost figurativnih motivov. Pričakujemo, da bomo na podlagi tega napredovali v razpravi o izmenjavi informacij med lovskimi in nabiralnimi skupinami s figurativnimi upodobitvami na makroregionalni ravni.*

KLJUČNE BESEDE – *skalne poslikave; kroženje informacij; lovci-nabiralci; holocen*

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Introduction

The settlement process in Patagonia involved significant changes in mobility, settlement, and resource appropriation strategies. This process, in turn, implied changes in the circulation of information between hunter-gatherer groups, a process that can be seen reflected in rock art (*Aschero 1988; Carden 2008; Fiore 2006; Re 2010; Whallon 2011*). For this reason, it is expected that differences will be observed in the composition, density, and distribution of these manifestations at different spatial scales and throughout occupational history (*Barton* et al. *1994; Wobst 1977*). Rock representations thus acquire theoretical-methodological relevance since they constitute an instance of niche construction through the transformation of the environment (*Odling-Smee* et al. *2003*) and can be used as an indicator of human mobility throughout a region (*Belardi* et al. *2016*).

Various investigations of rock art have been carried out at large spatial scales in southern Patagonia – between the Santa Cruz River to the north and the Strait of Magellan to the south (*Carden* et al. *2009; Charlin, Borrero 2012; Fiore 2006; Manzi, Carballo Marina 2012; Muñoz Soto* et al. *2021*). These works were based on the review and verification of information available in both their publications and those of other research teams. In this framework, analysing large-scale rock art manifestations entails considerable challenges due to the different methodologies used and the possible lack of data in the oldest research records (*Fiore, Hernández Llosas 2007*).

In the present paper, the figurative motifs (*sensu Gradin 1978*) located in the extreme south of southern Patagonia are of interest since they turn out to be a robust line of evidence to study the mobility of human populations and the circulation of information on a macro-regional scale that occurred over time among hunter-gatherer groups that inhabited different areas. In this sense, the figurative rock representations of the PAVF (Santa Cruz, Argentina-Magallanes, Chile) will be analysed from a comparative perspective with the Zona de Morros (ZM) (Santa Cruz, Argentina-Magallanes, Chile), the southern margin of Lake Argentino (SMLA) (Argentina) and the archaeological locality Cerro Benítez-Lago Sofía (CB-LS) (Chile) (Fig. 1).

Pioneering research in the study area has indicated that the rock art of the extreme south of southern Patagonia was mainly characterized by the predominance of complex symbols (*Menghin 1957*) or abstract-geometric motifs (*Bate 1970; 1971*). In this framework, the rock art manifestations of the Pali Aike volcanic field (PAVF) were included within the so-called Río Chico Style (*sensu Bate 1970; 1971*) based on the concentration of paintings in sites near the said river. The predominance of abstract designs initially characterized this style compared to less variability and frequency of figurative representations, most of these motifs being made in red tones, with less presence of black and white (*Bate 1970; 1971; Charlin* et al. *2023b*). At the temporal level, this style was assigned to the late Holocene, taking into consideration relative bases and indirect dating (*Bate 1970; Gómez Otero 1989–1990; Prieto* et al. *1998*). Subsequently, Mauricio Massone (*1982*) tool up the work started by Luis Felipe Bate (*1970; 1971*) based on new investigations in sites with rock art from the PAVF and CB-LS, differentiating two sub-styles for southern Patagonia: the Lago Sofía modality, in which the predominate dotted motifs, and the previously mentioned Río Chico modality, characterized by a greater emphasis on linear figures.

Over the years, records of rock art in the area have been supplemented by investigations carried out by different researchers (*Molina 1972; 1976; Sanguinetti de Bórmida 1982*). Thus, during the 1980s and 1990s, studies carried out at the PAVF revealed the presence of rock art in the middle valley of the Gallegos River, in the interfluve of the Gallegos-Chico rivers (*Gómez Otero 1983–1985*), and the Chico River basin (*Hernández Llosas* et al. *1999*). In the 2000s, with the expansion of the sampling, Liliana M. Manzi and Flavia Carballo Marina (*2012*) revealed new locations with paintings in the Gallegos River basin and in the Gallegos-Chico interfluve while integrating, in a supra-regional scheme, previously published information making comparisons of classes and diversity of motifs. Besides, through a Principal Component Analysis on a presence-absence matrix of types of motifs (figurative and non-figurative) and techniques, Judith Charlin and Luis Alberto Borrero (*2012*) noted differential trends between the PAVF and other close sectors of the current national territories of Argentina and Chile, such as the Zona de Morros (ZM), the southern margin of Lake Argentino (SMLA) and Última Esperanza (UE) (Fig. 1). This investigation demonstrated the existence of differential patterns of visual marking between these regions that are reflected in a predominance in the PAVF of linear geometric motifs, while in the

UE punctiform geometric motifs predominate. On the other hand, according to published data, anthropomorphic and zoomorphic motifs would be the most abundant in the SMLA. Likewise, the authors have pointed out that the sites located in the eastern steppe (PAVF) and the mountainous zone (CB-LS and SMLA) show different archaeological signatures that could belong to diverse archaeological populations (*Borrero, Charlin 2010*), although these differences in the archaeological record do not seem to correlate with rock art (*Charlin, Borrero 2012*). *A posteriori*, Manzi and co-authors (*2015*) reported the presence of motifs engraved in chopped and incised techniques as novel forms of execution in the rock art of PAVF, registering designs comparable to those recognized within the Río Chico Style.

In recent times, the archaeological investigations carried out in the PAVF have yielded new advances in rock art, particularly new data on the distribution and variability of painted and engraved representations in the PAVF, showing a greater diversity of figurative expressions (*Charlin 2014; Charlin* et al. *2023a; 2023b; Manzi* et al. *2015; 2019; 2022*). In this scenario, the discovery of engraved camelids in the Argentine sector of the PAVF has also been a novelty for research on rock art in southern Patagonia. The age of these representations could be assigned to the middle Holocene based on the morphological similarity they present with similar motifs painted in other regions of the Province of Santa Cruz (*Manzi* et al. *2022*). It is understood that these morphological similarities on a large spatial scale could provide data on social interaction, information circulation, and mobility circuits of the hunter-gatherer groups that inhabited the southern tip of Patagonia. This new set of rock representations questions the absence of engravings south of the Santa Cruz River (*Fiore 2006*) and the scarcity of figurative motifs in PAVF (*Bate 1970; 1971; Massone 1982*) and its late character (*Bate 1970; 1971; Charlin, Borrero 2012; Hernández Llosas* et al. *1999; Gómez Otero 1989–1990; Massone 1982; Prieto* et al. *1998*).

This study thus aims to conduct a comparative analysis of the figurative rock representations in the PAVF, the CB-LS locality, the SMLA, and the ZM, considering both their formal properties and spatial and temporal distribution. Through this analysis, we seek to contribute to the discussion on the circulation of information and communication at the macro-regional level in the extreme south of southern Patagonia.

Methodology

In the present work, each region under study corresponds to a mesospatial scale that, when considered together, makes up a larger surface that refers to a macroregional scale (*sensu Dincauze 2000*) (Fig. 1). In addition, a mesotemporal scale (*sensu Dincauze 2000*) will be used since it is of interest to analyse the sites that present figurative manifestations executed throughout the Holocene. In this framework, although the study of rock art can vary in scale, using regional or macroregional scales generally tends to be fruitful since redundancy patterns can be recognized in the selection of places with paintings and/or engravings and, to some extent, to understand long-standing preferences for specific geographic locations (*Charlin, Borrero 2012*).

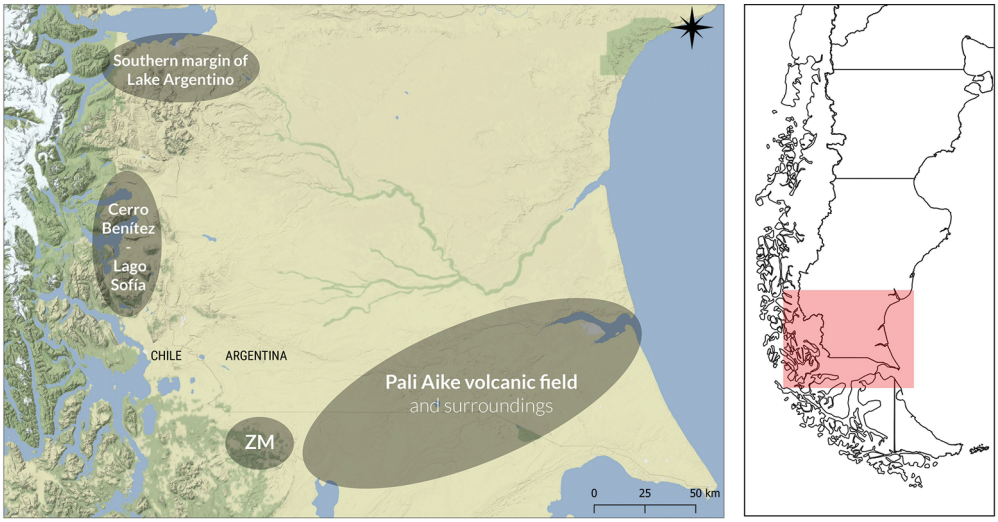

Fig 1. Study area location.* ZM: *Zona de Morros.

The sample under analysis was generated by integrating published data on figurative representations of the study macroregion, added to unpublished material from the PAVF product of the work carried out by the work team (Tab. 1). The units of analysis considered here are the site, the motif, and the element. In conceptual terms, the site is understood as a locus of concentrations of grouped or isolated rock motifs (*Gradin 1978*). Besides, the motif, as a minimum unit of analysis, is considered an execution unit motivated by a single act of painting, whether simple or compound designs with more than one element (*Aschero 1988; Gradin 1978*). The concept of 'element' is used to refer to the initial segmentation of separate discrete units in the support space, being defined based on their formal properties, both technical and morphological (*Gradin 1978; Re 2010*).

Region	Number of rock art sites		Number of sites with figurative motifs		Number of sites without figurative motifs	
	N	%	N	%	N	%
PAVF	73	100	44	60.27	29	39.72
CB-LS	13	100	5	38.46	8	61.54
SMLA	18	100	11	61.11	7	38.89
ZM	1	100	1	100	1	100
Total	105	100	61	58.09	44	41.90

Tab. 1. Regions with figurative rock representations in the extreme south of Patagonia compared on a macro-regional scale.

In the case of the records of the rock representations carried out by our work team, the general guidelines proposed by various authors were followed (*Fiore 2009; 2011; Hernández Llosas 1985).* In each case, the morphology of the represented motifs was documented, and other data such as size, colour, overlaps, and frequency were recorded (*Fiore 2011*) if the available literature allowed this information to be identified.

Regarding the morphological characterization of the types of figurative motifs, the following categories have been used: (a) anthropomorphic: motif/image whose shape resembles the human figure, with a greater or lesser degree of detail; (b) hand: motif whose potential referent is a hand; (c) finger: motif whose potential referent is a finger; three-digits (bird tracks): motif potentially refers to bird footprints or traces, such as the rhea (*Rhea pennata*). Among the execution techniques of the rock art representations, a first differentiation is made between paintings and engravings. Regarding the technical treatment, a distinction was made between punctiform, linear, flat, and combined (*Hernández Llosas 1985*). However, in the cases in which information on the technical treatment could not be obtained from the available bibliographic sources, detailed information on the matter was not provided. On the other hand, in the case of the painted motifs that make up our records, the current colour was characterized based on its comparison with the Munsell Soil Colour Chart catalogue (*1994*). As far as superposition is concerned, it is understood as when one motif is placed on top of another, partially or almost fully covering it (*Aschero 1988*).

Based on the literature consulted 105 archaeological sites with rock art were identified and differentially distributed within the study macroregion (Tab. 1), with most (close to 70%) concentrated in the PAVF region (*Bate 1970; 1971; Campan* et al. *2007; Charlin 2014; Gallardo 2009; Gómez Otero 1983–1985; Hernández Llosas 1992; Hernández Llosas* et al. *1999; Manzi, Carballo Marina 2012; Manzi* et al. *2015; 2019; 2022; Massone 1982; Molina 1969; 1972; Prieto 1989–1990; Prieto* et al. *1998*) (Tab. 1 and Fig. 1). The remaining sites are less frequently found in the SMLA (*Belardi 2003; Belardi* et al*. 1999; 2000; Carballo Marina* et al*. 1999; Franco* et al. *1999; Moreno 1969*), CB-LS and UE (*Bate 1971; Massone 1982; Muñoz 2020; Sepúlveda 2011*). Exceptionally, a site with rock art was recorded in the Zona de los Morros (ZM) (*Bate 1970; Charlin* et al*. 2011*) (Tab. and Fig. 1).

Since it was not possible to establish the frequencies of figurative motifs from some PAVF, SMLA, and CB-LS sites, a presence-absence table was used to establish the relative abundance of types of figurative motifs by region (Tab. 2). These proportions are calculated based on the number of sites, the type of representation present, and the total number of sites with rock art in the area (*Charlin, Borrero 2012*).

Results

Relative abundance and spatial distribution of figurative motifs in the extreme south of southern Patagonia

Regarding the sites with figurative representations according to each region, the figurative percentages, in terms of relative abundance or proportion, show

that the results obtained for SMLA (61.11%) and PAVF (60.27%) are extremely similar, although they differ in absolute terms since the PAVF has three times more sites (n=44) than the SMLA (n=11). Regarding the PAVF, the interfluve of the Gallegos-Chico rivers turns out to be the space with the most significant number of sites that record figurative representations (n=21), followed by the Chico River basin (n=13) and the Gallegos River basin (n=8). Finally, the number drops to two sites with a figurative presence in the areas surrounding the PAVF (Laguna Blanca, Chile). On the other hand, in the spaces with rock representations located in the CB-LS locality, 38.46% of them have figurative motifs (Fig. 1 and Tab. 1). In the ZM, only one site was registered, and it meets both categories, being a small sample to identify possible trends.

Regarding the relationship between the number of sites with figurative representations and the category of figurative represented, in the PAVF, the three-digits paintings and engravings are present in 52.27% of the sites, followed by zoomorphic paintings and engravings at 31.82%, and the anthropomorphs are in third place (27.27%). The positive and negative hands in total represent 31.82%. Lastly, only one site (MBV-EBV) found with positive fingers (Tab. 2). In the CB-LS locality, anthropomorphs and zoomorphs are found in more than half of the sites with figurative representations (60%), followed by three-digits (40%) and, finally, hand negatives (20%). Similarly, in the SMLA the most frequently captured figurative categories are anthropomorphs (45.45%) and zoomorphs (45.45%). The positive and negative hands follow in order of abundance (18.18%), with the three-digits being the least represented (9.09%).

Sample composition

Anthropomorphs

In the PAVF and nearby sites, there are 24 painted motifs and one engraved motif corresponding to schematized human figures (Fig. 2). The painted motifs were executed through linear and flat treatment; they are presented in frontal perspective with a rounded head, elongated body, and differentiated legs and arms. The dimensions of these representations are generally between 14cm long by 13cm wide. In the middle basin of the Gallegos River, the Puesto Cañadón Verde 1 and 2 (PCV) sites record three anthropomorphs in red made using the flat technique (*Manzi, Carballo Marina 2012*). On the other hand, the PCV2 anthropomorph presents limbs with curvilinear lines. In the interfluve of the Gallegos-Chico rivers, the Puesto El Cóndor (PEC) site has a red anthropomorphic product of recycling a three-digits. This motif resembles the human figure recorded at the Madre de Dios site in the Última Esperanza (UE) archipelago (*Muñoz 2020*). However, this motif was made using the punctiform technique, while in PEC, the linear technique was used. Otherwise, at the Meseta Bella Vista-Estancia La Carlota (MBV-ELC) site, there are four anthropomorphs in reddish tones, where two of them were made using the linear technique, and the rest present a flat treatment (*Manzi* et al. *2019*). Besides, in the Potrok Aike Lagoon (LPA), Julieta Gómez Otero (*1983–1985*) recorded three anthropomorphic motifs in red, one below a zoomorphic like a guanaco. According to the author, the other two anthropomorphic motifs have headdresses similar to the human figure from the Lago Roca III site located in the Lago Argentino area. Another anthropomorph with a headdress is found in the MBV-ELC-La Sixtina, whose motif corresponds to a schematic human figure made with linear treatment, where one lower extremity presents the shape of a three-digits and the other four strokes, the dimensions of this figure reach 119cm long by 73cm wide (*Manzi* et al. *2019*).

In the Chico River, the Markatch Aike 7B site presents a single human figure with linear technical treatment in red (*Hernández Llosas* et al. *1999; Molina 1972*). The human figure is "*framed by four 'cruciform' three of which, those facing up, seem to correspond to schematized three-digits*" (*Hernández Llosas 1992.12*). In the Chilean steppe sector, the Río Chico 1 and 2 (RCh) sites contain seven red-coloured anthropomorphs with linear and flat technical treatment; they were also recorded in red in Cañadón

Region	Motif classes					
	Anthropomorphs	Negative hand	Positive hand	Positive fingers	Three-digits (bird tracks)	Zoomorphs
PAVF	12	7	7	1	23	15
CB-LS	3	1	0	0	2	3
SMLA	5	2	2	0	1	5
ZM	0	0	0	0	1	0

Tab. 2. Relative abundance of figurative motifs by region in southern Patagonia.

Seco 1 (n=2) (*Bate 1971*). The Ush Aike (Oosin Aike) site presents four anthropomorphs, three in red and one in white, being the only one in that colour within this motif category in the entire PAVF (*Bate 1970; Gallardo 2009; Molina 1972*). To the south, at the Cañadón Leona 3 site, Bate (*1970*) identified abundant schematized anthropomorphic figures in red, black, and sometimes red bordered with black, made with the flat technique. The average size of these motifs is around 10cm, although some figures reach 20cm. Charlin (*2014*) states that the Chico River sites have the most significant number of painted anthropomorphic motifs. In this framework, the Gallegos River basin has the lowest frequency. Regarding the anthropomorphic engravings in the area, only one human figure with probable attire has been detected at the Lamasuario 1 site (interfluve of the Gallegos-Chico rivers) made using the scraping technique (*Manzi* et al. *2022*).

The CB-LS locality has three sites where painted anthropomorphic motifs have been found. In the second report from 1971, Bate notes the presence of anthropomorphs in reddish tones at the Laguna Sofía 1 and Lago Sarmiento 1 and 2 sites, although he does not specify the number of motifs. In Lake Sarmiento 1, anthropomorphs were found almost exclusively, reaching a larger size and with a broader line. Sometimes the inner surface is full of colour (*Bate 1971*).

With regard to the SMLA, the frequencies of the motifs have not been published, which is minimum numbers are used. In this context, anthropomorphs and zoomorphs constitute the most represented figurative motif. They were detected in reddish tones in Punta Walichu (*Moreno 1969 [1876–1877]*) and Chorrillo Malo 1, 6, and 7 (*Belardi* et al. *1994*; *Franco* et al. *1999*). Specifically, in Chorrillo Malo 1, there is a scene of schematic anthropomorphs in a dynamic attitude (*Belardi* et al. *2000.292*). On this point, Belardi *et al.* indicate that "*the design of the figures has been used, which go from largest to smallest, and their position to indicate depth of field*" (*Belardi* et al. *1999.10*). At the same time, the possibility of motifs being repainted is indicated for one of the anthropomorphic motifs from the Chorrillo Malo 6 site (*Belardi* et al. *2000*). Likewise, they are present in the Lago Roca 2 site in red, where they form a unit of meaning with the superimposed punctiform motifs (*Belardi* et al. *1999*). On the other hand, Manuel J. Molina (*1972*) surveyed an open-air wall bordering the main cave of the Punta Walichu site, where he recorded four human figures schematized in red of considerable dimensions (between 18.5cm long by 30cm maximum width); it is also pointed out by Molina (*1972.83*) that an anthropomorph has three fingers.

Based on the above, there are various forms of representation in the anthropomorphic motifs of the extreme south of southern Patagonia. Firstly, in the PAVF, the bodies present variation in the torso (elongated, globular, triangular); also, in some cases, the arms are extended upwards and present differences in their shape. In only one case are fingers distinguished on the hand of an anthropomorph from the MBV-ELC site. In turn, it can be observed that one of the anthropomorphs of the MBV-ELC and PCV2 is arranged laterally. Regarding the colour and technical treatment, based on the available information, it is argued that the red colour and the flat technique predominate over the linear one, not having detected punctiform figurative motifs. Examples from the SMLA show perspective and dynamism in the human figures, while those from the PAVF confirmed the presence of cephalic headdresses, recycled motifs, and a figure with a phallus. However, this last characteristic could be interpreted as a tail, as proposed by

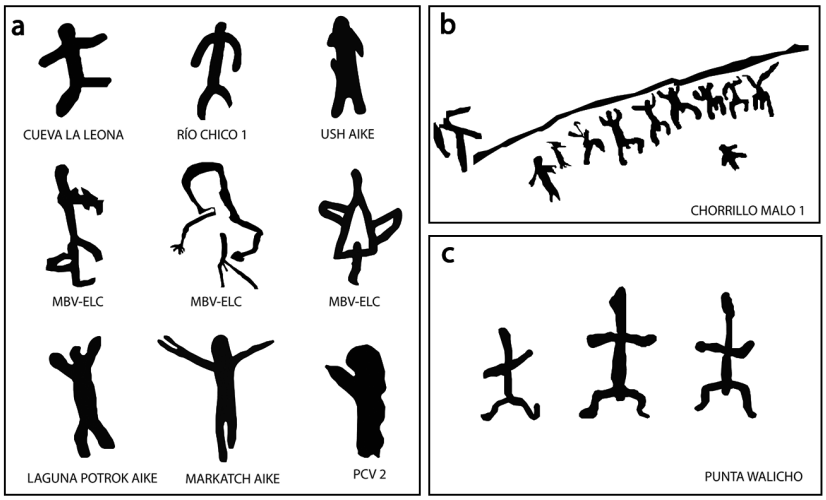

Fig 2. **a** ***Anthropomorphs from the Pali Aike volcanic field (the tracings of Cueva La Leona, Río Chico 1 and Ush Aike were taken from*** **Bate 1970*);* b** ***and*** **c** ***anthropomorphs from the southern margin of Lago Argentino (the tracks are published in*** **Belardi** ***et al.*** **1994** ***and*** **Menghin 1952*).***

Rodolfo M. Casamiquela (*1981.37*) for the anthropomorphic motifs of Punta Walichu. Thus, an additional difference between the PAVF and the SMLA (Chorrillo Malo and Punta Walichu) is that the anthropomorphs are represented in isolation in the former. In contrast, on Lake Argentino's southern shore, they are represented in scenes. This factor also influences the representation of postural differences.

Hands

In the case of PAVF hand negatives, they are only found in six locations. In the Gallegos River basin, the Abrigo Pintado de Güer Aike (APGA) (n=2) and PCV2 (n=1) sites present red hand negatives (*Manzi* et al. *2010; Molina 1972*). In the Gallegos-Chico interfluve, the EBV-ELC site records a hand opposing in white (*Manzi* et al. *2019*), while in the eaves near Cueva de los Contrabandistas, the negative corresponds to red (*Prieto* et al. *1989–1990*). Four white hand negatives were recorded at the Bajo El Cóndor 2 (BEC) site. Finally, to the south, they appear only in white in Río Chico 5 and Ush Aike (*Bate 1971; Gallardo 2009; Molina 1972*).

In CB-LS, the only site that presents hand negatives is Sitio Lago Sarmiento 1, although the exact number of these motifs is unknown. The negatives were executed in yellowish-white and are superimposed on the anthropomorphic and zoomorphic ones (*Bate 1971*). On the other hand, the SMLA records a high frequency of red hand negatives in Punta Walichu (*Moreno 1969*) and Punta Bonita 2 (*Belardi 2003; Carballo Marina* et al. *1999*).

Unlike the negatives, the hand positives are more abundant in the PAVF. In the Río Gallegos basin, the APGA site is the only one that presents black hand positives (n=2). Another northern PAVF site is Alero de los Pescadores (ADLP), where two positives were recorded in red (*Molina 1972*). However, the most significant number of positives for hands is found in the Gallegos-Chico interfluve, with the Meseta Bella Vista-Estancia La Carlota (MBV-ELC) being the space with the highest frequency (n=16). In this regard, 13 positives are painted red, while three are executed in white (*Manzi* et al. *2019*). The Bella Vista Plateau-Estancia Bella Vista (MBV-EBV) also has hand positives (n=6), most of which are red except for one motif in white (*Manzi* et al. *2019*). Another interfluvial site with this type of representation is Alero del Artista (*sensu Manzi* et al. *2015, Site 1 sensu Charlin 2014*), registering a single positive in red. Finally, in the southern PAVF area, a red hand positive was detected at the Rose Aike 3 site in association with a series of long parallel tracks (*Massone 1982*). Regarding finger positives, they have been found in MBV-EBV (n=6).

This figurative was not found in the literature in the CB-LS locality. On the other hand, in the Lago Argentino area, examples were recorded in Punta Walichu (*Moreno 1969*) and Chorrillo Malo 5 (*Belardi 2003; Belardi* et al. *1994*).

Three-digits (bird tracks)

Three-digits are present in most of the sites recorded in the Gallegos River basin (n=6) (*Molina 1969*). The APGA site records three red three-digits (*Molina 1972*), while Güer Aike's Alero 1 has two in red tones (*Manzi, Carballo Marina 2012*). Likewise, the Alero Romario Barria (ARB) site has five three-digits, one executed in white and the rest in red (*Campan* et al. *2007*). Two of the three-digits motifs are found below vertical parallel compound strokes at this site (*Manzi, Carballo Marina 2012*). On the other hand, PCV1 (n=4), PCV2 (n=3), and PCV4 (n=1) have three digits in red (*Manzi* et al. *2010*). In PCV1, a compound three-digits was detected above an isolated three-digits and a spot (*Manzi, Carballo Marina 2012*).

Regarding the interfluve of the Gallegos-Chico rivers, in MBV-ELC, the three-digits (n=6) were made in red (n=4), black (n=1), and white (n=1) colours (*Manzi* et al. *2019*). These motifs were also revealed in Potrok Aike by Gómez Otero (*1983–1985*). On the other hand, Puesto El Cóndor (PEC) is the location with the most significant number of this figurative in the PAVF (n=13), all executed in red (*Manzi* et al. *2010*). They were also detected in reddish tones in Bajo El Cóndor (n=2) and Alero del Artista (n=2) (*Charlin 2014*; *Manzi* et al. *2015*). Finally, and similarly, in the Chico River area there are many sites that present this figurative. The Markatch Aike site has a total of nine red three-digits (*Hernández Llosas 1992*). Likewise, in Rose Aike 3, three were recorded in red tones (*Massone 1982*). Exceptionally, Site 6-Cave 5 (S6.C5, Ea. Pali Aike) has two white three-digits; the three-digits are above abstract motifs in deep red (*Hernández Llosas* et al. *1999*). Three-digits were also detected in Laguna Sota 1 (*Massone 1982*) and the Cañadón Leona 3 site in black (*Bate 1970*).

Concerning the engraved three-digits in the PAVF, they are present in the interfluve of the Gallegos-Chico rivers, where they were made using three tech-

niques: incision, abrasion, and polishing, as well as combinations of these. The morphology of the three-digits varies according to the way of incising and the instrument used, generating a U- or V-shaped stroke. The Bajo El Cóndor 3 (BEC3) site records the most significant number of this type of figurative (n=16), where abrasion, polishing, and abrasion-polishing techniques were used (*Manzi* et al. *2015*). They were also recorded in BEC1 (n=8), BEC2 (n=3), and Campo El Cinco, block 1 (n=1) (*Manzi* et al. *2015*).

Three-digits are the only type of figurative motif present in the Zona de los Morros and are found at the Morro Chico site (*Bate 1970*). There, the low number of motifs detected is noted, which coincides with the low archaeological signal from the area (*Charlin* et al. *2011*). The three-digits were painted in red, and one was recorded for each panel (a and b) (*Bate 1970*).

In CB-LS, two sites present this type of motif: Laguna Sofía site and Lago Sarmiento 2, both surveyed by Bate (*1971*). These motifs were made in reddish tones. Unfortunately, there are minimal numbers since the frequency of rock representations has not been published. On the other hand, according to the consulted bibliography, in the SMLA only three-digits are found at the Chorrillo Malo 7 site, executed in red (*Carballo Marina* et al. *1999*; *Belardi* et al. *2000*).

There is a great variety in the representation of these motifs (Fig. 3). In this regard, the convergence of the angles varies; the contours can appear in 'U' or 'V', the vertex can be oriented upwards or downwards, the thickness of the line also varies, and sometimes the succession of several three-digits whose structure and/or overlap make up a trail, as can be seen at the Alero 1 site of Güer Aike. Likewise, the three-digits appear in the PAVF associated with abstract and figurative motifs.

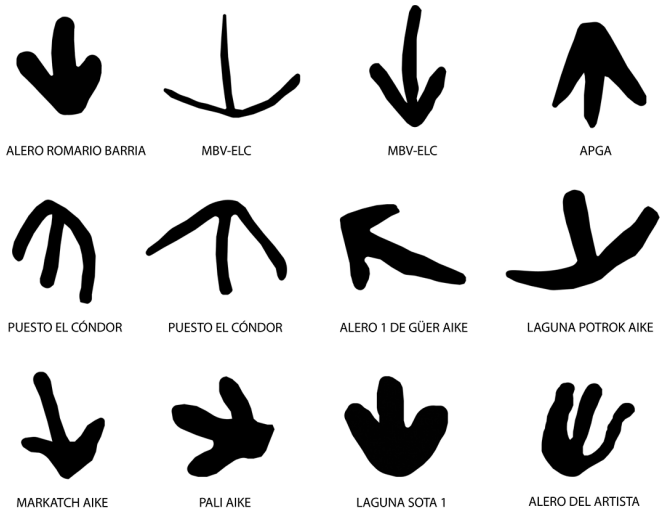

Fig. 3. Three-digits of the Pali Aike volcanic field.

Zoomorphs

The painted zoomorphs in the PAVF were all executed in red tones and using the linear technique. They are found in five sites: PCV1 (n=1), PEC (n=2), LPA (n=2), and Río Chico 2 (RCh2) (n=1) (*Bate 1971; Campan* et al. *2007*; *Manzi* et al. *2010; 2012; 2015; 2019*). In the PCV1 and PEC sites, the zoomorphic motifs correspond to matuastos (*sensu Schobinger, Gradin 1985*). In the case of the RCh2 site, Bate (*1971*) does not specify which animal the motif corresponds to in his second report. Otherwise, in the LPA, Gómez Otero (*1983–1985*) pointed out the presence of a matuasto in a light red colour; above the motif, an isosceles triangle was made, also in a red.

In the CB-LS area, the zoomorphic motifs were painted red and made from dots. They are located at Lago Sofía 2, Cerro Benítez 2 (n=1), and Lago Sarmiento 1 (n=2) (*Bate 1971; Massone 1982*). In this last site, Bate (*1971*) pointed out that these motifs are in articulation with anthropomorphs and could be felines. On the other hand, in Cerro Benítez 2, it is indicated that the zoomorphic motif is complemented by a series of parallel strokes, strokes cut at right angles, and curved lines (*Massone 1982*).

As for the SMLA, zoomorphs are present in considerable numbers. First, at the Chorrillo Malo 1 site, red schematic matuastos (*Pristidactylus scapulatus*) were detected (*Belardi* et al. *1999*). Likewise, in Chorrillo Malo 6, "*a possible matuasto*" was found in two red tones (*Belardi* et al. *2000. 294*). On the other hand, they have been detected in Lago Roca 1, 2, and 3 (*Belardi 2003*). The zoomorphs of Lago Roca 1 and 3 correspond to naturalistic guanacos, while the animal motifs of Lago Roca 2 refer to schematic matuastos (*Belardi* et al. *1999*; *Belardi 2003*).

Zoomorphic engravings make up a class of designs that do not correspond to those recognized within the so-called Río Chico Style and its regional variations, nor to its modalities or substyles *(sensu Bate 1970; 1971; Massone 1982*). The engravings represent camelids and are only present in the PAVF (Prov. Santa Cruz), specifically in the locations Lamasaurios I to X in Meseta Bella Vista-Estancia la Carlota, Campo

El Cinco, and Barda del Molino. In total, 64 full-body guanaco motifs and 13 motifs correspond to anatomical parts of camelids, specifically the necks and hind/front quarters (*Manzi* et al. *2022*) (Fig. 4).

Discussion and final considerations

From the execution of graphic representations such as rock art, the hunter-gatherer populations that inhabited the extreme south of southern Patagonia modified their environment. In this framework, due to their obtrusiveness in the landscape, these manifestations could have acted as milestones that guided the circulation of human populations (*Belardi* et al. *2020*; *Borrero* et al. *2011*).

Based on the results obtained in this study, it is highlighted that although the figurative representations decrease in variety and frequency as one advances through Patagonia and toward the Strait of Magellan (*Gallardo* et al. *2022*), the new investigations in the PAVF indicate that the figurative motifs have great ubiquity in the sites of the last space of the continental sector, presenting a more significant variability and an increase in the number of figuratives than previously documented (Fig. 5). In the PAVF, the most frequently executed figurative category is the three-digits, both painted and engraved. In this sense, it is noted that the ability of rock representations to transmit information can be evaluated through the standardization of their motifs. This implies reproducing characteristics such as the motifs' shape, size, and colour on different supports. The visual uniformity of this structure allows its visual encoding and decoding, which facilitates the transmission of information (*Fiore 2006; 2011*). The codes associated

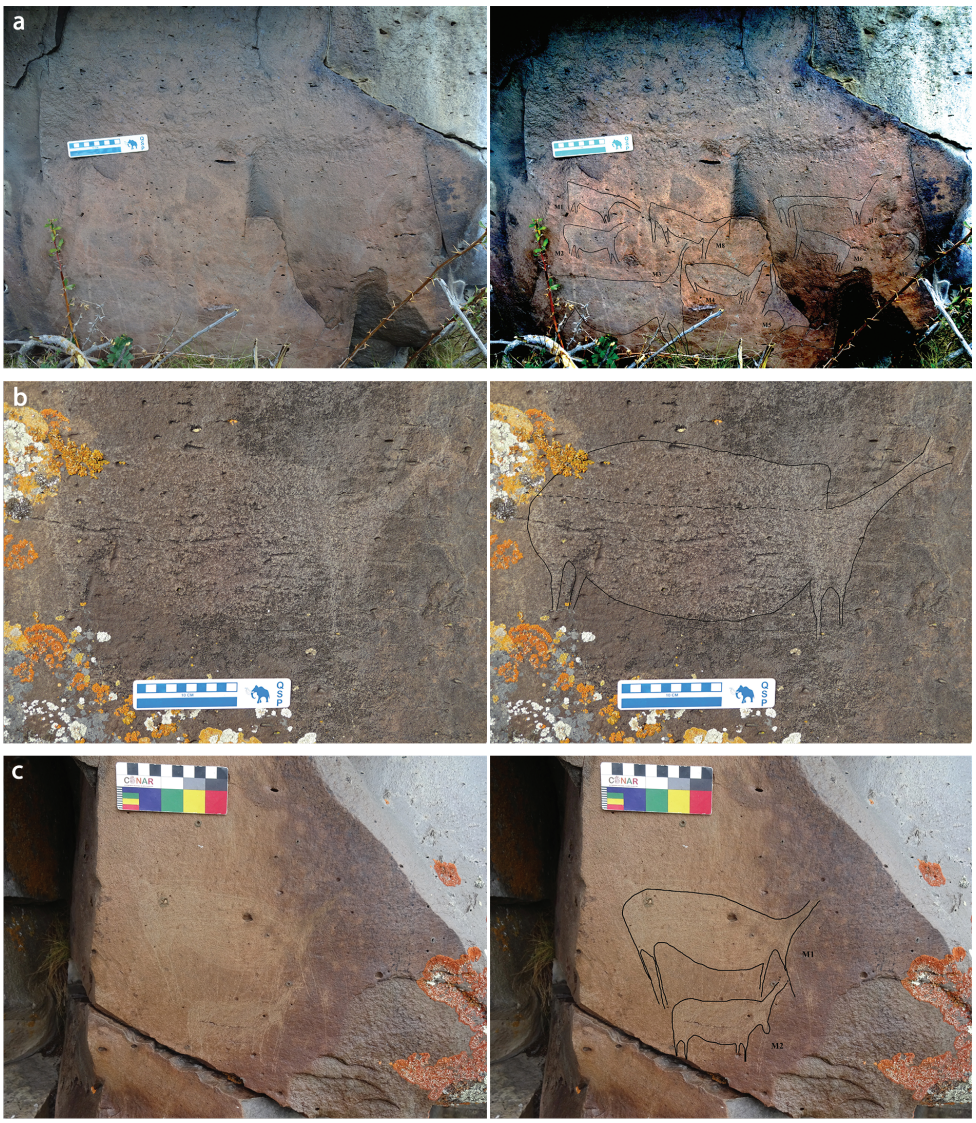

Fig. 4. Engravings of camelids registered at Lamasaurios sites.

with this motif were thus widely adopted and appropriated by the hunter-gatherer groups that inhabited the area (*Wobst 1977; Barton* et al. *1994*). In this sense, the presence of three-digits assigned to the Río Chico Style in Morro Philippi (*Ortiz Troncoso 1973*) suggests that this sector would have formed part of the broader range of action of the population node settled in the PAVF (*Charlin* et al. *2011*).

The second category mainly reflected in the PAVF is zoomorphs, especially those executed using engraving. On the other hand, in the CB-LS locality and the SMLA painted anthropomorphs and zoomorphs are the most frequently executed rock art representations (*Charlin, Borrero 2012*). The schematization of painted zoomorphic and anthropomorphic motifs is a feature shared between the PAVF and CB-LS (*Bate 1970; 1971*). Exceptionally, naturalist zoomorphs have been reported at the Lago Roca 1 and 3 sites in the SMLA. With regard to the presence and/or absence of certain figurative motifs, it has not been possible to trace the positive category of fingers in the available bibliography for the locality CB-LS and the SMLA.

In addition, the finding of recorded engraved camelids in the PAVF marks a precedent for rock art representations in the extreme south for which there was no record in this area of Patagonia. Based on morphological comparisons with similar designs, these motifs could evidence the flow of information between the human groups of the PAVF and those found in the Strobel plateau, the north bank of the Santa Cruz River, the central plateau, and the river area Pinturas (*Gradin* et al. *1979*; *Carden 2008; Fiore, Ocampo 2009; Manzi* et al. *2019; 2022; Re 2010; 2017*). At the macroregional level, given the morphological similarities with designs identified in different southern and central/southern Patagonia sectors, these representations could be assignable to the middle Holocene (*Manzi* et al. *2019; 2022*).

With regard to the technical treatment of the painted motifs, the anthropomorphs of the PAVF have been executed using flat and linear techniques with a predominance of the latter. Similarly, in CB-LS, both techniques were used to execute these motifs with a predominance of the linear technique over the flat one (*Muñoz 2020*). In the case of the painted zoomorphs, the technical treatment used in the PAVF has been linear, unlike CB-LS, where they were executed using the punctiform technique. Besides, the three-digits were made by linear technical treatment, where in some cases the curvilinear line can be distinguished from the straight line. For their part, figurative engravings have only been found in the PAVF, and the available information indicates that a wide variety of techniques were used (incision, scraping, polishing, and combinations of these) (*Manzi* et al. *2019; 2022*). In short, it is highlighted that the main difference between the Río Chico and Lago Sofía modalities applies to the figurative motifs based on points as distinct from those made using the flat and/or linear technique.

In the case of the colours used, most of these motifs were painted in reddish tones, with less presence of black, white, and bichrome tones (*Bate 1970; 1971; Sepúlveda 2011; Charlin* et al. *2023b*). In the case of

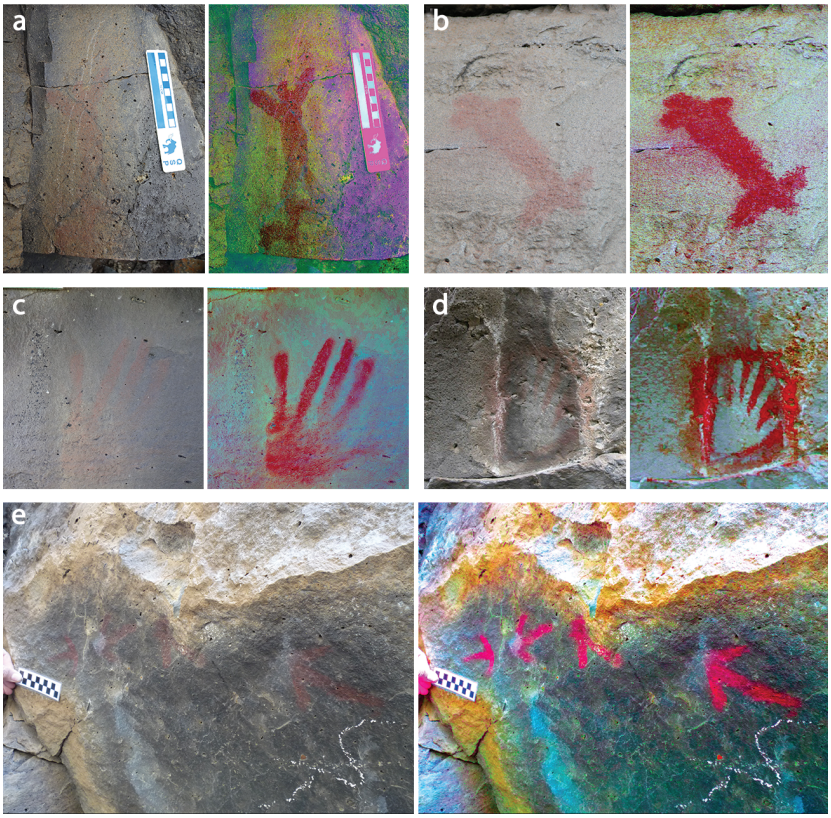

Fig. 5. Examples of figurative motifs depicted in the Pali Aike volcanic field (left: original; right: D-Stretch plug-in (image* j*): a anthropomorphic; b zoomorphic; c and d hands; e three-digits.

the PAVF, this coincides with the geochemical results, where the abundant local availability of hematite in the primary outcrops was confirmed, as well as its low cost of obtaining it, either from the altered vesicular basalt or as a saprolite buried a little depth (*Charlin* et al. *2023b*).

Regarding superimpositions related to painted figurative motifs, in PAVF they are found in three sites (ARB, LPA, and S6.C5), while in CB-LS they are present in sites LS1 and LS2. On the other hand, superimpositions were documented in Punta Walichu (SMLA). In summary, however, due to their low number it can currently be said that superimpositions are uncommon in the rock art of the extreme south of southern Patagonia.

Meanwhile, in CB-LS, the age of the paintings assigned to the Lago Sofía modality could be 2870±65 years BP, according to the dating obtained for the Cerro Benítez 2 (Dos Herraduras) site (*Masone 1982*). In the case of the PAVF, Manzi, and co-authors (*2019*) differentiate three temporal segments: the first comprises camelid engravings whose temporal depth could go back to approximately 5000 years BP according to macroregional morphological comparisons. These first rock art manifestations of the PAVF would be linked to specific moments in which the space was occupied (*sensu Borrero 1994–1995*). Furthermore, the representations of engraved camelids, similar to the painted motifs in other areas of Patagonia, allow us to envisage communication on a larger scale and a greater temporal depth than is commonly assumed for PAVF rock art.

The second segment (*Manzi* et al. *2019*) would be made up of the so-called Río Chico Style (*sensu Bate 1970; 1971*), assignable to the late Holocene, considering the few available datings of layer pigments (*Bate 1970; Gómez Otero 1989–1990; Prieto* et al. *1998*). As a result, it can be observed that two repertoires of rock art ensembles were executed in the PAVF, and the first would include the camelids as part of the oldest representations of the study area. These motifs would represent a colonization stage (*sensu Borrero 1989–1990*) that would have begun in the middle Holocene and indicates the possible connection with groups of humans from central-southern Patagonia (*Manzi* et al. *2019; 2022*). On the other hand, a second figurative pattern is identified that would be framed within the so-called Río Chico Style. These representations, whose execution is probably later, could be related to a stage of effective occupation (*sensu Borrero 1989–1990; 1999*). Notably, the number of sites with rock art for the late Holocene is decidedly higher (n=63) than those that would correspond to the middle Holocene (n=10).

Although the Río Chico Style has been assigned to the late Holocene, the temporality of the abstract and figurative motifs that make up this group have been the subject of debate by the various researchers who have worked in the area. This is because specific motifs have been executed over time, and some are shared by various 'styles' (*sensu Menghin 1957*). In this regard, Molina (*1969*) maintained that "*the footprint style*" (*sensu Menghin 1957*) together with the radiated concentric circles, are relatively modern for PAVF rock art. However, these motifs have been attributed to different moments in time and generally to the last *c*. 4000 BP (*Lasheras Corruchaga, Fatás Monforte 2015*). On the other hand, Molina (*1969*) raised the possibility that the oldest representations of the PAVF correspond to the Negative Style of Hands detected in the Güer Aike Painted Coat.

Regarding the Negative Style of Hands, Osvaldo Menghin (*1957*) argued that a set of simple geometric symbols had probably been combined from the beginning with the representations of hands. Given this, it would be prudent not to assign them to a temporal block since the hand negatives are present at different times throughout the entire stylistic sequence of the Pinturas River area, representing Stylistic Groups A–E (*Gradin* et al. *1979*), and the archaeological record of this area continues to be used as a basis for the interpretation of the stylistic sequences of other sectors of Patagonia. Furthermore, some hand negatives date from relatively recent times (*c*. 520 BP) in Viuda Quenzana (Santa Cruz) (*Brooks* et al. *2018*). Therefore, they may not necessarily be part of the Rio Chico Style. The last segment would include large painted motifs (varying between 10 and 119cm), such as three-digits in red and anthropomorphs with possible cephalic headdresses (*Gómez Otero 1983–1985*), and sexual features associated with fretwork motifs (*Manzi* et al. *2019*) that could be assigned to historical moments (*c.* 500 BP) (*Belardi 2004*). In this regard, Bate (*1971*) pointed out that the Lago Sarmiento modality would include large-sized anthropomorphs and zoomorphs. However, there are no dates to draw a parallel with the representations of considerable size present in the PAVF.

Based on this, even though the low number of painted sites and the lack of regionalization in the rock representations of southern Patagonia has been pointed out (*Carden 2008; Fiore 2006*), this study highlights an increase in diversity and frequency of painted and engraved figurative motifs, according to research carried out in recent years in the Pali Aike volcanic field. In addition, it is stated that the type and flow of information transmitted through rock art have undergone formal modifications over time, with two different rock art assemblages in the PAVF, accounting for different regional occupational processes (*Aschero 2000; Borrero 1994–1995*). Finally, the classes of rock representations are not the same at a macro-regional scale, although it is evident that the absence of significant regionalization in the rock repertoires seems to indicate an open network of information flow between the populations that occupied the eastern steppe (PAVF) and the forest-steppe ecotones (ZM, CB-LS, and SMLA).

Future work will assess whether these changes in rock art occurred due to population replacements and/or divergences (*Charlin 2020*). To this end, the information provided by the other lines of evidence studied in these regions will be included in the discussion, with particular emphasis on sensitive indicators of human mobility.

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Zoomorphic imagery and social process during the Early Bronze Age: the case of Koçumbeli-Ankara

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ABSTRACT – *Through the agency of animals, we think about our identity, landscape and society, and therefore animal imagery holds a special place in approaches to human thought. Through a study of the zoomorphic figurine assemblage recorded at the Early Bronze Age site of Koçumbeli-Ankara, we argue that the zoomorphic figurines of this time period were produced through a meaningful linking of particular images and raw materials to particular use contexts. For example, the ambiguously sexed zoomorphic figurines of clay are usually found within the settlement contexts, whereas the rest of the zoomorphic imagery, in the form of elaborately decorated and often male-sexed metal statues and standards, are found in 'elite' burials located in cemeteries. This occurs on the background of an emergent form of ritual control, which was negotiated through the separation of cemetery and settlement. In these contexts, the authority of the past was invoked via ancestral imagery through the careful employment of new raw materials, such as metals, that equally became agential in the separation of age, gender and class-based differences within society, at the eve of the centralization process in Anatolia.*

KEY WORDS – *figurines, Early Bronze Age, Anatolia, ritual, centralization*

Podobe živali in družbeni proces v zgodnji bronasti dobi: primer Koçumbeli-Ankara

IZVLEČEK – *S pomočjo živali razmišljamo o svoji identiteti, pokrajini in družbi. Živalske podobe imajo zato posebno mesto v proučevanju človekovih misli. S pomočjo študije zbira živalskih figuric, najdenih na zgodnje bronastodobnem najdišču Koçumbeli-Ankara, trdimo, da so bile živalske figurice v tem času narejene v smiselni povezavi izbranih podob, surovin in posebnih kontekstov uporabe. Tako na primer živalske figurice nedoločenega spola običajno najdemo v naselbinskih kontekstih, ostale upodobitve živali v obliki dovršeno okrašenih kovinskih kipcev, ki so pogosto samci, pa v 'elitnih' pokopih na grobiščih. To je povezano z obrednim nadzorom, ki je bil dogovorjen ob ločitvi grobišča od naselja. V teh kontekstih so bile pretekle avtoritete priklicane s pomočjo podob prednikov ob skrbni uporabi novih surovin, kot so kovine, ki so prav tako postale dejavnik pri ločevanju starostnih, spolnih in razrednih razlik v družbi na predvečer procesa centralizacije Anatolije.*

KLJUČNE BESEDE – *figurine; zgodnja bronasta doba; Anatolija; obred; centralizacija*

Introduction

Prehistoric animal imagery has been frequently associated with rituals that were performed to increase the efficacy of subsistence activities, such as hunting and herding of dietary species (*Conkey 1989; Rice*, *Paterson 1985; 1986*), and the symbolic significance of dietary meat distribution and hunting in the construction of social hierarchies (*Arbuckle 2014; 2015)*. However, animal representations are not al-

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ways associated with dietary species. For example, snakes, vultures, lions or bears often hold prominent positions in prehistoric imagery (*Chauvet* et al. *1996; Peters*, *Schmidt 2004; Mellaart 1967; Özkaya* et al. *2013*). Arguably the skin, fur, teeth and bone of symbolically significant animals, specifically the wild and dangerous category, may have been used to signal prestige and social status in prehistoric times (*Peters*, *Schmidt 2004; Hodder*, *Pels 2010; Arbuckle 2012; Russel 2012; Meskell 2015; Mouton 2017; Owens*, *Hayden 1997; Hamilakis 2003*). At the same time, thinking via animals involves deeper ontological contemplation about who we are and how we are related to the landscape and each other (*Wynn* et al. *2009; Porr 2010; Hill 2011; Russell 2012; Arbuckle 2015; Lewis-Williams 2014; Mithen 1988; Leroi-Gourhan 1964; 1968)*. This thought is often reflected in animistic creation myths and within wider beliefs of animal-human relations, parts of which can be invoked through a careful use of various forms of portable and non-portable objects, at particular settings. Therefore, animals and animal imagery can be approached as mediums through which concepts about social positions, status and identity are negotiated.

Prehistoric wall paintings, rock carvings, landscape installations or statues and personal ornaments with animal themes are extremely valuable to understand the variety of human understandings of self and the perceptions of the social landscape. Among these, three dimensional and portable statuettes, *i.e.* 'figurines' hold a special place in understanding the function and meaning of prehistoric imagery. Through the use of various materials, such as stone, clay, bone, horn or metal, figurines are symbolically charged objects that can either depict abstract forms (such as geometric shapes) or naturalistic shapes (such as zoomorphic, anthropomorphic or hybrid). The recent methodological developments provided by the materiality and agency approaches, posit that the selection of raw materials, production techniques, size, colour, find contexts and discard patterns as well as the thematic focus and variation of figurines are outcomes of culturally structured behaviour and provide clues to the constitution of symbolic worlds and the social relations in prehistoric societies (*Nanoglou 2009; Lesure 2011; Meskell 2015; Gemici*, *Atakuman 2021)*. In this context, just as the animals selected for representation are important, their sex, and social behaviour may be used to understand the negotiation of social concerns in relation to group and individual identities (*Porr 2010; Russell 2012*). Such approaches have been widely employed in anthropomorphic figurine studies; frustratingly, however, the use and function of zoomorphic figurines are much less understood, particularly in Anatolian prehistory.

The aim of this study is to understand the use and function of the zoomorphic figurines, during the Early Bronze Age of Anatolia (EBA, *c.* 3200–2000 BC), through the case study of the North Central Anatolian site of Koçumbeli-Ankara (Figs. 1 and 2). The Early Bronze Age in Anatolia is a period of significant social and economic change, leading to the emergence of elites and formation of social complexity associated with centralization, the specialized production of metal objects, textiles and long-distance trade networks extending from the Aegean to Mesopotamia (*Şahoğlu 2005; Çevik 2007; Efe 2007; Sagona*, *Zimansky 2009.172–224; Bachhuber 2011; 2015; Düring 2011.257–299; Steadman 2011.229–259; Schoop 2014*). The anthropomorphic figurines of this time period have been an attractive topic of research in traditional typological approaches (*Makowski 2005; Mina 2008; Yalçın*, *Yalçın 2013; Martino 2014*), while their links to the social process of change have

Fig. 1. The Location of Koçumbeli, the other sites mentioned in the text.

also been demonstrated in recent studies (*Atakuman 2017; 2019*).

The Early Bronze Age site of Koçumbeli and its zoomorphic figurines

Koçumbeli is a small EBA settlement located on hilly terrain in the south-west of Ankara, within the campus of the Middle East Technical University. The site was excavated in the 1960s for a short period of time and there are no absolute dates, but recent stylistic studies on the material culture indicate a time period of occupation that probably covers the early part of the 3rd millennium BC, based on similarities to the other EBA sites in the vicinity, such as Demircihöyük, Alacahöyük, Etiyokuşu, Ahlatlıbel, and Karaoğlan (*Atakuman 2017; Bertram 2008; Bertram*, *İlgezdi 2008*; *Tuna* et al. *2012*).

Unfortunately, there is not any contextual information, nor a systematic study regarding the zoomorphic figurines or zoomorphological remains of Koçumbeli, except a brief mention of a few objects in the original report (*Tezcan 1966.7*). Our study at the METU-Museum of Archaeology identified a total of 20 zoomorphic figurines from the site (Tab. 1, Figs. 2,3,4,5, see Appendix). All of these 20 zoomorphic figurines were hand-shaped, possibly with locally available clay sources which were often mixed with chaff and small stone inclusions. Baking seems to have occurred in the range of 600°C to 800°C, possibly in an open fire. Finished colours vary between beige, reddish beige, brown beige and black. The majority have soot on their surfaces, but it is hard to tell whether the soot appeared during the baking process or because of contact with fire after they were discarded. The majority of the figurines were broken at the horns, legs and protruding facial parts, but it is not possible to know whether this was a deliberate act (as may have been the case with the anthropomorphic figurines, see *Atakuman 2017*) or the result of natural processes.

Typological considerations

A significant portion of the Koçumbeli zoomorphic figurine assemblage involves 'horned' animals, which appear to be representations of cattle, sheep, goat and boar. However, it is quite difficult to tell the exact type of animal at first sight. In an attempt to identify these animal types, we primarily focused on the physical attributes, such as horn and tail shapes as well as the body's morphology. In this context, the long-tailed zoomorphic figurines have been identified as cattle, whereas the short-tailed zoomorphic figurines are categorized as sheep or goat. The horn shapes are also used as an identifier where possible, *i.e.* the crescent-shaped horns belong to cattle whereas the horns that curve backwards from the face are identified as belonging to sheep or goat. Ultimately, out of the twenty zoomorphic figurines of the Koçumbeli assemblage, ten are categorized as cattle (Type I, Fig. 2), seven as sheep/goat (Type II, Fig. 3), one as boar and one as a piglet (Type III, Fig. 4) as well as one bird (Type IV, Fig. 5).

Fig. 2. Koçumbeli animal figurines Type I – cattle.

Beyond the general typology, our focus has also been on the sex, age and domestication status represented in each figurine, where possible. In our assemblage, explicit sexual attributes, such as genitalia, are entirely absent. Horns are not a reliable indicator of

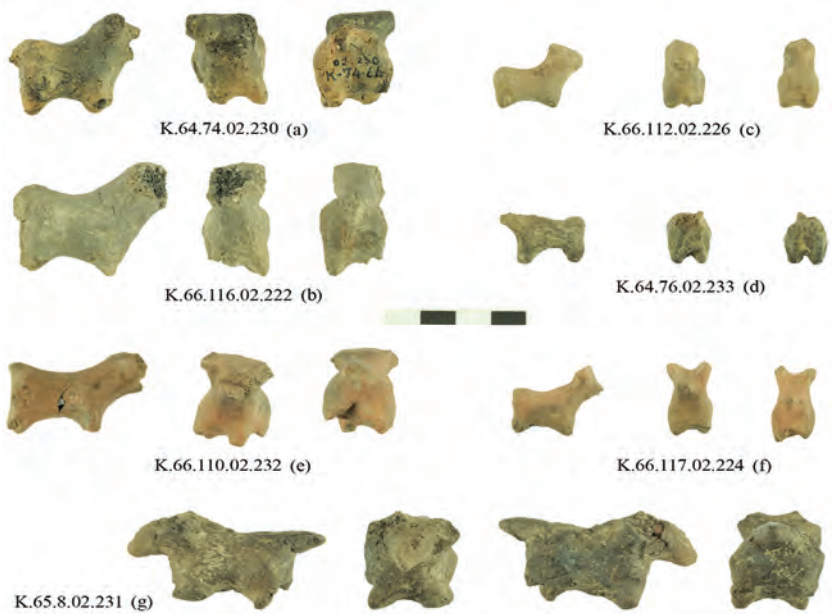

Fig. 3. Koçumbeli animal figurines Type II – sheep/goat.

sex either, since they can be present on both sexes of wild and domesticated adults of all of the above-mentioned species, albeit the domesticated males of sheep and goat have relatively more prominent horns than the females. Boar tusks are also more prominent in males. Within the assemblage, all of the goat, sheep and cattle figurines are identified as adults due to the presence of horns, since the juveniles do not have prominent horns in these species. There is one potential male boar (Type III, Fig. 4.a) within the assemblage, while there is also a potential representation of a piglet (Type III, Fig. 4.b).

Admittedly, it is difficult to rely on the size differences to identify sex or age differences, considering the possibility that each of these figurines may have been produced by different individuals at different time periods with different stylistic concerns. Nevertheless, in some cases size differences can be related to sex differences, such as rams (*e.g.*, Fig. 3.g) and bulls (*e.g.*, Fig. 2.i). For example, size difference in the two possible boar representations seems to be related to age (Fig. 4). There are also indications that some of the figurines were produced in pairs of slightly different sizes, (Fig. 2.a-b,c-d,e-f,g-h; Fig. 3.a-b,c-d), and these size-wise distinguished pairs of sheep, goat and cattle might be representative of sexual dimorphism, as the males are physically bigger in these species.

Within the above-mentioned evaluations, our 'Type I, the cattle group' figurines are in varied colours (beige, reddish beige, brownish beige and black) and sizes. Except for two (Fig. 2.i,j), all of them are grouped together with regard to their long tails. One of these two exceptional figurines is broken in half from the torso (Fig. 2.i). Its exceptional size might be representative of a male individual. The other one of these two exceptions is the only Jet-Black figurine with a different body morphology than the rest of group (Fig. 2.j) – it has a slender body which resembles a deer. However, it is more likely to be a 'bull' as found in the metal statues of 'the Royal Cemeteries' of Alacahöyük (Fig. 7 and Tab. 3, see Appendix).

Seven figurines have been identified as sheep/goat (Type II, Fig. 3), which come in various colours (beige, reddish beige and brownish beige) and sizes. The tails in four specimens were depicted as short and pointy (Fig. 3.a,b,e,f), one as short and protruding (Fig. 3.g) and the other two did not have tails Fig. 3.c,d). Horns are relatively poorly preserved compared to Type I, although it seems that all have similar horn types with Type I, apart from one example whose horns lean backward, and thus this particular items might be a representation of a goat (Fig. 3.f). The figurine with a protruding tail (Fig. 3.g) has a more robust body than the other Koçumbeli zoomorphic figurines, and it differs from the rest in terms of body proportion and features. Regarding the physical attributes, it is thought that it might be a representation of a ram.

Besides the above, there are two figurines which can be categorized as pig/boar (Type III). The bigger one of these two has tusks and probably represents a wild male boar (Fig. 4.a). A similar but smaller piece without horns resembles a piglet (Fig. 4.b). Type IV is unique within the whole assemblage and resembles a bird (dove?), similar in nature to the bird attachments found on the metal statuettes and standards of Alacahöyük (Fig. 5).

Discussion: contextuality, materiality, and use in comparative perspective

There are many EBA sites that produced significant amounts of zoomorphic figurines (see Fig. 1), such as, Alişar (*Von der Osten 1937*), Ahlatlıbel (*Koşay*

Fig. 4. Koçumbeli animal figurines Type III – boar, piglet.

1934), Karaoğlan Mevkii (*Topbaş* et al. *1998*), Çiledirhöyük (*Türktüzün* et al. *2014*), Troy (*Blegen* et al. *1951a*), Kanlıgeçit (*Özdoğan* et al. *2012*), Küllüoba (*Deniz*, *Ay 2006*), Şarhöyük (*Darga 1994*), Höyüktepe Sandalcı *2014*), Seyitömer Höyük (*Bilgen 2015*), Demircihöyük (*Baykal-Seeher*, *Obladen-Kauder 1996*), Alacahöyük (*Koşay 1937; Gürsan-Salzmann 1992*), Horoztepe (*Özgüç*, *Akok 1958*) and Kalınkaya (*Yıldırım*, *Zimmermann 2006).* However, a systematic analysis regarding the zoomorphic imagery has not yet been attempted, and remains a difficult task, since contextual information for many of the items is not available. Table 2 (see Appendix) summarizes our attempt to summarize this comparative information.

The thematic and typological analysis of comparative sites reveal that the majority of the represented species are 'cattle' followed by sheep and goat and then fewer pig, deer and other animals such as tortoise, birds, *etc.* (Tab. 2). This general picture also holds for the Koçumbeli assemblage (Tab. 1 and Figs. 2,3,4,5). In contrast, Benjamin Arbuckle's (*2013; 2014*) analysis of zooarchaeological assemblages from a number of EBA sites demonstrates that more than half of all the identified animal species at any given site are of sheep and goat, with lower numbers of cattle. This is interesting and suggests that animal imagery may not be merely about the most consumed species. Cattle seem to be a symbolically important sacrificial animal both within the 14 'royal tombs' of Alacahöyük and for the seven 'elite' and male graves of the Sarıket cemetery near Demircihöyük, (*Seeher 2000; Massa 2014.Tab. 2).* Such symbolic importance may be related to the late domestication of cattle, hierarchies established via sharing its meat, or its reproductive cycle and the social behaviour that may be metaphorically likened to that of humans, *e.g.*, the nine-month pregnancy period.

In terms of the raw materials, clay is the most common raw material which is found at almost every settlement from the beginning to the end of the EBA period. Stone zoomorphic figurines were only observed at Alişar. This site has a very complex stratigraphy, but the stone zoomorphic figurines can probably be dated to the Late Chalcolithic and/or the early stages of the EBA period. The perforations found on all of these stone zoomorphic figurines suggest that they might have been used as amulets/pendant or the ornaments to hang, a phenomenon that is also observed in the animal imagery bearing objects of the earlier Chalcolithic period from sites such as Köşk Höyük and Domuztepe (*Atakuman 2015a*).

As for the contexts, the clay figurines of zoomorphic and anthropomorphic variety are usually associated with domestic contexts, while the metal statuettes/figurines of both zoomorphic and anthropomorphic variety have been found in association with 'elite' burials of north-central Anatolia (*Atakuman 2017*). More interestingly, a deliberate depiction of sex is very rarely seen in the clay or stone zoomorphic figurine representations, although the zoomorphic metal statuettes, which are almost always associated with burial contexts, often represent male cattle and deer, *i.e.* bull and stag. Because the majority of these objects seems to be designed to be carried on a pole or a pedestal, Hatçe Baltacıoğlu (*2006*) thinks that they represent the Hattic deities of power and fertility, such as Tešup and Arinna and according to Winfried Orthmann (*1967*) these animals were also used to pull the ceremonial wagons that carried the deceased. In line with these interpretations, Aslı Özyar (*1999*) elaborates that some of these statuettes may be family emblems that represented the status of the deceased.

Although their actual purpose is unclear (see *Zimmerman 2008* for a critical evaluation), it is safe to assume that these objects were used in ritual displays

Fig. 5. Koçumbeli animal figurines Type IV – bird.

Fig. 6. Comparison of imagery on Domuztepe house pots, Alacahöyük Standard (from* Atakuman 2015a; Müller-Karpe 1974*).

associated with elite burials, since no metal statuettes or figurines have been found in domestic contexts. Indeed, the quality of these metal figurines and statuettes, which are all bronze casts sometimes decorated with gold and silver, reflect the intensive skills in metalworking and knowledge of metallurgy and resources of the period, and thus metal artifacts are considered an important signal of rank and status. From a different angle, it seems likely that the imagery depicted in some of these metal objects is a derivation of the Late Neolithic/Early Chalcolithic symbolism which can be found on the ritually significant 'house pots' recovered from Domuztepe (*Atakuman 2015a; 2015b;* Fig. 6). These pots were used in rituals of social regeneration in context of human and object burials at this site (*Atakuman*, *Erdem 2015*) and seem to depict a story about houses with seasonal birds on roof (possibly cranes, storks or similar) in relation to a checkerboard patterned area (possibly the ancestral location on the tell where rituals of house closing and object burials were performed). Arguably, the story behind the depiction recorded the time and season of the rituals as well as the ancestral connections of various households to the tell-place both in oral and material tradition, and it is likely to be related to one of the well-known wall paintings at Çatalhöyük, the so-called 'town map' (see *Atakuman 2015a.Figs. 15 and 16*).

Fig. 7. Jet-Black cattle figurine from Koçumbeli (on the right), the Alacahöyük metal bull statuette (on the left).

Looking at the Koçumbeli zoomorphic figurine assemblage as a whole, it is interesting to note that some figurines have been produced in pairs with hints of either of sex and/or age differences. A similar pattern of pair production has also been observed previously within the anthropomorphic figurine assemblage of Koçumbeli (*Atakuman 2017*), which was interpreted as a possible representation of sex and related status difference. Differences in status may have also been communicated through the particular selection of dark vs light colours, possibly to invoke concepts of death, ancestry or life and reproduction. The only shiny Jet-Black bull figurine (Fig. 7) is noteworthy in this regard which was probably produced by using a special production technique (such as oil raku) to achieve this shiny black colour. Similarly, the two boars, seem to have been deliberately dark coloured, possibly during a reductive firing process (Fig. 4). Again, a similarly structured pattern of deliberate black colouring was observed in three of the most elaborately manufactured anthropomorphic figurines, potentially representing high-status individuals (see *Atakuman 2017.Figs. 7a*, *8a*).

In this context, we should also note that there is comparability in numbers of anthropomorphic and zoomorphic figurines of Koçumbeli (26 anthropomorphic *vs.* 20 zoomorphic figurines) and based on our above-mentioned detection of other similarities in size, colour and sex differences, it seems plausible to think that they were produced within the same ritualized context, which most likely interlinked domestic and communal spheres, possibly during seasonal events that celebrated and invoked cycles of both human and animal regeneration as well as death (*Atakuman 2017*). It is well known that cattle, sheep, goat and deer were preferred sacrificial animals in the seasonally invoked religious celebrations of the 2nd millennium BC (*Mouton 2017.243; Collins 2001.79*).

Symbolic continuity *vs.* ritual shift in Anatolian prehistory

Before coming to a conclusion, we would like to briefly trace the continuities and shifts in the use of zoomorphic imagery in an Anatolian context, in order to be able to highlight the agency of these objects during the major social transitions, such as the transition to agriculture and the emergence of complex societies. In Anatolia, the earliest evidence of animal imagery in the form of painting and engraved stones and of wild cattle, bison, ibexes, deer, and wild goats, is known

from the Epi-Palaeolithic contexts of Öküzini and Beldibi caves, and the many rock art sites scattered through landscape, specifically of south-east Anatolia (*Eker 2023; Bostancı 1959; Otte* et al. *1995; Sagona*, *Zimansky 2009; Tumer 2018*). Animal representations go through a symbolic explosion during the Early Holocene of south-west Asia, which coincides with the emergence of settled communities that are increasingly reliant on food production and eventually agriculture of domesticated species during the Neolithic (*c.* 10 000–7000 BC). For example, during the Pre-pottery Neolithic (PPNA, *c.* 10 000–8500 BC), a wide range of wild species of both dietary and non-dietary varieties, most notably snakes, scorpions, lions and vultures are vividly depicted at Göbekli Tepe's communal ritual structures, composed of elaborately decorated monumental anthropomorphic pillars, statues, statuettes and miniature grooved stones (*Schmidt 2007*). It is interesting to note that, much of this imagery occurs in context of a deliberate emphasis on male sexuality (*Peters*, *Schmidt 2004.183–185).* Similar representations are also observed on Körtik Tepe's stone vessels (*Özkaya* et al. *2013*) while the use of wild cattle horn installations in houses of Hallan Çemi (*Twiss, Russell 2009*), demonstrate that remains of particular animals became an important component of zoomorphic imagery.

During the PPNB, the wider variety of species represented in previous periods began to diminish, as clay increasingly became the raw material of choice to produce figurines. Indeed, at sites such as Nevali Çori, Çayönü, Ain Ghazal and Çatalhöyük, figurines of pre-domesticated and domesticated animals, such as goat, sheep, pig and cattle, started to dominate the imagery, although small numbers of bear, deer, fox, dog, felines and so on continue to be present in assemblages (*Rollefson 1986; 2008; Morales 1990; Schmandt-Bessarat 1997; Morsch 2002; Russell*, *Meece 2006*). During this time period, zoomorphic as well as anthropomorphic imagery was increasingly concentrated in and around the 'house', both in the form of wall paintings and installations of animal remains, such as cattle horns, and figurines (*Meskell 2015; Düring 2007).*

Indeed, the 'houses' of the Neolithic were symbolically charged places where the concepts of life and death were metaphorically contemplated via the circulation of human and animal imagery together with the circulation of the living and dead animals and humans (*Düring 2005; 2007; Russell*, *Meece 2006; Kuijt 2008; Meskell* et al. *2008; Hodder, Pel 2010; Atakuman 2014; Meskell 2015*). Such a circulation was intensified during communal ritual activities which usually came to the fore during the seasonally invoked house renovation cycles. During these ritual events, symbolically significant architectural elements of the prior house structure, such as the bucrania and horn installations as well as the actual human remains were carried and implemented in the new phase of the house (*Hodder*, *Cessford 2004; Boz*, *Hager 2013).* As a result, multiple bucrania installations and a rich burial record accumulated in the last phases of a 'history house' (*Hodder, Pels 2010*), that competitively displayed house success and continuity during the rituals linking the past and present.

The wall paintings of these 'history houses', as well as the remains of animal horns that were used as wall installations within them, indicate that there continued a deliberate focus on male species of animals (*Mellaart 1967; Hodder, Pels 2010*). However, the sex is often ambiguous on zoomorphic figurines. Nevertheless, among the zoomorphic figurine assemblages of Çatalhöyük and Ain Ghazal a concern with different life-stages of animals seems to be evident, as adults and juveniles were represented accordingly (*Schmandt-Besserat 1997; Rollefson 2008; Martin*, *Meskell 2012*). Moreover, at both sites some zoomorphic figurines were found to be 'stabbed' or punctured by flint blades (*Schmandt-Besserat 1997; Martin*, *Meskell 2012*). Because the majority of these figurines depicted cattle at Çatalhöyük, which were still going through domestication at this site, Lynn Meskell (*2008*) suggested that hunting cattle in these communities was a symbolically important act, possibly constructing sex- and age-based status differences, as in rituals of initiation.

Jacques Cauvin (*2000*) explains this shift toward horned animals, as the birth of a new belief system within which social identities, and specifically gender roles, were constituted with references to the changing perceptions of the 'wild' and new ways of controlling it, during the Neolithic Process (see also *Helmer* et al. *2004*). Similarly, Ian Hodder (*1990*) claimed that such a 'symbolic domestication' was mediated with creative uses of imagery in various forms, either as animal horn and head installations or wall paintings and figurines within the 'house' context, where the emergent sex- and age-based status differences were negotiated with reference to the concepts of wild and domestic, aging and sexuality, as well as death and regeneration.

Ultimately, on the one hand we observe a deliberate emphasis on male sexuality in rituals of communal nature where elaborate displays are prepared within the history houses, which were performed during the competitive place making activities involving funerary rituals and communal feasting; on the other hand, the community members may have also used the opportunity provided by the malleable character of clay to think and constitute their place in relation to the wide scale rituals of social regeneration (*Atakuman 2015*). This may have been through a variety of daily ritualized uses, such as the use of figurines as 'toys' for the education and initiation of children as well as wider rituals of initiation and other forms of social regeneration rituals during which social structure was negotiated. Unfortunately, the burial record of the time period, albeit rich and meticulously analysed, does not allow us to make any inferences about the sex and age based status differences during this time period (*Kuijt 2008*). Yet, we understand that the meaning and function of imagery is not merely in the image, but particularly in the context and the deliberate staging of referential relationships between the animate and the inanimate things within this context.

Arguably, a similar pattern of figurine production continued into the Early Bronze Age in Central Anatolia and it may be tempting to see a continuity in the contextually structured use of signs of an ancestral belief system that circulated since the Neolithic, *e.g.*, an emphasis on maleness in communal displays. However, we also see important shifts in the contexts and raw materials, which are fundamental to a better understanding of the agency of figurines within the EBA social scene. In fact, one important shift is related to the concept of the cemetery which seems to have emerged in tandem with the increasingly more visible status differences based on sex and age (*Bachhuber 2011; Atakuman 2017*). We think that such a division of spaces of death vs life is significant to understand the meaning and function of figurines during the EBA and we elaborate on this below.

As a general rule, during the EBA the adults and subadults of both sexes were mostly interred in cemeteries, whereas infants were usually buried under house floors, *e.g.*, at sites such as Beycesultan, Kusura, Kalınkaya, Gavurtepe and so on (*Wheeler 1974; Yıldırım* et al. *2018; Selover*, *Durgun 2019*). Furthermore, the differential treatment of males and females is apparent both in terms of their body positions and the grave goods, such as at the Sarıket cemetery near Demircihöyük. Here, metal objects were recorded in burials of all age and sex groups, while weaponry (daggers, copper mace heads, axes, spearheads) and silver figurines, whetstones, razors, lead diadems and gold rings are almost always associated with male graves. Adult males have also been found to be closely associated with more elaborate grave forms, such as the stone-lined pit and stone cist graves, which make up a mere 4% of all grave types. Within this group, seven adult male graves seem to hold a higher political status, as these burials contained knobbed maces and more significantly were associated with completely articulated cattle burials (*Seeher 2000; Massa 2014*).

At the site of Alacahöyük, the 14 'royal' tombs are clearly separated from the ten 'commoner' graves, the latter potentially predating the former (*Gürsan-Salzmann 1992.67–139; Koşay 1934; 1937; 1938; 1966*). Children and adults of both sex groups were buried usually with ceramic vessels and some personal ornaments, such as a bracelet, an earring, and a pin within the commoner graves. In contrast, children and infants were not found in any of the royal tombs which were composed of at least four adult females (tombs H, T, A, L) and five adult males (tombs B, R, T', A', K). The sex of the remaining burials was not identifiable (tombs S, D, E, C, F). Here, both male and female graves contained highly crafted metal objects, such as bull or stag statuettes as well as standards combining composite images of abstract shapes and animal imagery, together with personal ornamentation items such as rings, 'ear-studs', bracelets, diadems, pins and daggers (Tab. 3). Metal vessels and anthropomorphic metal and some clay figurines were also recorded in many of the tombs. Many of the tombs also contained skeletal remains, specifically skulls of sacrificial animals, such as cattle, sheep, goat, and dog. Within this scene, tomb B of a male individual is outstanding, as it involved the only stamp seal, made of stone, found in the cemetery. This burial also contained six metal disc standards (the highest number found within a single grave), the only clay anthropomorphic figurine and the only two clay zoomorphic figurines found within the cemetery. On the other hand, tomb H and tomb A, both of which are of females, included a greater variety and number of objects. In fact, tomb H contained ten ceramic and metal vessels, 13 metal anthropomorphic figurines (including gold sheet 'idols') and one bone figurine, eight castanets, 30 metal pins and more than six necklaces.

At Koçumbeli, one stone cist grave with an unsexed adult was found to be lying on its right side facing east, with two gold 'ear-studs' and a metal dagger, which tentatively indicate a male burial (*Yakar 1985.196*). No cemetery in the vicinity has been reported; however, at the site of Ahlatlıbel, only a few kilometres southwest of Koçumbeli, burials of mixed age and sex groups, with many copper, lead and gold objects, were found in 18 intramural graves of both pithos and stone cist types (*Koşay 1934*; *Özgüç 1948*).

As mentioned previously, the ambiguously sexed clay zoomorphic figurines are usually found within the settlement contexts, whereas the rest of the zoomorphic imagery, either in the form of cattle burials or in the form of elaborately decorated and often male-sexed metal statues and standards are found in 'elite' burials located in cemeteries. For example, at Demircihöyük, the majority of the 241 zoomorphic figurines that were found were recovered from the settlement contexts, whereas there were no zoomorphic figurines in the Sarıket cemetery, although cattle burials were found in relation with possibly male elite burials (*Seeher 2000; Massa 2014*). As for the anthropomorphic figurines, there were more than 200 clay figurines in the settlement whereas only 10 anthropomorphic figurines, all from sub-adult graves, were recovered from a total of six graves (*Seeher 2000.74–126; Massa 2014.84*). At the site of Alacahöyük, a total of fourteen zoomorphic clay figurines were recovered from the domestic contexts, whereas only two were from the elite graves and none from the non-royal/commoner graves. As for the anthropomorphic figurines of Alacahöyük, most of the clay figurines came from the settlement contexts, whereas the metal objects were found in graves (*Atakuman 2017*).

It seems that the zoomorphic figurines were produced through a meaningful linking of particular raw materials and particular themes (*e.g.*, types of animals) to particular use contexts, in an attempt to mediate/articulate/curate class and gender based social identities during a social process that amounted to 'political centralization' in central Anatolia by the end of the EBA. For a similar approach to the Greek Neolithic figurine corpus see Stratos Nanoglou (*2008; 2009*). This picture is similar to what we also observed in the study of the anthropomorphic figurine assemblage of Koçumbeli (*Atakuman 2017*).

Conclusion

We argue that the figurines of both anthropomorphic and zoomorphic variety were probably produced together and worked together to invoke a variety of themes of life, death, sex, place/genealogical continuity and success, all of which were fundamental ingredients in the creation of status-related identity discourses. Although clay is an easier medium to work with, to express finer details (*e.g.*, anthropomorphic figurines with many details of sex, ornamentation *etc.*), the use of metals to produce figurines is entangled in the emergent role of new raw materials to express status differences during the wider processes of centralization.

According to Christoph Bachhuber (*2008.242–48; 2015*), a fundamental aspect of this process is the gradual separation of the settlement and cemetery from the Early Chalcolithic on, and the employment of different prestige displays in these separate contexts. For example, the highland sites of Central Anatolia began to invest more in the elaboration of personal status in lavish funerary ceremonies, such as seen at Alacahöyük, while the lowland sites of the Aegean and Mediterranean (such as Karataş-Semayük) invested in monumental architecture. Metal figurines, as new items of prestige displays, were reserved for those lavish cemeteries of 'elites' in the Central Anatolian sphere, since they demonstrated ideological control over sacred images and economic control over close-by raw material resources (*Zimmermann 2008; Bachhuber 2011; Lehner, Yener 2014; Yalçın, Yalçın 2013*). Similarly, working with metals required complex knowledge of the craft as well as control over resources and labour, and thus the use of this raw material in any public display indicated the individuals' economic influence over wide areas.

Furthermore, metals incorporated qualities of both malleability (like clay) and rigidity (like stone or bone), together with shine, glitter, and possibly sound. Such enhancements to the traditional sacred imagery that had been around since the Neolithic indicate a structured articulation of the emergent elite classes, as well as the increasing political significance of some male members of the society. In this context, the use of metal figurines of often male-sexed big-game animals (such as deer or bull) in elite funerary contexts may be related to the hierarchical order of these animals in religious ideology rather than the

Pre Pottery Neolithic	Pottery Neolithic	Early Bronze Age
Hybrid imagery of animals and humans, as in the anthropomorphic pillars of Göbekli tepe. Horn installations are present in huts, such as at Hallan Çemi. Main raw material is stone during the PPNA, whereas clay is increasingly more popular during the PPNB. Imagery concentrating mostly on wild, dangerous species, often involving non-dietary animals. Pre-domesticates become the main focus during the PPNB.	Zoomorphic and anthropomorphic imagery are distinguished. The 'house' becomes the main context of animal imagery which can be depicted as wall paintings, installations or figurines. Maleness is indicated in wall paintings and horn installations whereas the sex is ambiguous in figurines. Domesticates with horns are the main focus, however, some of these are not the most consumed species. Main choice of raw material is clay to produce figurines of both anthropomorphic and zoomorphic variety.	Zoomorphic and anthropomorphic imagery are distinguished. Domesticates with horns are the main focus, however, some of these are not the most consumed species. Main choice of raw material in domestic contexts is clay to produce figurines of both anthropomorphic and zoomorphic variety, however, metal items are used in 'elite' burials, which are often separated from the domestic context, as in cemeteries.
Negotiation of group structure and composition with references to the animistic beliefs involving hybridity of human and animal spirits.	Emergence of the competitive 'house', where ritual and economic control was controlled by households that negotiated their success through displays of ancestral continuity. These displays involved both zoomorphic and anthropomorphic imagery and the actual remains of humans and animals.	An attempt to emphasize age, gender and class based differences through a new form of ritual control which was negotiated through the separation of burial and settlement contexts as well as structured employment of new materials, such as metals, to produce traditional imagery that was used in lavish displays.

Tab. 4. Temporal shifts in use of zoomorphic imagery in relation to the social contexts of change.

differences in subsistence practices of the Anatolian Early Bronze Age sites (*Arbuckle 2014; 2015*).

Arguably, the traditional rituals of death that simultaneously triggered social regeneration (as in seasonal festivals) were undergoing a major transformation along with the increasingly more complex and stratified society. During this process, the domestic control over the potent rituals of death and social regeneration began to be limited, the public domains of symbolic and economic control, such as cemeteries, became the focus, which is typical of the political centralization process. Through the structured use of raw materials and themes in different contexts, the meaning of images were actively manipulated, as society was provoked to contemplate the circulating ideas of the self, society and new scales of authority. Whereas the Kocumbeli figurine assemblage is completely made up of clay items, some objects of gold, copper and bronze have been recovered from the site. Indeed, the small Koçumbeli community was aware of the changes in the political landscape and restructuring itself in relation to the emerging networks of exchange and prestige by mediating alternate inland routes of 'the Anatolian Trade Network' (*Şahoğlu 2005*) or the 'Great Caravan Route' (*Efe 2007*), that connected north-central Anatolia to the south and southeast regions.

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Appendix

Tab. 1. Catalogue of Koçumbeli animal figurines.

Type	Description
Type I Cattle Fig. 2.i	L: 5.6cm, H: 5.5cm, W: 3.6cm Handmade clay figurine. Polished. Not complete. Horns, back part of the body and front and hind limbs are broken. Triangular pinched face and eyes are indicated with a single hole. Soot on the surface and on the broken parts (Possible contact with fire after breakage). Not fine clay, chaff and very small stone inclusion can be seen. The biggest figurine in the group, because of the size and the horn type it remains cattle maybe an adult male ox. Clay color is reddish beige. (inventory number: K.66.107.02.214)
Type I Cattle Fig. 2.f	L: 3.7cm, H: 3.3cm, W: 2.6cm Handmade clay figurine. Well-polished. Almost complete. Highly smooth surface. Horns and face (probably triangular pinched face) are broken. Tail is long and indicated by pinching. Slight soot on the surface. There is an engraved line at the back of the head. Front and hind limbs are complete also they are most probably shaped by pinching. Dorsal part of the figurine is defined with a smooth curve. Not fine clay, chaff and very small stone inclusion can be seen. Clay color is brown beige. (inventory number: K.66.109.02.217)
Type I Cattle Fig. 2.g	L: 3.0cm, H: 2.8cm, W: 1.9cm Handmade clay figurine. Polished. Almost complete. One of the horns and face are broken. Feet are made as small protrusions. Tail is long and indicated with two parallel engraved lines. Front and hind limbs are complete also they are most probably shaped by pinching. The color on the broken parts is same with the color on the surface. Not fine clay, chaff and very small stone inclusion can be seen. Clay color is reddish beige. (inventory number: K.65.51.02.215)
Type I Cattle Fig. 2.a	L: 3.2cm, H: 3.7cm, W: 2cm Handmade clay figurine. Polished. Almost full. Horns or ears are broken. Face is triangular pinched face. Eyes are indicated with a single hole. Tail is long and indicated with two parallel engraved lines at the back side. Buttocks are slightly pronounced. Front and hind limbs are complete also they are most probably shaped by pinching. Not fine clay, chaff and small stone inclusion can be seen. Clay color is beige. (inventory number: K.64.72.02.225)
Type I Cattle Fig. 2.c	L: 4.2cm, H: 3.6cm, W: 2.1cm Handmade clay figurine. Well-polished. Almost complete. Dark Brown Slip? Horns or ears are broken. The deep line on the face suggests that its eyes might have been depicted with a single hole. Slight soot on the surface. Neck part is longer than the other figurines. Body is getting wider from front to back. Back limbs are taller than the front limbs. Tail is long and indicated with two parallel engraved lines. Front and hind limbs are complete also they are most probably shaped by pinching. There is a little bump on the ventral part (Sexual characteristic?). Buttocks are pronounced. Not fine clay, chaff and small stone inclusion can be seen. Clay color is beige. (inventory number: K.64.73.02.218)
Type I Cattle Fig. 2.d	L: 4.1cm, H: 3.3cm, W: 1.9cm Handmade clay figurine. Polished. Almost complete. Surface is knotty. Horns are broken. Front limbs are not very distinctive or broken and right hind limb is broken. Slight soot on the surface. Triangular pinched face but nose looks like broken. Eyes are not indicated. Buttocks are slightly pronounced. Tail is long. The color of the broken parts is not clear, but it seems the color is same with the surface. Not fine clay, chaff and very small stone inclusion can be seen. Clay color is reddish beige. (inventory number: K.66.108.02.216)
Type I Cattle Fig. 2.e	L: 3cm, H: 3.2cm, W: 1.8cm Handmade clay figurine. Polished. Almost full. Horns are broken. Face is triangular pinched face. Eyes are not indicated. Tail is long. Front and hind limbs are complete. Soot on the surface. They are most probably shaped by pinching. Not fine clay, chaff and small stone inclusion can be seen. Clay color is brown beige. (inventory number: K.64.207.02.227)
Type I Cattle Fig. 2.b	L: 4.9cm, H: 3.1cm, W: 2.5cm Handmade clay figurine. Polished. Head is missing. Tail is long and indicated by grooves from both side. Front and hind limbs are complete also they are most probably shaped by pinching. Soot on the surface. Not fine clay, chaff and small stone inclusion can be seen. Clay color is reddish beige. (inventory number: K.64.71.02.220)

Tab. 1. Continued

Type I Cattle Fig. 2.h	L: 3.7cm, H: 2.3cm, W: 1.6-1.1-1.5cm Handmade clay figurine. Polished. Almost complete. Triangular pinched face. Horns are broken. Eyes are defined with little holes. It is one of the smallest in the whole group. Slight soot on the surface. Front and hind limbs are complete also they are most probably shaped by pinching. Right back limb is darker than the other parts. Tail is pronouncedly defined with a plastic ledge. Waist is quite thin. Not fine clay, chaff and small stone inclusion can be seen. Clay color is brown beige. (inventory number: K.65.50.02.219)
Type I Cattle Fig. 2.j	L: 6.6cm, H: 4.4cm, W: 2.1-1.4-1.8cm Handmade clay figurine. Well-Polished. Relatively elegant. Horns, two front limbs, left hind limb and tail are broken. Elongated body, neck and legs. Oil raku technique is possibly applied. Face is triangular pitched face. Eyes are not indicated. Tail is plastic and short. Not fine clay, chaff and small stone inclusion can be seen. Clay color is beige. (inventory number: K.66.219.02.223)
Type II Sheep/ Goat Fig. 3.a	L: 3.8cm, H: 3.0cm, W: 2.2cm Handmade clay figurine. Polished. Almost full. Horns, part of face, part of tail are broken. The deep line on the face suggests that its eyes might have been depicted with a single hole. Soot on the surface and broken parts. Front and hind limbs are almost complete also they are most probably shaped by pinching. Tails is short and probably shaped by pinching. Not fine clay, chaff and small stone inclusion can be seen. Clay color is reddish beige. (inventory number: K.64.74.02.230)
Type II Sheep/ Goat Fig. 3.e	L: 4.3cm, H: 2.9cm, W: 2.1cm Handmade clay figurine. Polished. Almost full. Broken in the middle (During excavation?). Horns or ears, face and left hind limb are broken. The deep line on the face suggests that its eyes might have been depicted with a single hole. Dorsal part is darker than ventral part. Limbs are most probably shaped by pinching. Tails is short and pointed. Forehead is stuffy. Limbs are most probably shaped by pinching. Not fine clay, chaff and small stone inclusion can be seen. Clay color is beige. (inventory number: K.66.110.02.232)
Type II Sheep/ Goat Fig. 3.f	L: 3.2cm, H: 2.7cm, W: 1.5cm Handmade clay figurine. Polished. Almost full. One of the smallest figurines. Face is triangular pinched face. Eyes are not indicated. Tail is small and short, most probably shaped by pinching and a little bit broken. Horns or ears are broken. If these are horns, they are going towards back side. There are two parallel engraved lines at the back of the head. Front and hind limbs are complete also they are most probably shaped by pinching. Not fine clay, chaff and small stone inclusion can be seen. Clay color is brown beige. (inventory number: K.66.117.02.224)
Type II Sheep/ Goat Fig. 3.c	L: 3.1cm, H: 2.6cm, W: 1.4cm Handmade clay figurine. Well-polished. Almost full. Horns or ears are broken. Face is triangular pinched face. Eyes are not indicated. Front and hind limbs are complete. They are most probably shaped by pinching. Tail is not indicated. Buttocks are slightly pronounced. Not fine clay, chaff and small stone inclusion can be seen. Clay color is reddish beige. (inventory number: K.66.112.02.226)
Type II Sheep/ Goat Fig. 3.d	L: 3.3cm, H: 1.9cm, W: 1.7cm Handmade clay figurine. Polished. Almost full. Head is broken. There is soot on the broken parts (Possible contact with fire after breakage). Limbs are full and looks like shaped with a tool. Not fine clay, chaff and small stone inclusion can be seen. Clay color is beige. (inventory number: K.64.76.02.233)
Type II Sheep/ Goat Fig. 3.b	L: 4.5cm, H: 3.8cm, W: 2.0cm Handmade clay figurine. Polished. Horns and face are broken. Tail is short and plastic. There is soot on the broken parts (Possible contact with fire after breakage). Right front and hind limb are broken. Buttocks are slightly pronounced. On the left side of the body there is a “T” shaped engraving (it is not known intentional or unintentional). Not fine clay, chaff and small stone inclusion can be seen. Clay color is beige. (inventory number: K.66.116.02.222)
Type II Ram? Fig. 3.g	L: 6cm, H: 3.4cm, W: 2.9cm Handmade clay figurine. Polished. Horns and face are broken. Tail is short and plastic. Soot on the surface and broken parts. Right front and hind limb are broken. Buttocks are slightly pronounced. On the left side of the body there is a “T” shaped engraving (it is not known intentional or unintentional). Not fine clay, chaff and small stone inclusion can be seen. Clay color is beige. (inventory number: K.65.8.02.231)

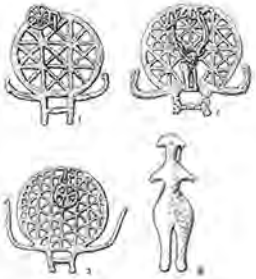
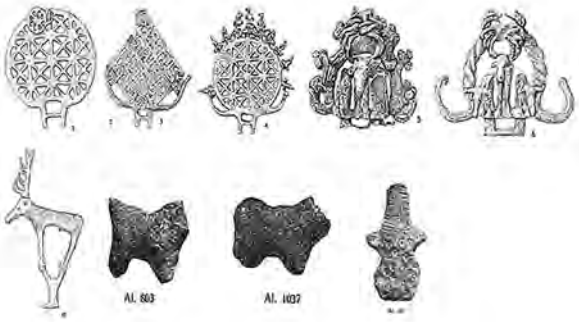
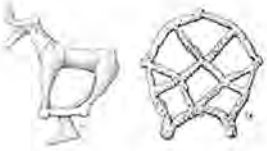
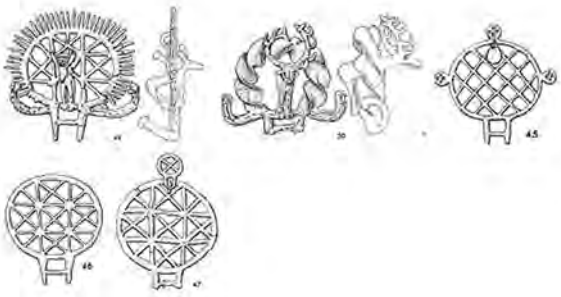
Tab. 1. Continued

Type III Wild Boar Fig. 4.a	L: 6cm, H: 3.4cm, W: 2.9cm Handmade clay figurine. Polished. Horns and face are broken. Tail is short and plastic. Soot on the surface and broken parts. Right front and hind limb are broken. Buttocks are slightly pronounced. On the left side of the body there is a "T" shaped engraving (it is not known intentional or unintentional). Not fine clay, chaff and small stone inclusion can be seen. Clay color is beige. (inventory number: K.64.77.02.229)
Type III Piglet Fig. 4.b	L: 4.9cm, H: 3.2cm, W: 1.3cm Handmade clay figurine. Well-polished. Right front and back limbs are broken. Also, there is a breakage on the right side of the body. Soot on the surface and broken parts. It has a small face with eyes defined with a single hole. There are two dots and under of them a curved line on the tip of the face thought as representations of nose and mouth. On the back of the eyes, there are dots which are circling the face. These dots are followed by a single line which is also circling the face. Whole body is covered with parallel lines from front to back. The space between these lines filled with dots (except dorsal part). Tail is slightly pointed and short. Under the tail there are two diagonal lines which are extends towards the back limbs and two rows of dots are filling the area between these lines. It seems like there is a slight line on the ventral part. Not fine clay, possible chaff inclusion, if there is stone inclusion it is not visible. Clay color is reddish beige. (inventory number: K.64.8?.02.221)
Type IV Bird Fig. 5	L: 4.0cm, H: 2.5cm, W: 1.4cm Handmade clay figurine. Well-polished. May not be an animal figurine. One end is bent downward and getting thin and the other end is shorter and bent upward. On the bottom part of there is a hole in the middle. Depth of the hole is 0.4cm. and diameter in 0.3cm. Not fine clay, chaff and small stone inclusion can be seen. Clay color is beige. (inventory number: K.66.204.02.228)

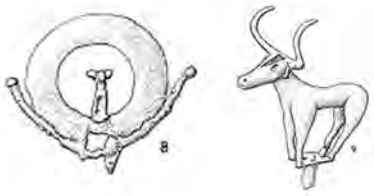
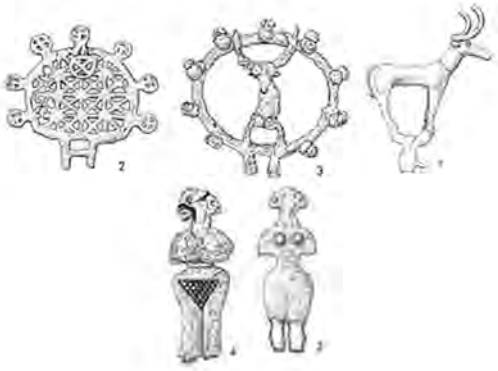
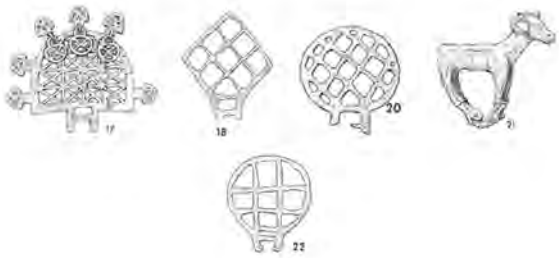
Tab. 2. Animal figurines from comparative EBA settlements.

Sites	Number of Zoomorphic figurines published or mentioned	Raw materials/types/contexts
Alişar *Von der Osten 1937; Schmidt 1932*	32	• 3 stone horned animal depictions with no spatial context info • 6 stone abstract animal depictions with no spatial context info • 1stone rabbit animal depiction with no spatial context info • 9 clay cattle depictions with no spatial context info • 9 sheep/goat depictions with no spatial context info • 3 clay unidentified animal depictions with no spatial context info • 1 clay dog (?)with no spatial context info
Ahlatlıbel *Koşay 1934*	5	• 1 clay sheep/goat depiction from child burial • 1 clay sheep/goat depiction with with no spatial context info • 1 clay cattle depiction with no spatial context info • 2 clay snake or bird depiction with no spatial context info
Alacahöyük *Koşay 1937; Gürsan-Salzmann 1992*	29	• 11 clay horned animal depictions with no spatial context info • 1 clay owl (?) depiction with no spatial context info • 1 clay rabbit (?) depiction with no spatial context info • 1 clay turtle (?) depiction with no spatial context info • 7 metal stag depictions found in the royal tombs • 8 metal cattle (probably bull) depictions found in the royal tombs
Çiledir *Türktüzün* et al. *2014*	2	• 2 clay sheep/goat depictions with no spatial context info
Demircihöyük *Baykal-Seeher, Obladen-Kauder 1996*	76 of 241 is published	• 42 clay cattle depictions from courtyard and front rooms of the houses • 17 clay sheep/goat depictions from courtyard and front rooms of the houses • 15 clay head and body fragment of horned animal depictions from courtyard and front rooms of the houses • 2 clay unidentified animal depictions from courtyard and front rooms of the houses (17 of them found in situ – 9 from storage bins and 8 from front rooms of houses)
Horoztepe *Özgüç, Akok 1958*	4 metal	
Höyüktepe *Sandalcı 2014*	4	• 1 clay cattle depiction with no spatial context info • 1 clay sheep/goat depictions with no spatial context info • 2 clay horned animal depictions with no spatial context info
Kalınkaya *Yıldırım, Zimmermann 2006*	2 metal	
Kanlıgeçit *Özdoğan* et al. *2012*	5	• 1 clay sheep/goat depiction with no spatial context info • 1 clay horn fragment of an animal depiction with no spatial context info • 2 clay bird depiction fragments with no spatial context info • 1 clay unidentified animal depiction with no spatial context info
Karaoğlan Mevkii *Topbaş* et al. *1998*	1	• 1 clay sheep/goat with no spatial context info
Küllüoba *Deniz, Ay 2006*	6	• 1 clay cattle depiction with no spatial context info • 5 clay sheep/goat depiction with no spatial context info
Seyitömer *Bilgen 2015*	15	• 14 clay horned animal depictions from fill deposits • 1 clay horned animal depictions from a room as in situ
Şarhöyük *Darga 1994*	2	• 2 clay sheep/goat depiction with no spatial context info
Troy *Blegen* et al. *1951a*	2	• 2 clay sheep/goat with no spatial context info

Tab. 3. Alacahöyük Royal Tombs in relation to sex, animal imagery bearing objects and other burial gifts (six sources have been used to construct this table, while the images have been gathered from the Herman Müller-Karpe (1974), the content of the burials have been written by comparing the information from Ayşe Gürsan-Salzman (1992), Nejat Bilgen (1993), and Hâmit Z. Koşay (1937; 1938; 1966).

Tomb name	Sex & # of individuals	# of artefacts & categories	Standards, statutes and figurines
Tomb A	Female 1 individual	2 ceramic vessels, 2 metal vessels, 8 hooks, 21 pins, 3 standards, 1 statuettes (stag), 14 borers, 3 barrettes, 1 mirror, 129 beads, 1 comb, 1 ring, 1 battle axe, 2 bracelets, 1 piece of textile, 1 diadem, 2 castanets	
Tomb A'	Male 1 individual	3 standards, 5 vessels, 3 knives, 1 hook, 1 mirror, 1 sword 828 sewn pieces, 1 diadem, 1 figurine, 1 barrette, 2 bracelets, 5 pins, 2 tubing, 1 statuette (stag)	
Tomb B	Male 1 individual	6 standards, 1 statuette (stag), 3 hooks, 1 diadem, 2 vessels, 2 handles, 1 mace head, 8 sheaths, 2 pins, 1 pair of earrings, 18 sewn ornaments, 2 earplugs, 331 beads, 3 bells, 3 figurines, 2 vessels, 10 sherds, 2 spindle whorls, 4 borers, 1 stamp seal	
Tomb C	Unidenfied 3 individual	3 standards, 1 dagger, 1 knife, 4 vessels, 5 sheats, 7 borers, 20 tubes for gold plating objects, 34 nails, 1 disc, 3 necklaces, 1 sewn piece	
Tomb D	Unidentified 1 individual	6 standards, 6 hooks, 1 statuette (bull), 1 diadem, 1 vessel, 1 dagger, 1 knife, 1 borer, 111 sewn pieces, 1 earplug, 2 necklaces and pieces from necklace, 1 spool, 99 nails	

Tab. 3. Continued

Tomb name	Sex & # of individuals	# of artefacts & categories	Standards, statutes and figurines
Tomb E	Unidentified 1 individual + 1 skull	3 standards, 2 hooks, 1 statuette (bull), 2 axes, 1 battle axe, 1 shield fragment, 2 sheaths, 2 arrowheads, 2 nails, 1 diadem, 33 sewn pieces, 1 pair of earrings, 28 stone beads,1 vessel, 1 sherd, 27 metal beads	
Tomb H	Female 1 individual	1 standard, 1 statuette (bull), 1 diadem, 10 vessels, 4 figurines, 4 bracelets, 6 necklaces , 1 comb, 30 pins, 1 hook, 2 sheaths, 2 balls, 2 maces,1 dagger, 176 sewn pieces/ornaments, 1 pendant, 7 pieces of plating, 8 castanets, 92 beads, 1 disc, 2 axes,1 knife	
Tomb K	Male 1 individual	9 vessels, 1 diadem, 2 mace, 2 mace heads, 3 mace handles, 4 pins, 2 daggers, 2 necklaces, 23 sewn pieces, 1 comb, 2 standards, 1 statuettes (bull), 2 borers, 1 hook, 1 sword, 2 bracelets, 3 discs,4 spindle whorls,1 adze, 1 earing, 3 belts,1 pair earplugs, 2 knives, 4 legs of furniture	
Tomb L	Female 1 individual	2 metal human figurine, 4 standards, 1 bull statuettes, 1 diadem, 2 vessels,1 barrette, 3 bracelets, 1 spindle whorl, 1 spoon, 1 pin, 2 earplugs, 2 sewn pieces, 4 hooks, 3 borers, 1 metal sheath, 3 necklaces, 5 buttons	
Tomb S	Unidentified 1 individual	1 sword, 1 standard (fragment), 6 hooks, 1 band/diadem, 1 vessel, 4 amulets/medallions, 6 earplugs, 2 sewn pieces, 14 beads, 1 pin head 8 tubing and plating pieces, 1 axe, 1 spindle whorl/bead, 9 awls	
Tomb T	Female 1 individual (Phase II)	4 standards, 6 hooks, 1 statuette (bull), fragments of vessel, 2 bells, 1 vessel, 9 sheaths, 2 daggers/spearheads, 8 pins, 14 tubes, 4 bracelets, 6 ringlets, 2 castanets, 606 beads, 10 bracelets, 1 diadem, 95 sewn pieces	
Tomb T'	Male 1 individual (Phase I)	1 vessel,7 pieces of plating, 6 bracelets, 3 spindle whorls, 5 knives, 1 polishing stone, 2 handles (ceramic vessel)	

Techno-typology and provenance of the obsidian chipped stones from Sofular Höyük, an Early Neolithic settlement near the Kızılırmak in Central Anatolia

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ABSTRACT - *Recent excavations at Sofular Höyük (Nevşehir, central Turkey) uncovered Aceramic Neolithic deposits dating to the late 9th and early 8th millennium cal BC and a lithic industry almost entirely made of obsidian. This study focuses on the techno-typology of this lithic assemblage and provides a first look at the material procurement strategies through geochemical characterization. Our results show that Sofular Höyük shares many general techno-typological features with contemporary sites in Central Anatolia, placing the settlement within the locally rooted traditions of the region, while the pXRF analysis of a selection of obsidian artefacts indicates the presence of two Cappadocian sources, namely Göllüdağ and Acıgöl.*

KEY WORDS – *Sofular Höyük; Early Holocene; Pre-Pottery Neolithic (PPN); lithic technology; obsidian sourcing*

Tehno-tipologija in izvor obsidianovih odbitkov iz Sofular Höyüka, zgodnje neolitskega naselja blizu Kızılırmaka v osrednji Anatoliji

IZVLEČEK – *Nedavna izkopavanja v Sofular Höyüku (Nevşehir, osrednja Turčija) so odkrila plasti predkeramičnega neolitika iz poznega 9. in zgodnjega 8. tisočletja pr. n. št., s kameno industrijo, ki je skoraj v celoti iz obsidiana. V študiji se osredotočamo na tehno-tipologijo kamenega zbira in s pomočjo geokemične določitve ponujamo prvi pogled na strategije oskrbovanja s surovinami. Rezultati analiz kažejo, da naselje Sofular Höyük deli mnoge osnovne tehno-tipološke značilnosti s sočasnimi najdišči v Centralni Anatoliji, kar ga umešča v lokalno zakoreninjene tradicije regije, vendar pXRF analiza izbranih artefaktov iz obsidiana kaže navzočnost dveh oskrbovalnih virov v Kapadokiji, Göllüdağ in Acıgöl.*

KLJUČNE BESEDE – *Sofular Höyük; zgodnji holocen; predkeramični neolitik (PPN); tehnologija kamenih orodij; pridobivanje obsidiana*

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Introduction

Sofular Höyük is a site near the modern city of Nevşehir in Central Anatolia (Turkey), close to the southern bend of the Kızılırmak River (Fig. 1). It is a small mound settled on a natural hill on the bank of a seasonal stream locally called Kışlacık, and lies above Miocene deposits containing vertebrate fossils which led to its discovery during a paleoanthropological survey project in 2011 (*Başoğlu* et al. *2014*). The site was notable for a dense scatter of worked obsidian, while other archaeological materials encountered during systematic surveys included numerous grinding stones but no ceramics (*Başoğlu* et al. *2018; Karakoç 2019*). Preliminary examinations of this lithic scatter indicated that Sofular might belong to an early stage of the Neolithic period, which would possibly represent the earliest farming community in the eastern part of the Cappadocian Volcanic Province. This prompted the initiation of archaeological excavations by a Turkish team under the leadership of Okşan Başoğlu, which lasted from 2016 to 2019 (*Başoğlu 2022; Başoğlu* et al. *2018; Güngördü, Başoğlu 2018; 2019; Karakoç 2019*) and continued in a small area in 2021.

These excavations have revealed the presence of an Aceramic Neolithic settlement in Sofular (*Başoğlu* et al. *2018*). In addition, it is now known that the mound was used as a cemetery in the Ottoman era, which seriously disturbed the underlying occupation layers. Illicit digging had also destroyed parts of the mound prior to the archaeological excavations, sometimes down to the lowest levels. These interferences with the prehistoric deposits, unfortunately, impede the stratigraphical and chronological correlation of the architectural remains and the various small finds encountered, including chipped stone artefacts, and at the moment prevent a better understanding of the original spatiotemporal patterns left behind by the inhabitants of the mound (*Güngördü, Başoğlu 2019*). Nevertheless, it is possible to observe remnants of mudbrick walls that probably belonged to domestic buildings. They appear to be closely built with no streets in between, a pattern that is familiar from numerous Neolithic sites in Central Anatolia such as Aşıklı Höyük (*Özbaşaran* et al. *2018*), Musular (*Özbaşaran* et al. *2012*), Çatalhöyük (*Hodder, Cessford 2004*) and Sırçalıtepe (*Balcı* et al. *2021; 2022*). Excavated finds from various trenches include botanical and faunal

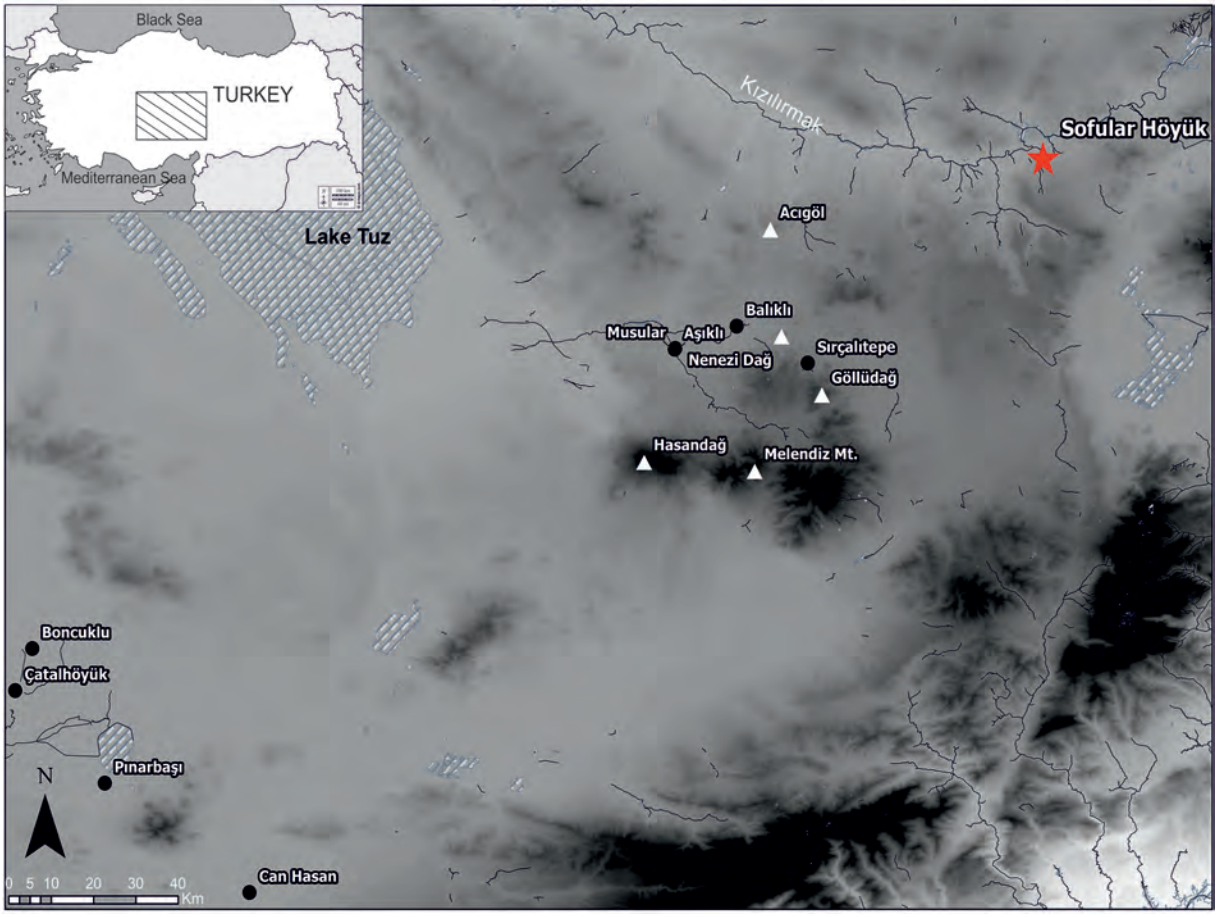

Fig. 1. Map showing the location of the study area, obsidian sources, and the sites mentioned in the text.

remains, bone and stone implements, beads and pendants in different forms, grinding stones, pestles, and polished axes (*Başoğlu* et al. *2018*). A particular concentration of such materials was found between the two trenches L10 and L11, with ashy areas that are likely refuse dumps. Finally, an important component of the Sofular assemblage is the rich chipped stone industry, predominantly made on obsidian, which forms the focus of this study.

Radiocarbon samples analysed from Sofular Höyük are summarized in Table 1. Four calibrated dates on charcoal and animal bone agree on an interval of *c.* 7800–7600 BC, and another charcoal sample falls within *c.* 8200–7800 BC. Meanwhile, direct dating of one of the burials in the overlying cemetery indicates a Late Medieval/Early Modern age, corresponding to a period when the region was under Ottoman control.

Even though the eastern periphery of south-central Anatolia where Sofular Höyük is located is not well known and Neolithic sites with comparable dates are lacking, the rest of the region contains a rich and well-investigated Early Neolithic record that forms the basis of comparisons for the finds recovered from this settlement (*Başoğlu* et al. *2018*). Archaeological excavation projects in sites such as Aşıklı Höyük (*Özbaşaran* et al. *2018*) and Musular (*Özbaşaran* et al. *2012*) in Cappadocia, and Boncuklu (*Baird* et al. *2012*) and Pınarbaşı (*Baird 2012*) in the Konya Plain have pushed Central Anatolia to prominence within Early Neolithic research in Southwest Asia. It has been demonstrated that plants were cultivated by sedentary/semi-sedentary communities in the Konya Plain and Cappadocia as early as the 9th millennium cal BC (*Asouti, Fairbairn 2002.184*; *Baird* et al. *2018*). The same millennium also saw the emergence of (wild) caprine management strategies in Aşıklı Höyük, ultimately resulting in domesticated breeds (*Stiner* et al. *2022*). The dominantly local character of these developments was confirmed by recent analyses on ancient human DNA, whereby it was seen that the early farmers of Central Anatolia descended mainly from local populations that inhabited the region in the Epipalaeolithic (*Aydoğan* et al. *in press*).

The techno-typological analyses of chipped stones form another component of research. Unlike the periods that came after the initial emergence of farming societies in Southwest Asia, the general lack of ceramics from the Epipalaeolithic and Early Neolithic forces a focus on lithic materials recovered from excavation and survey projects to better understand regional developments (*Balkan-Atlı1994*; *Balkan-Atlı, Binder 2003; 2012*; *Carter, Milić 2013*; *Carter, Shackley 2007*; *Kayacan 2003*; *Yıldırım-Balcı 2011a*). In the same way, the analysis of chipped stone assemblages has been one of the main targets of archaeological research in Central Anatolia to better understand the causes and mechanisms at work at the origin of farming in this region (*Binder 2002.85*). One advantage of the south-central Anatolian plateau in this regard is its proximity to sources of obsidian, which is a suitable raw material for making stone tools. Cappadocia in Central Anatolia is quite rich in obsidian deposits due to relatively recent episodes of rhyolitic volcanism (*Mouralis* et al. *2019*), and it is possible to distinguish between different sources using geochemical analyses (*Poidevin 1998*). The most extensively exploited outcrops in prehistory are known from Göllüdağ, Nenezi Dağ, and Acıgöl in this region (*Binder* et al. *2011; Chataigner 1998; Poupeau* et al. *2010*). Although its use took place over a considerable time interval from the Palaeolithic to the Bronze Age, sometimes at a great distance from the sources themselves (*Frahm, Hauck 2017; Frahm, Tryon 2019; Mouralis* et al. *2018; Slimak* et al. *2007*), the most widespread use of Cappadocian obsidian occurred in the context of ear-

Lab ID	Material	Context	$\delta^{13}C$	^{14}C age BP	cal BC
TÜBİTAK-0179 (Sofular #2)	Charcoal	Trench L11 Hearth 2	-26.4±0.6	8735±29	7940-7894 (8.7%) 7863-7852 (1.3%) 7842-7603 (85.5%)
TÜBİTAK-0180 (Sofular #3)	Charcoal	Trench L10 Fill	-25.2±1.8	8858±47	8225-7792 (95.4%)
TÜBİTAK-0181 (Sofular #4)	Charcoal	Trench L10 Hearth 1	-23.3±0.8	8740±29	7941-7894 (10.5%) 7864-7605 (85.0%)
TÜBİTAK-0182 (Sofular #5)	Charcoal	Trench L10 Hearth 1	-26.5±0.4	8716±28	7933-7918 (1.6%) 7821-7599 (93.9%)
TÜBİTAK-0183 (Sofular #10)	Bone (animal, burnt)	Trench L10 Discard area	-18.0±0.8	8720±39	7940-7894 (6.8%) 7862-7852 (1.0%) 7842-7598 (87.7%)
TÜBİTAK-0186 (Sofular #6)	Bone (human)	Trench L11 Burial 8	-17.8±0.6	326±25	1489-1640 AD (95.4%)

Tab. 1. Radiocarbon dates from Sofular Höyük. Calibrated with OxCal v. 4.4.4 (*Bronk Ramsey 2009*) using IntCal20 (*Reimer *et al.* 2020*).

ly farming societies in Southwest Asia, when it was embedded in far-reaching exchange networks that ranged from the Aegean to the Southern Levant (*Carter* et al. *2020; Ibáñez* et al. *2016; Milić 2014*). However, Cappadocian obsidian was already present in the Epipalaeolithic layers of Öküzini (near the southern coast of Turkey in Antalya) (*Carter* et al. *2011*) when, at broadly the same time, Natufian sites in the Levant were procuring obsidian from Göllüdağ (*Akkermans, Schwartz 2003.82; Khalaily, Valla 2013.197–98*). More locally, Epipalaeolithic occupants of Pınarbaşı also used obsidian to manufacture chipped stone implements (*Pirie 2011*). Communities in Central Anatolia kept utilizing the Cappadocian sources during the following Aceramic Neolithic period. Göllüdağ and Nenezi Dağ were intensively exploited to make stone tools at many sites near these sources, including Aşıklı Höyük (*Kayacan, Altınbilek-Algül 2018*), Musular (*Kayacan, Özbasaran 2007*), and Sırçalıtepe (*Balcı* et al. *2021*). Some of these communities might have been supplied directly from specialized workshops in the close vicinity of the outcrops themselves (*Balkan-Atlı, Binder 2012*). Further west in the Konya Plain, approximately 150 to 190km from the outcrops, the same trend continued: Boncuklu Höyük (*Muller* et al. *2018.724*), Can Hasan III (*Ataman 1988*), Neolithic Pınarbaşı (*Baird 2012.201*), and Çatalhöyük (*Carter* et al. *2005; 2006; Carter, Milić 2013*) appear to have relied heavily on Central Anatolian obsidians, sometimes complemented with more local raw materials.

While it is thus possible to map the southern and western distribution of Central Anatolian obsidians with some confidence, the same cannot be said about the north-eastern portion of the Anatolian plateau – at least partly due to the general paucity of evidence from north-central Anatolia (*Düring 2008*). The location of Sofular Höyük is critical in this context, as it lies along a tributary of the Kızılırmak River, to the northeast of Cappadocian sources (Fig. 1). It is approximately 40km from Acıgöl and about 60km from Göllüdağ and Nenezi Dağ. As a newly discovered contemporary of the Central Anatolian Early Neolithic, Sofular Höyük presents a good opportunity to investigate the dynamics of lithic procurement and manufacture and to shed light on a relatively less-known part of the region. To this end, we present here the results of the techno-typological examination of over four thousand chipped stone artefacts, almost all of them obsidian, excavated between 2016 and 2018 in Sofular. This is accompanied by a preliminary investigation into the raw material preferences in the site using portable X-ray fluorescence.

Materials and methods

Excavations at Sofular Höyük between 2016 and 2018 uncovered a total of 4860 chipped stone artefacts from three different trenches and surface deposits. Lithic artefacts are concentrated near the mudbrick walls and around the large ashy zone between trenches L10 and L11, with numerous chipped stone debris, blade segments, flake fragments, and broken tool pieces, hinting at possible discard zones. Sediments from the excavation were dry sifted using 1, 3, and 5mm sieves to recover debris and other by-products smaller than 1cm.

The chipped stone assemblage, mainly consisting of blade and flake tools, is dominated by obsidian (Tab. 2). Other raw materials like basalt, chert, quartz, and quartzite are present but very rare (less than 1%). Basalt was modified only to serve as heavy-duty tools (Fig. 2). The assemblage does not include any tools made on chert, but there are a few pounded pieces and possible percussion fragments found at different levels and the surface of the site. Some quartz and quartzite pieces were modified into ornaments such as beads and pendants (Fig. 3).

	Obsidian	Chert	Other	Basalt	Total
Blades	1985	0	0	0	1985
Flakes	868	1	2	12	883
Chips and chunks	1823	7	0	0	1830
Core trimming elements	108	0	0	0	108
Cores	49	0	3	0	52
Spalls	2	0	0	0	2
Total	4835	8	5	12	4860
Retouched	1076	0	0	7	1083
Microburins	350	0	0	0	350

Tab. 2. Raw materials in the chipped stone assemblage from Sofular Höyük.

With a total of 4835 pieces and making up an overwhelming proportion of the assemblage (99.5%), obsidian forms the focus of our investigations. To better understand the use of this raw material by the inhabitants of Sofular Höyük, the assemblage was first subjected to a techno-typological examination. The typology of the blanks was defined to

classify them either as flakes or blades, and then characterized into further tool types like scrapers, burins, and borers. Complementing these typological investigations are the technological examinations to describe the tool-making techniques, core reduction stages, and retouching patterns on the tools, with the overall aim of understanding the lithic 'operational sequences' (*chaîne opératoir*es). While defining the blanks in the assemblage we did not discriminate between 'blades' and 'bladelets', and instead described all laminar products as blades.

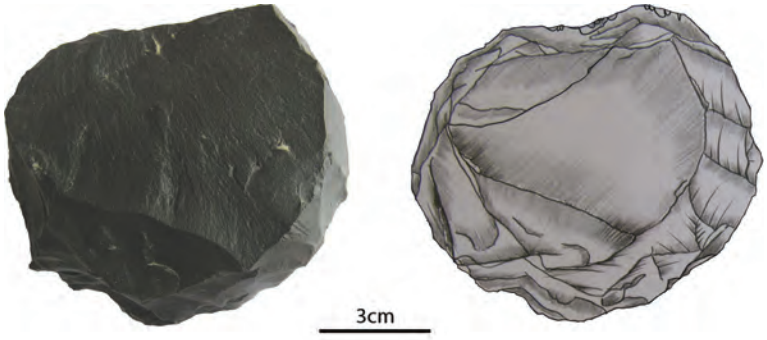

Fig. 2. Basalt heavy-duty tool.

Procuring raw materials is a critical part of any operational sequence in lithic production. As mentioned, most chipped stone finds in Sofular Höyük are made of obsidian, a raw material that readily lends itself to geochemical provenance analyses. As a preliminary to further investigations, eight visual groups were determined based on the colour and texture of the obsidian artefacts in Sofular: (1) transparent greyish-black, (2) transparent striped smoky greyish-black, (3) transparent smoky greyish-black, 4) opaque reddish with black speckles, (5) semi-transparent and very smoky greyish-black, sometimes with white spots, (6) semi-transparent greyish-green, sometimes striped, (7) semi-transparent and very smoky bluish-black, (8) opaque reddish-brown with extensive black speckles (*cf. Fujii 1995; Kayacan, Altınbilek-Algül 2018; Kayacan, Özbaşaran 2007; Milić* et al. *2013.App. 21.1; Yıldırım-Balcı 2007*) (Fig. 4, Tab. 3). Categorized in this way, it is seen that the Sofular assemblage mostly comprises transparent (glassy) or translucent greyish/bluish-black obsidians (visual groups 1, 2, 3, 5, and 7), together with small amounts of greenish-grey and reddish/reddish-brown specimens (visual groups 4, 6, and 8). It is worth noting that the reddish/reddish-brown obsidians are primarily retrieved from the lower levels of the mound.

Fig. 3. Various raw materials:* 1,2 *cores,* 3 *flake, and* 4 *pendant.

Early results of prior investigations into the obsidian sources represented in Sofular have previously been reported (*Karakoç 2019.69–87*), but unfortunately none of these analyses were finalized or published. As a part of a new programme of obsidian characterization, a total of 63 artefacts were selected in this study to be analysed chemically. The main concern that directed our sampling strategy was the representation of all eight visual groups. Objects from different size categories were also included within each sub-group when possible. It must be emphasized that such a limited sample can only allow an exploratory survey, both in terms of the proportion of total obsidian objects examined and as a selection based on macroscopic properties, since it is not possible to securely differentiate between obsidian sources around the Mediterranean based solely on visual criteria (*Williams-Thorpe 1995. Tab. 2*). It is hard to be certain how well any given visual category captures a chemically homogenous group, exacerbated by the difficulties in ensuring the replicability of different visual groups compiled by different researchers: variation might be expected between observations made under different lighting conditions, or simply because of the size and geometry of the objects. Nevertheless, the analysis of our sample forms a cross-cutting basis to probe into the variety of obsidian sources used in Sofular Höyük, pending a more comprehensive and contextual investigation of the assemblage together with the clarification of the stratigraphic relations between the different excavated deposits.

Selected artefacts were analysed through non-destructive X-ray fluorescence (XRF) spectroscopy. Although different techniques are available for ob-

taining compositional profiles (*Gratuze 1998*), it is the concentrations of mid-Z elements from Rb to Nb that are most frequently used to differentiate between the obsidian sources utilized in Southwest Asia, when necessary supplanted with elements like Ti, Mn, Fe, Zn, Ga, Ba, Pb (*Campbell, Healey 2016; Carter* et al. *2023; Frahm, Carolus 2022; Mouralis* et al. *2018; Orange* et al. *2013*). The portable XRF (pXRF) system used in this study is a Hitachi X-MET8000 Expert Geo device that allows the detection of such major and trace elements with a resolution that permits the discrimination of different sources (*Gemici* et al. *2022*).

Fig. 4. Representative samples from the eight visual groups of obsidian.

Analyses were conducted in REE-FP mode, in which two beams (50kV-15μA and 15 kV-20μA) alternately sweep the objects. Artefacts were analysed on their flattest sides, using a standard measurement time of 60 seconds. The 63 Sofular artefacts analysed form a heterogeneous group in terms of their morphology, ranging from very small, planar pieces to large and amorphous specimens. The vertical dimension of each sample as it was positioned on the pXRF screen was thus recorded as a proxy of the thickness available for X-ray penetration, and together with the weight of the artefacts, provides a control against possible anomalies caused by size and morphology. Both sample thickness and instrumental calibration are known to affect the results obtained by pXRF measurements, but the use of elemental fractions prevents their interference with geological source assignment (*Frahm 2016; Gemici* et al. *2022*) and forms the basis of our comparisons with published elemental data to identify the obsidian sources represented among the sample from Sofular Höyük.

Results

Obsidian sources

At first glance, elemental results from the 63 Sofular artefacts indicate the presence of both a low-Sr and a high-Sr component that cuts across the identified visual groups and various thickness thresholds (Tab. 4, see below). Plotting Nb against Rb, normalized by Zr, verifies this separation, and further divides the high-Sr group (filled triangles in Fig. 5) into three (Fig. 5. a). The presence of four distinct groups is further supported by the bivariate ratio plot of Ti/Mn vs. Zn/Ga (Fig. 5.b), which also makes the outliers of the low-Sr group (empty triangles in Fig. 5) more visible. Two of the three high-Sr groups are represented by single artefacts among the analysed samples, and three measurements from each of these two artefacts were taken (and plotted) to rule out possible anomalous readings and to confirm their separation from other groups.

The same fourfold separation of Sofular artefacts is affirmed on the ternary graph of Rb, Sr, and Zr (Fig. 6). Plotted on the same diagram with Sofular samples are the data from published literature, selected so as to include different compositional analysis techniques such as XRF, ICP-MS (inductively coupled plasma mass spectrometry), NAA (neutron activation analysis), and PIXE (proton-induced X-ray emission). They contain Central Anatolian obsidians (which form the geographically closest sources of obsidian to Sofular Höyük), 'Galatian' obsidians from Northwest

Visual group	Surface	Trench L11	Trench L10	Trench K10	Total
1	821	1320	801	222	3164
2	246	47	94	12	399
3	176	168	103	20	467
4	4	0	1	0	5
5	68	216	52	19	355
6	53	93	34	7	187
7	31	166	48	11	256
8	0	1	1	0	2
Total	1399	2011	1134	291	4835

Tab. 3. Distribution of Sofular Höyük obsidians with respect to the visual groups used in this study.

Anatolia (at an intermediate distance, though apparently used only locally; *Milić 2016.75*), and the numerous obsidian sources of Southeast Anatolia (more distant but known to have reached Central Anatolia during the Ceramic Neolithic; *Carter* et al. *2008*). Despite this variety of available resources, the analysed Sofular artefacts are seen to align exclusively with the Central Anatolian sources (Fig. 6).

The published Central Anatolian data taken into consideration here agree well on the elemental ratios of Rb, Sr, and Zr for the major sources in the region and also the main sub-groups that can be detected within these sources, even though these analyses were conducted by different researchers using a variety of techniques (EDXRF, NAA, ICP-MS, PIXE) which sometimes exhibit differences in raw concentrations (Tab. 5, see below). An inspection of the elemental ratios of Rb, Sr, and Zr indicates that the four groups identified through pXRF analyses in Sofular Höyük fit comfortably into the Göllüdağ and Acıgöl sources (Tab. 5), a pattern also confirmed by a bivariate ratio plot of Sr/Rb vs. Zr/Rb using the same comparative dataset (Fig. 7) (*cf. Healey 2022.Fig. 2*). Specifically, among the Göllüdağ artefacts identified in Sofular (n=49), all except one cluster with the eastern outcrops (Göllüdağ East) while the other maps onto the western outcrops (Göllüdağ West, in particular Göllüdağ 2) as identified by Didier Binder et al. (*2011*). One outlier within the Göllüdağ East group remains noticeable (SOF 088), though it is not clear whether this is caused by the extreme size of the artefact (one of the smallest in both thickness and weight among the analysed samples), or the high chemical diversity naturally present within the Göllüdağ East complex (*Binder* et al. *2011*) (or a combination of both). Acıgöl artefacts (n=14), meanwhile, originate from the higher-Sr outcrops in the east ante-caldera dome (Acıgöl EAAC) as defined by Jean-Louis Poidevin (*1998.Fig. 7*). All of this group can be attributed to EAAC 2 except one, which clusters with EAAC 1 (both as defined by *Gratuze 1999*). Table 6 provides summary statistics of these obsidian groups identified in Sofular Höyük.

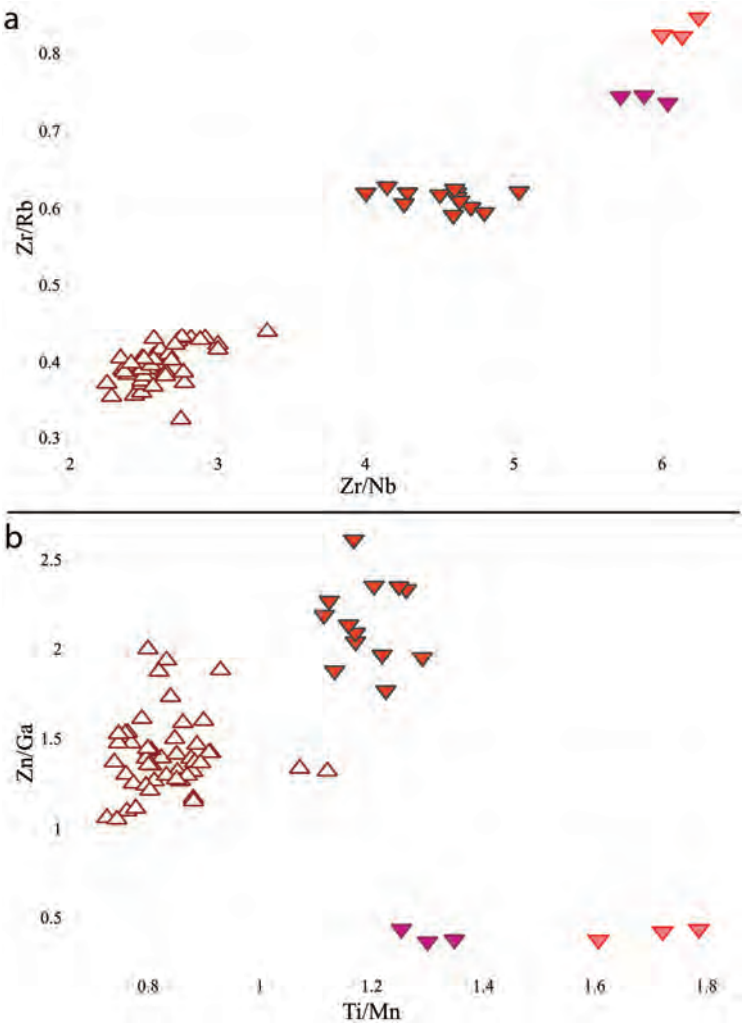

Fig. 5. Bivariate ratio plot of (a) Zr/Nb vs. Zr/Rb and (b) Ti/Mn vs. Zn/Ga showing the internal grouping of the analysed Sofular artefacts. Empty triangles correspond to the low-Sr group while filled triangles correspond to the three high-Sr groups. Note that two of these three high-Sr groups are represented by single artefacts and three measurements from each are presented here.

Surprisingly, Nenezi Dağ, which lies at a comparable distance from Sofular Höyük (Fig. 1), is not represented in the analysed assemblage.

Despite the visual variety represented (Fig. 4), it is seen that the analysed artefacts from Sofular Höyük can be confined within two spatially restricted geological complexes. Source assignments cross-cut the visual groups identified, as both Göllüdağ and Acıgöl artefacts can be found in visual groups 1, 4, and 6. At the same time, visual groups 2, 3, 5, and 7 remain exclusive to Göllüdağ East, which dominates with 48 out of 63 artefacts assigned to it. However, it is not yet possible to generalize this proportion to the rest of the obsidian assemblage due to the nature of the sampling strategy employed. One curiosity is

the reddish/reddish-brown obsidians (visual groups 4 and 8 in this study), also attested in the earlier levels of the broadly contemporary Aşıklı Höyük (*Kayacan, Altınbilek-Algül 2018.Fig. 2)* and encountered among various surface collections in the broader region (*Duru, Kayacan 2018*). Three such samples from Sofular Höyük analysed in this study cluster together with the more familiar-looking obsidians from Acıgöl EAAC 2, and a fourth comprises the single Acıgöl EAAC 1 artefact among the analysed samples. In addition, one reddish obsidian was brought from Göllüdağ West and is likewise the sole representative of its chemical group among the 63 analysed artefacts. These five reddish/reddish-brown specimens include blanks, debris and one core, and none were turned into tools (Tab. 4). In fact, only one tool among the analysed samples can be attributed to Acıgöl (1/14, 7%), while this number is significantly higher for Göllüdağ (25/49, 51%) (Tab. 4). Any such techno-typological pattern remains to be confirmed by future analyses.

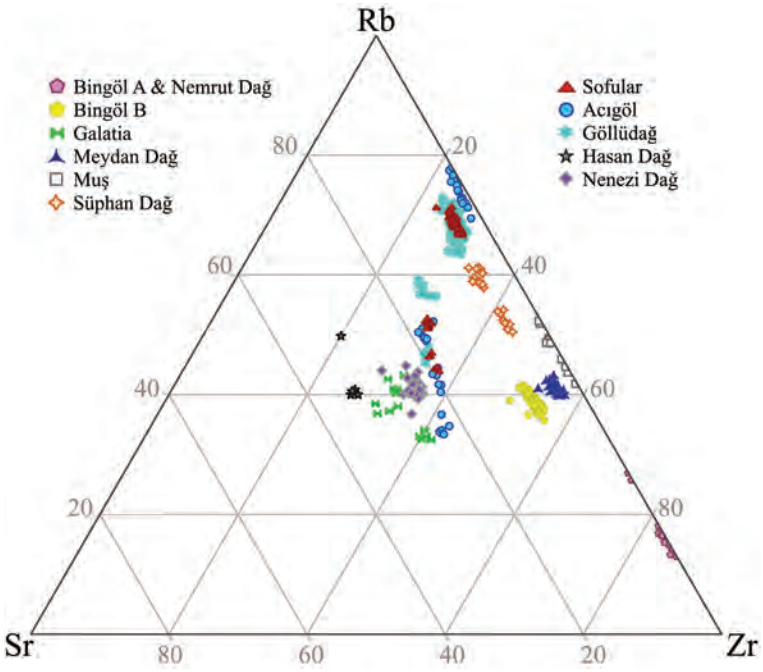

Fig. 6. Relative concentrations of Rb, Sr, and Zr for the analysed Sofular artefacts together with published elemental data from Central, Northwest, and Southeast Anatolian sources. Bingöl A & Nemrut Dağ (*Gratuze 1999; Kobayashi, Mochizuki 2007; Orange *et al.* 2021; Poupeau *et al.* 2010). *Bingöl B (*Frahm, Carolus 2022; Gratuze 1999; Orange *et al.* 2021; Poupeau *et al.* 2010). *Galatia (*Gratuze 1999; Keller *et al.* 1996; Oddone *et al.* 1997; Poupeau *et al.* 2010). *Meydan Dağ (*Chataigner, Gratuze 2014; Frahm, Carolus 2022; Kobayashi, Mochizuki 2007; Orange *et al.* 2021; Poupeau *et al.* 2010). *Muş (*Chataigner *et al.* 2014; Kobayashi, Mochizuki 2007; Orange *et al.* 2021; Poupeau *et al.* 2010). *Süphan Dağ (*Chataigner, Gratuze 2014; Kobayashi, Mochizuki 2007; Orange *et al.* 2021; Poupeau *et al.* 2010). *Refer to Table 5 for the surveyed publications pertaining to Central Anatolian sources.

Technology

The inhabitants of Sofular acquired obsidian from the sources as preforms (Fig. 8), at a distance of more than 40km on foot. The weights of the longest preforms range between 800 and 900g, but the average weight of all preforms is 600g, and none are longer than 15cm. The preforms were likely suitable for reducing blade cores with single or double striking platforms after a short preparation. Besides preforms, the assemblage includes cores and core fragments, cortical flakes and lateral blades, core trimming elements such as natural and crested blades, debris smaller than 1cm, and other by-products, thus presenting evidence for every stage of an operational sequence at the settlement itself. Even though the overall number of reddish/reddish-brown obsidians is low, no major difference is apparent with the darker coloured obsidians in this regard. As mentioned above, both Göllüdağ and Acıgöl seem to have supplied reddish/reddish-brown obsidians together with darker variants to Sofular Höyük, though there might have been differences in their use and the meanings ascribed to them.

The industry includes 49 cores and core fragments, representing about 1% of the whole assemblage (Tab. 7). It is possible to define two distinctive blade core types: single-striking platform cores and double-striking platform cores. Single-platform cores are more common in deposits uncovered at the lowest levels, and their sizes are smaller than the others (Fig. 9.3). Such cores have flat striking platforms visibly inclined towards the back. Platforms were prepared by removing a single wide flake, and these platforms sometimes exhibit abrasions or small flake/chip scars on their edges. The dorsal sides are cortical, as the knappers generally reduced the preforms along only one knapping surface. However, some single-striking platform cores also have extraction scars at their distal ends, probably related to controlling the shape of the primary blade blanks. These cores can nevertheless be defined as unidirectional. Such cores are typical in the earliest levels of Aşıklı Höyük (*Kayacan, Altın-*

bilek-Algül 2018). Single-striking platform (unipolar) blade cores are also represented in Göllüdağ obsidian workshops such as Kayırlı-Bitlikeler and Kömürcü-Kaletepe (*Balkan-Atlı* et al. *2008; Cauvin, Balkan-Atlı 1996*). The samples in Kayırlı are defined as pyramidal unipolar blade cores with a natural or flat back, while Kömürcü-Kaletepe mainly provides typical unidirectional blade cores modified from bifacial preforms. On the other hand, pressure reduced single-platform prismatic blade cores of Kömürcü-Kaletepe (*Balkan-Atlı* et al. *2008.206*) are not represented in Sofular.

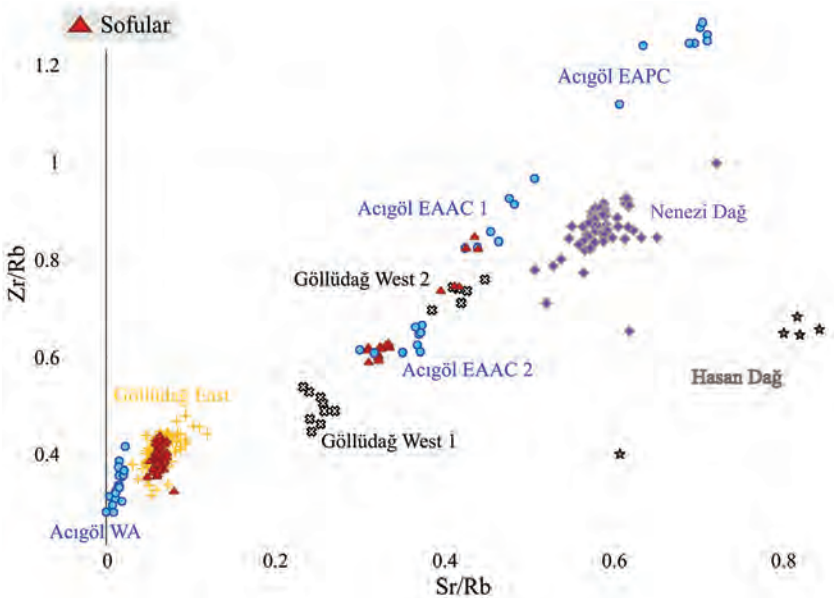

Fig. 7. Bivariate ratio plot of Sr/Rb vs. Zr/Rb for the analysed Sofular artefacts together with published elemental data from Central Anatolian sources. Refer to Table 5 for the surveyed publications.

Double-striking platform cores in Sofular (Fig. 9.1,2) were mostly recovered from the mound's upper levels and the topsoil. These have two opposite platforms, and removals on their first knapping surfaces are bidirectional. Their dorsal sides are typically natural, but they can also feature a crested section. Since these cores have one knapping surface, their exhausted forms are generally flat, and the opposite platforms are narrow. Similar cores are encountered in the upper levels at Aşıklı (*Yıldırım-Balcı 2011a*; *Kayacan, Altınbilek-Algül 2018*), Musular (*Kayacan 2003*), Sırçalıtepe (*Balcı* et al. *2021; 2022*), as well as Kayırlı-Bitlikeler (*Cauvin, Balkan-Atlı 1996*). Meanwhile, the bidirectional ('naviform') cores at Kömürcü-Kaletepe are aimed at ob-

	n	Rb	Sr	Y	Zr	Nb	Ti	Mn	Ga	Zn	
Göllüdağ East	48	222.8	14.0	25.0	87.8	34.0	487.6	586.2	18.6	25.9	**MEAN**
		22.2	1.8	3.3	9.6	4.1	48.3	49.5	2.4	3.1	**ST.DEV.**
		10.0%	13.0%	13.4%	10.9%	12.0%	9.9%	8.4%	12.9%	11.8%	**RSD**
> 3 mm	28	225.8	14.1	25.8	88.9	35.2	491.5	589.1	18.9	26.0	**MEAN**
		17.0	1.7	2.8	7.9	3.2	45.3	32.3	2.6	2.8	**ST.DEV.**
		7.5%	12.4%	10.8%	8.8%	9.0%	9.2%	5.5%	13.6%	10.8%	**RSD**
Göllüdağ West 2	1*	198.0	80.7	23.3	147.0	25.0	766.0	589.0	54.3	21.3	**MEAN**
		6.6	0.6	0.6	4.0	0.0	16.5	12.1	5.5	0.6	**ST.DEV.**
		3.3%	0.7%	2.5%	2.7%	0.0%	2.1%	2.1%	10.1%	2.7%	**RSD**
Acıgöl EAAC 1	1*	167.0	72.3	23.0	139.0	22.7	744.3	436.3	44.3	18.3	**MEAN**
		8.9	4.5	2.6	9.6	1.2	77.4	35.9	4.0	2.3	**ST.DEV.**
		5.3%	6.2%	11.5%	6.9%	5.1%	10.4%	8.2%	9.1%	12.6%	**RSD**
Acıgöl EAAC 2	13	235.2	75.7	29.5	144.2	32.0	665.2	558.7	22.5	47.8	**MEAN**
		33.8	11.1	4.3	21.5	4.9	77.0	65.2	4.0	6.1	**ST.DEV.**
		14.3%	14.7%	14.4%	14.9%	15.4%	11.6%	11.7%	17.5%	12.8%	**RSD**
> 3 mm	5	228.8	73.4	28.8	140.8	31.8	662.0	543.2	22.4	45.8	**MEAN**
		8.4	2.7	1.6	3.3	1.7	24.9	17.8	2.0	1.5	**ST.DEV.**
		3.7%	3.6%	5.6%	2.4%	5.4%	3.8%	3.3%	8.7%	3.2%	**RSD**
	**Average of three measurements*										

Tab. 6. Elemental statistics of the groups identified among the analysed Sofular Höyük obsidians (concentrations in ppm).

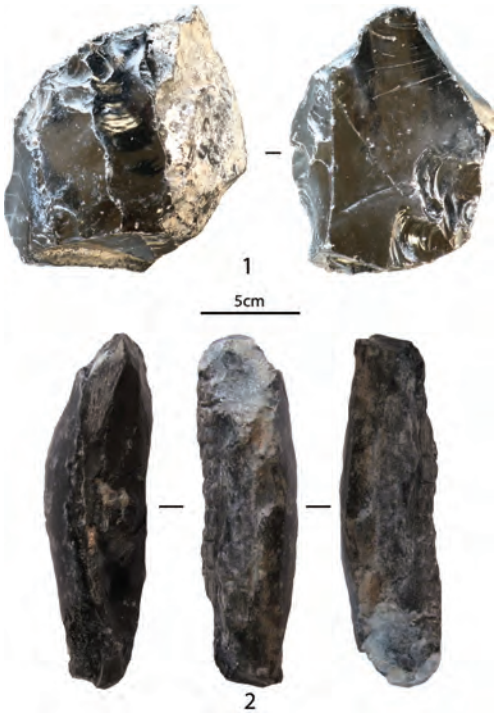

Fig. 8. Obsidian preforms.

taining regular pointed blades with trapezoid basal and triangular distal sections and are distinct from the opposed-platform cores recovered from Sofular and other Central Anatolian sites (*Balkan-Atlı* et al. *2008*; *Balkan-Atlı, Binder 2012*).

The average dimensions of the blade cores are 41.7 x26.3x17.3mm, with a maximum length of 7cm and a minimum of 3cm. Unlike the blade cores, informal and flake cores have smaller dimensions and were knapped until exhausted. The latter are rare at Sofular, with only a few recorded instances. Although most are multidirectional flake cores, there are some unipolar and bidirectional examples. Similar flake cores were also recovered from Aşıklı Höyük (*Yıldırım-Balcı 2011a*). These likely represent a recycling of exhausted blade cores at both Aşıklı Höyük (*Kayacan, Altınbilek-Algül 2018.371*) and Sofular.

Categories	Retouched	Total	%
Blades	674	1985	41.1%
Flakes	367	868	18.0%
Chips and chunks	1	1823	37.7%
Core trimming elements	33	110	2.3%
Cores	1	49	1.0%
Total	1076	4835	100.0%

Tab. 7. Technological distribution of the obsidian assemblage from Sofular Höyük.

Blade blanks are the dominant products in the assemblage, comprising 41% of the entire collection and 66% of all blanks. Most are broken pieces, consisting of proximal, medial, and distal segments. The abundance of proximal blade segments (33%) in the lower levels might have resulted from a more intensive application of the microburin technique, as numerous microburin pieces are attested among the materials from the lowest levels of the ashy deposits and in the areas between the trenches L10 and L11. The striking platforms of the blades are straight or linear, and some exhibit traces of platform edge preparation. Scars on the dorsal faces of the blades are unidirectional (62%) or bidirectional (37%). Noticeable and expanded bulbs and irregular dorsal scars indicate that they were knapped by direct percussion.

We cannot talk conclusively about the initial sizes of all the blades, as most of them are represented by broken blade segments. It is, however, possible to observe some variation in the dimensions of the unbroken specimens (Tab. 8). These values are relatively small compared to the blade blanks at sites such as Aşıklı Höyük (*Yıldırım-Balcı 2007; 2011a*) and nearby Musular (*Yıldırım-Balcı 2007.382–390*). At the same time, a 9cm central blade blank without a distal tip is conspicuous among the Sofular lithics. It is the longest and thickest blade blank in the assemblage

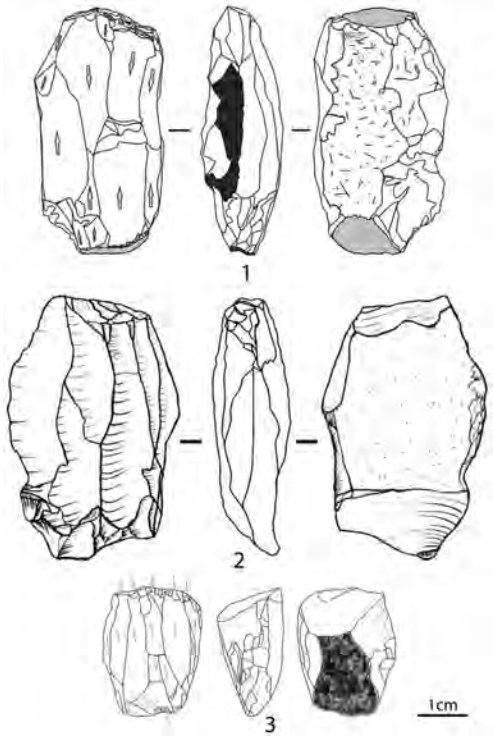

Fig. 9. Various exhausted obsidian cores with double (1–2) and single-striking platforms (3).

and was found in the upper-level deposits of trench L11. Since the average dimensions of the unknapped preforms are 131.3x99.31x53.44mm, with the longest preform being 14.7cm and the thickest 14.2cm, it is possible that this 9cm central blade was knapped at the settlement. Nevertheless, similarly large blanks are very rare.

The production of flakes at the settlement was the result of different knapping processes. Most of them were knapped as a part of the blade reduction sequence, either during the removal of the cortical surfaces on the preforms, core shaping/rejuvenation, or the preparation of the striking platforms. However, some of the flake cores are the result of recycling or secondary use of exhausted blade cores. Such blade cores were presumably deemed unfit for detaching further blades in the required dimensions and were used for flake production instead. The abundance of scrapers made on flakes demonstrates that flake blanks were, in any case, essential for the inhabitants of the settlement. In addition to primary and secondary flakes and blades, core trimming elements such as crested and plunging pieces indicate the various *in situ* knapping sequences at the site.

Typology

Retouched flakes and blades form a considerable portion of the Sofular Höyük assemblage. Formal tools include laterally retouched pieces, various scrapers made on flakes, backed blades, notched and denticulated pieces, burins, microliths, borers and awls, points, truncations, scaled pieces, and heavy-duty tools (Tab. 9). Some informal tools made on core trimming elements are also present, but these are not common implements at the settlement.

Blade sizes (mm)	Length	Width	Thickness
Mean	35.35	11.38	4.01
Maximum	83.73	27.03	9.43
Minimum	8.09	1.14	1.01
Standard deviation	4.76	1.01	0.43

Tab. 8. Dimensions of the unbroken obsidian blades recovered from Sofular Höyük.

The assemblage contains numerous laterally retouched blades and blade segments, and these comprise *c.* 39% of the tools. Such pieces were originally retouched either along one side or along both sides. Blades were also modified to produce backed blades, geometric microliths, burins, borers, awls, and points (Fig. 10.1), as well as truncations and denticulated-notched pieces. The latter category mainly involves notches, as denticulates are rare, with only one sample made on a blade segment encountered so far. Points are primarily single-shouldered pieces, although there are also a few double-shouldered examples that have parallels among Byblos points. The microburin technique was employed to produce segment pieces modified into small backed blades/bladelets and geometric microliths (Fig. 10.2,3). Microliths, with an average size of 23x33mm, make up 3.5% of the tools (Tab. 9). They mainly comprise scalene triangles (Fig. 10.2), but there are also some rare lunates.

Tool Types	Surface	L11	L10	K10	Total	%
Retouched blades	118	204	75	27	424	39.4%
Scrapers	73	59	20	13	165	15.4%
Retouched flakes	61	53	16	9	139	12.9%
Backed blades	13	41	22	5	81	7.5%
Denticulated/notched pieces	34	31	7	5	77	7.2%
Burins	14	23	10	5	52	4.8%
Microliths	3	14	11	10	38	3.5%
Borers/awls	18	11	2	1	32	3.0%
Retouched core trimming elements	8	9	4	4	25	2.3%
Points	7	13	0	1	21	2.0%
Truncations	5	6	2	1	14	1.3%
Spalls	2	1	0	0	3	0.3%
Heavy-duty tools	2	0	0	0	2	0.2%
Scaled pieces	1	0	1	0	2	0.2%
Retouched cores	0	0	1	0	1	0.1%
Total	359	465	171	81	1076	100.0%

Tab. 9. Main tool categories represented in the obsidian assemblage from Sofular Höyük.

Notably, the collection has 350 microburins (both proximal and distal pieces), corresponding to *c.* 7.2% of the assemblage. Microburins are much more common in trenches L10 and L11, excavated to their lowest levels, while only a few microburins are found in trench K10, which was excavated only in its upper levels. Likewise, surface finds include only rare microliths and microburins (*Karakoç 2019.337, App. 1–2*). Deposits from the trench

K10 have not been radiocarbon dated and exact stratigraphical correlations between different layers are not yet available, but based on these findings it appears that the microburin technique was applied more frequently in the earlier phases of Sofular Höyük. Even though the number of microliths exhibits a parallel decrease between trenches L10-L11 and K10, their proportions at the moment do not entirely support this notion (Tab. 9). However, microliths appear underrepresented compared to microburins (38 microliths *vs.* 350 microburins) for reasons that are unclear.

There is a strong relationship between certain tools and blank types at Sofular Höyük. For example, end-scrapers were rarely made on blades or core trimming elements (only seven pieces were made on blades, Fig. 10.6). Instead, they were mainly produced from thick rejuvenation flakes and core preparation flakes (Fig. 11). Burins and borer/awls, meanwhile, were made on both blades and flakes. The latter has relatively thick blanks, with occasional cortex remnants on the dorsal surface. Most of their piercing tips are broken or blunted, possibly due to use. Even though crested blades or plunging flakes were not turned into end-scrapers, some were modified to be used as burins or borer/awls, sometimes exhibiting use-wear and retouched edges. Settlers might have used these tools for a wide range of purposes, but they were likely linked to the manufacture of pendants and stone beads found at the settlement. Two scaled pieces (*piéces esquillées*) and two heavy-duty tools in the obsidian assemblage might likewise be related to activities such as woodworking, bone tool manufacture, or building construction/maintenance. Tools were modified with steep and semi-steep retouch, generally on the dorsal faces of the blanks and expanded along the lateral edges but not towards the central surfaces. Some pieces also exhibit inverse retouch on their ventral surfaces, but these are not regular or continuous and are often concentrated in a specific area. These patterns might have resulted from tasks such as hafting, fastening with a cordlike material, or repair/refitting. The diversity of possible uses, together with the large number of chipped stone pieces retrieved from the site, attest to the essential part the lithic tools no doubt played within the daily rhythm of life in the settlement.

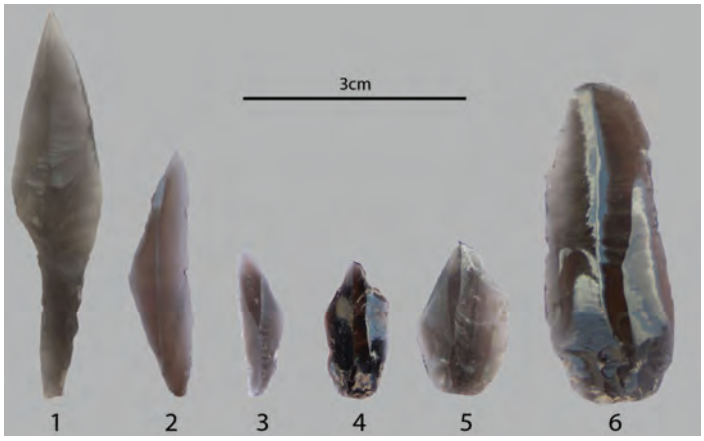

Fig. 10. Various tools from different levels:* 1 *double-shouldered and retouched point,* 2,3 *geometric microliths,* 4,5 *microburins,* 6 *blade end-scraper.

Discussion

The preliminary analysis of the obsidian sources used in Sofular Höyük has yielded intriguing results. Even though a more exhaustive investigation of the obsidian assemblage is necessary to confirm the patterns identified and to obtain representative proportions of different sources, initial findings indicate the use of only Göllüdağ (East and West) and Acıgöl (EAAC) obsidians to the exclusion of Nenezi Dağ. This would represent a contrast between Sofular Höyük and the other Early Neolithic settlements of Central Anatolia, where Göllüdağ and Nenezi Dağ are the primary sources that were used (whereas Acıgöl obsidians are found only rarely). Such appears to be the case in sites such as Aşıklı Höyük (*Kayacan, Altınbilek-Algül 2018.366–68*), Musular (*Kayacan, Özbaşaran 2007*), and Sırçalıtepe (*Balcı* et al. *2021*), all of which are close to the sources themselves, and also in Boncuklu (*Muller* et al. *2018.724*) and Can Hasan (*Ataman 1988.50–51*) to the west (although at some of these sites such conclusions rest on visual observations and/or restricted sample sizes and therefore might be misleading). The relative popularity of Acıgöl obsidians in Sofular Höyük might have been due to Acıgöl's relative proximity to the site, around 40km to the southwest, but both Nenezi Dağ and Göllüdağ are at comparable distances and there must have been other factors that influenced the difference in their acquisition. In any case, the Sofular community does not appear to be a part of the exchange networks that conveyed Nenezi Dağ obsidian to communities further west, perhaps because of this very orientation that such networks operated with.

Nevertheless, lunate and triangular-shaped geometric microliths manufactured using the

microburin technique are present within the assemblage in Sofular Höyük, and hint that the site is rooted in the broader Epipalaeolithic tradition of Central Anatolia as known from the site of Pınarbaşı. In Epipalaeolithic Pınarbaşı, microliths make up 25% of the formal tools, and these are predominantly lunates (*Pirie 2011*). The rarity of blade and flake blanks in corresponding sizes and the small number of microburins in the assemblage have led to the conclusion that these lunates were probably not produced at the settlement itself (*Pirie 2011.91*). Scrapers follow microliths with 16% of the total, and have an inclination towards small thumbnail types with quite invasive, regular retouch (*Baird* et al. *2013; Pirie 2011.91*). Scrapers are also common in Sofular (15%), mainly made on large, thick flakes with circular and semi-circular forms, but the industry also includes large carinated ones. These differences in size, if not a reflection of the fundamental differences in the respective modes of subsistence, could be the result of the obsidian sources (heavily relied upon at both settlements) being closer to Sofular than Pınarbaşı.

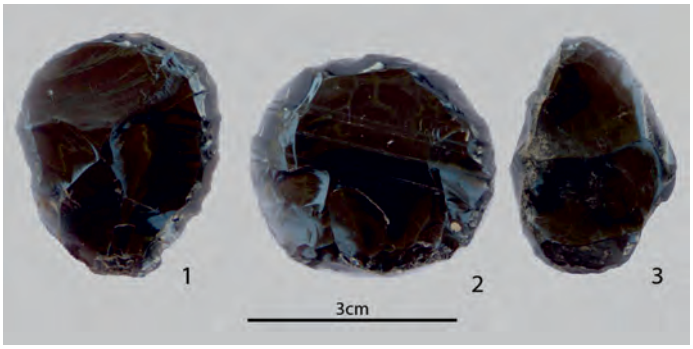

Fig. 11. Scrapers made on rejuvenation flakes.

Obsidian is also the main raw material in the lithic industry of the succeeding 10th/9th-millennium BC levels in Pınarbaşı (*Baird 2012.194*). This industry is dominated by bladelets reduced from bidirectional cores. A few naviform cores were also noted, and some bidirectional cores may have originally been classic naviforms used to obtain larger bladelets and small blades (*Baird 2012.195*). Like Sofular, the microburin technique was used in Pınarbaşı to turn bladelets into elongated scalene microliths, and a large number of microburins were likewise recovered. However, microliths are the dominant tools in the obsidian industry at these levels in Pınarbaşı (*c.* 10%). Geometric and non-geometric microliths are also recovered from nearby Boncuklu (*Baird* et al. *2012; Muller* et al. *2018*), made using the microburin technique as in Sofular. The similarities between the Boncuklu assemblage (8300–7800 BC) and that of the 10th/9th millennium BC Pınarbaşı have previously been emphasized (*Baird* et al. *2012.231*; *Baird* et al. *2018.E3082*). Boncuklu, like Pınarbaşı, is characterized by an abundance of microliths (20%) with a variety of forms (*Muller* et al. *2018*), most notably scalene triangles (*Baird* et al. *2018.E3082*). Boncuklu lithic industry also includes notches, burins, scrapers, and piercers in lower proportions (*Muller* et al. *2018.726*).

Sırçalıtepe is a PPN settlement closer to Sofular Höyük, in the Cappadocian part of Central Anatolia. Recent excavations at this site revealed a mid-8th millennium BC settlement with well-preserved architectural elements and chipped stone artefacts exclusively made of obsidian (*Balcı* et al. *2021*). Various scrapers on flakes and arrowheads, such as oval points with pressure retouch, have been noted in the chipped stone assemblage, but neither microliths nor microburins have been reported yet. Circular and semi-circular scrapers on thick flakes from Sırçalıtepe have been compared to examples in Aşıklı Höyük, Musular, and Sofular Höyük (*Balcı* et al. *2021.76*). Aşıklı Höyük is also located in broadly the same region as Sofular and both sites have contemporary levels *(Duru 2018; Özbaşaran* et al. *2018; Yelözer* et al. *2019*). Similar forms are present in both sites, such as microliths and circular and semi-circular scrapers, and blade blanks removed from cores with single or double-striking platforms. Microliths recovered from Level 4 in Aşıklı Höyük are predominantly triangles, while lunates are rare (*Astruc 2018.358*). Like Sofular, geometric and non-geometric microliths appear more numerous in the earlier occupation levels of Aşıklı, becoming rarer in the upper levels (*e.g.*, from *c.* 10–15% to 2–4% in Area 2JK) (*Kayacan, Altınbilek-Algül 2018.373–375*). This trend can also be traced in other sites in Central Anatolia: microliths are not found at Musular (*Özbaşaran* et al. *2012.163*), which succeeds the main occupation in the neighbouring Aşıklı Höyük; similarly, while Çatalhöyük contains some microlithic elements such as bladelets made on-site using Göllüdağ obsidian, the microlithic tradition and the sizeable opposed platform blade technology disappears from Level Pre-XII.B onwards (*Carter, Milić 2013.497; Carter 2011.12*).

Significantly, Aşıklı Höyük knappers appear to have preferred the direct percussion technique (but some possibly pressure detached pieces have been report-

ed; *Yıldırım-Balcı 2007.285*), and the industry does not include typical naviform cores of the contemporary Levantine PPNB sphere (*Kayacan, Altınbilek-Algül 2018.380*) (even though some naviform end-products are present; *Yıldırım-Balcı 2007.435*). "*A local tradition distinct from that of Kömürcü-Kaletepe and the Levant*" has been suggested for Aşıklı Höyük Level 4 based on such distinctions (*Astruc 2018.361*). Similar preferences are likewise characteristic of Sofular Höyük and other Early Neolithic settlements in Central Anatolia. The pressure technique was not preferred to detach blanks, and various projectile forms on large blades (part of the "*Big Arrowhead Industries*"), so popular in the Levantine PPNB (*Kozłowski 1999.110–113, Tabs. 22–23; Shea 2013.278–280*), were not taken up. Sofular, Aşıklı Höyük, Pınarbaşı (10th/9th millennium BC occupation), and Boncuklu all continued using microliths instead, and specifically focused on triangular forms. The proportion of microliths in Sofular is more comparable to that found at Aşıklı Höyük, whereas the emphasis on these tools is more pronounced in Pınarbaşı and Boncuklu. Even though the Sofular assemblage includes a significant amount of microburins (a good indicator that the microliths were produced at the settlement), a comparatively limited number of microlithic tools are present. Although it is not yet possible to point at the causes of such divergences, the overall impression provided by the techno-typological analysis of the chipped stone assemblage from Sofular Höyük indicates that the settlement is a part of the Central Anatolian Early Neolithic, with similarly local traditions in chipped stone production that can be traced to the earlier periods of the same region (Tab. 10).

Conclusions

Archaeological research in Central Anatolia has demonstrated that obsidian was a very popular raw material during the periods surrounding the establishment of the earliest farming communities in the region. Sofular Höyük is no exception to this pattern. Our studies on the obsidian assemblage from this site indicate that the inhabitants relied on preforms transported into the settlement to knap blade and flake products, applying unidirectional and bidirectional reduction sequences mainly on blade cores with single or double striking platforms. They snapped blades using the microburin technique, particularly in the earlier phases and modified them into microliths or backed blades, a practice which apparently declined in the later part of the occupation. Settlers also made use of flake tools, mainly as scraping implements such as circular and semi-circular end-scrapers. The techno-typological preferences largely follow the contemporary sites in the region, placing Sofular Höyük within the Early Neolithic traditions of Central Anatolia. However, the results of the preliminary prove-

	Single-platform cores	Double-platform cores	Naviform cores	Pressure reduced cores	Microliths/ microburin technique	Levantine point types	References
Pınarbaşı (Epipalaeolithic)	x				x		*Baird 2012; Pirie 2011*
Pınarbaşı (10th/ 9th mill. BC)	x	x	Few		x		*Baird 2012; 2019*
Aşıklı	x	x			x	Few	*Astruc 2018; Kayacan, Altınbilek-Algül 2018; Yıldırım-Balcı 2011a; 2011b*
Boncuklu	x	x	Few?		x		*Baird* et al. *2012; Baird 2019; Muller* et al. *2018*
Can Hasan III	x	x				Few	*Ataman 1988*
Kömürcü-Kaletepe	x	x	x	x		x	*Balkan-Atlı* et al. *2008; Balkan-Atlı, Binder 2012*
Levantine PPNB		x	x	x		x	*Borrell 2017; Kozlowski 1999; Shea 2013*
Sırçalıtepe		x					*Balcı* et al. *2021; 2022*
Sofular	x	x			x	Few	**This study** (see also *Karakoç 2019*)
Çatalhöyük	x	x			x	x	*Carter* et al. *2005; Carter, Milić 2013; Conolly 1999a; 1999b*

Tab. 10. Comparative table of selected techno-typological features in various Central Anatolian sites and the Levantine PPNB.

nance analyses demonstrate the presence of Göllüdağ and Acıgöl obsidians in the settlement and point at a possible lack of Nenezi Dağ material, in contrast to the established practices in the western part of the south-central Anatolian plateau where communities procured obsidian mainly from Göllüdağ and Nenezi Dağ. The presence of red-coloured obsidians at Sofular Höyük and certain other Neolithic sites also raises questions about the materiality of such obsidian varieties, and associated social implications emerge as an avenue of research. We are hoping to expand the scope of our geochemical investigations in the future to confirm and elaborate on the patterns of raw material preference detected in this study. The clarification of the stratigraphy and the chronological relations of the various deposits and features excavated will also enable a finer-tuned examination of both obsidian acquisition and techno-typological trends in this important prehistoric settlement near the Kızılırmak.

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Tab. 4. Sofular Höyük obsidians analysed in this study and their elemental concentrations (ppm). Objects sorted according to Sr content in descending order. Multiple analyses of SOF 002 and SOF 004 are reported separately.

ID	Trench/level (m)	Techno-typology	Visual group	Result	Thickness (mm)	Weight (gr)	Rb	Sr	Y	Zr	Nb	Ti	Mn	Ga	Zn
SOF 014	L10/1077.90-1077.38	Blade	6	Acıgöl EAAC 2	2.0	0.5	312	99	38	190	41	890	730	32	63
SOF 007	L10/1077.98-1077.78	Blade	6	Acıgöl EAAC 2	2.2	0.8	277	90	34	171	38	715	636	26	59
SOF 001	L11/1077.38	Blade	8	Acıgöl EAAC 2	2.9	1.1	268	87	35	166	36	668	589	25	47
SOF 004a	L10/1077.74-1077.73	Flake	4	Göllüdağ West 2	1.1	0.3	197	81	23	147	25	756	603	48	21
SOF 004c	L10/1077.74-1077.73	Flake	4	Göllüdağ West 2	1.1	0.3	205	81	23	151	25	785	582	58	22
SOF 004b	L10/1077.74-1077.73	Flake	4	Göllüdağ West 2	1.1	0.3	192	80	24	143	25	757	582	57	21
SOF 006	L10/1078.16-1078.10	Flake	6	Acıgöl EAAC 2	9.3	10.9	243	78	32	146	31	700	571	26	46
SOF 002a	L11/mixed	Debris	4	Acıgöl EAAC 1	2.9	0.7	177	77	25	150	24	831	465	48	21
SOF 012	L10/1077.79-1077.74	Flake	6	Acıgöl EAAC 2	2.9	1.0	231	77	30	145	35	581	521	21	46
SOF 005	L10/1077.99-1077.90	Blade	4	Acıgöl EAAC 2	2.3	1.8	235	76	29	146	29	683	583	24	49
SOF 003	Surface	Core	4	Acıgöl EAAC 2	14.7	15.1	221	74	28	137	32	669	518	22	43
SOF 024	K10/1078.40-1078.06	Flake	1	Acıgöl EAAC 2	5.3	4.9	221	73	28	138	30	641	553	22	47
SOF 002b	L11/mixed	Debris	4	Acıgöl EAAC 1	2.9	0.7	164	72	24	135	22	720	448	45	17
SOF 013	L10/1077.99-1077.90	Blade (retouched)	6	Acıgöl EAAC 2	3.3	1.1	233	72	28	143	31	671	537	20	47
SOF 009	L10/1077.79-1077.74	Flake	6	Acıgöl EAAC 2	2.3	1.9	218	70	26	132	31	611	523	18	47
SOF 010	L10/1077.99-1077.90	Flake	6	Acıgöl EAAC 2	3.9	3.6	226	70	28	140	35	629	537	22	46
SOF 002c	L11/mixed	Debris	4	Acıgöl EAAC 1	2.9	0.7	160	68	20	132	22	682	396	40	17
SOF 015	L10/1077.72-1077.70	Flake	6	Acıgöl EAAC 2	2.1	0.8	202	65	26	120	25	612	508	17	40
SOF 008	Surface	Flake	6	Acıgöl EAAC 2	2.4	0.3	171	53	21	101	22	577	457	18	42
SOF 088	L10/1077.38	Blade	1	Göllüdağ East	1.7	0.1	237	19	22	77	28	480	448	21	28
SOF 097	K10/1080.85-1080.61	Flake (scraper)	3	Göllüdağ East	5.9	5.3	244	17	27	103	38	576	634	19	27
SOF 102	K10/1080.85-1080.61	Flake (retouched)	3	Göllüdağ East	4.5	5.0	249	17	30	97	39	555	621	22	30
SOF 106	K10/1080.85-1080.61	Blade	5	Göllüdağ East	2.8	0.5	293	17	35	118	46	574	728	18	29
SOF 027	L11/1077.86-1077.74	Blade (retouched)	3	Göllüdağ East	4.2	3.5	267	16	29	95	39	639	570	22	29
SOF 039	Surface	Flake (retouched)	2	Göllüdağ East	3.5	2.6	235	16	29	87	35	488	631	20	25
SOF 061	L10/1077.74-1077.73	Flake	5	Göllüdağ East	3.5	2.4	251	16	27	99	39	496	638	27	30

Tab. 4. continued

SOF 090	K10/1080.85-1080.61	Blade (retouched)	7	Göllüdağ East	3.3	1.1	236	16	25	92	37	456	611	19	28
SOF 092	K10/1080.85-1080.61	Flake (notched)	2	Göllüdağ East	4.4	3.4	223	16	25	88	37	488	586	16	31
SOF 119	K10/1080.85-1080.61	Flake	3	Göllüdağ East	4.6	2.9	223	16	30	90	36	448	600	19	29
SOF 035	L10/1077.74-1077.73	Flake	2	Göllüdağ East	4.4	5.5	233	15	26	95	37	486	608	14	28
SOF 037	Surface	Blade	2	Göllüdağ East	2.3	0.5	231	15	25	86	31	532	617	17	27
SOF 038	K10/1077.72-1077.70	Flake (retouched)	1	Göllüdağ East	2.6	0.3	249	15	23	92	36	551	669	23	32
SOF 086	L10	Blade	5	Göllüdağ East	2.7	1.8	223	15	25	85	34	533	608	18	25
SOF 111	K10/1080.85-1080.61	Flake	1	Göllüdağ East	2.2	0.6	237	15	29	102	35	515	639	20	27
SOF 114	K10/1080.85-1080.61	Flake (retouched)	1	Göllüdağ East	8.9	20.7	252	15	30	102	41	547	643	22	28
SOF 116	K10/1080.85-1080.61	Flake (endscraper)	2	Göllüdağ East	4.8	4.4	234	15	27	94	35	473	594	18	25
SOF 122	K10/1080.85-1080.61	Blade	3	Göllüdağ East	2.5	0.7	215	15	24	83	30	469	587	18	26
SOF 020	L10/1077.74-1077.73	Flake	5	Göllüdağ East	4.7	4.5	222	14	27	89	36	477	594	21	30
SOF 028	L10/1077.98-1077.78	Flake (endscraper)	6	Göllüdağ East	7.3	10.2	211	14	25	90	33	444	582	15	23
SOF 051	L10/mixed	Flake	1	Göllüdağ East	2.6	2.3	226	14	27	94	36	476	625	21	23
SOF 054	L10/mixed	Blade (retouched)	1	Göllüdağ East	2.5	1.9	221	14	23	95	37	442	598	19	26
SOF 060	L10/1077.98-1077.78	Blade	5	Göllüdağ East	3.6	2.3	219	14	23	82	33	502	589	19	25
SOF 065	K10/1077.86	Flake	5	Göllüdağ East	8.8	8.3	218	14	25	85	35	512	597	19	24
SOF 075	L11/mixed	Blade (retouched)	3	Göllüdağ East	3.8	1.7	216	14	27	93	33	506	555	19	27
SOF 091	K10/1080.85-1080.61	Blade (retouched)	7	Göllüdağ East	3.5	1.9	236	14	29	92	39	482	648	20	21
SOF 093	K10/1080.85-1080.61	CTE (retouched)	2	Göllüdağ East	9.4	9.8	233	14	27	91	36	511	580	20	23
SOF 094	K10/1080.85-1080.61	Flake (retouched/ burin)	3	Göllüdağ East	6.7	9.0	236	14	28	102	37	514	582	19	26
SOF 115	K10/1080.85-1080.61	Flake (retouched)	2	Göllüdağ East	2.4	1.6	223	14	23	82	32	471	575	16	30
SOF 016	L10/1077.90-1077.34	Flake	6	Göllüdağ East	2.3	1.2	194	13	21	78	30	481	535	15	24
SOF 017	L10/1077.73-1077.72	Blade	7	Göllüdağ East	2.3	0.8	233	13	25	90	34	477	620	19	28
SOF 036	L10/1077.38	Blade (retouched)	2	Göllüdağ East	1.8	1.1	214	13	22	77	31	512	582	19	25
SOF 067	Surface	Blade (retouched)	5	Göllüdağ East	2.4	0.9	215	13	24	88	33	540	581	17	32
SOF 069	K10/1077.72-1077.70	Blade (retouched)	5	Göllüdağ East	3.3	2.2	202	13	21	84	28	467	561	17	22
SOF 080	Surface	Blade	5	Göllüdağ East	3.1	1.8	212	13	24	81	32	473	556	17	24

Tab. 4. continued

SOF 103	K10/mixed	CTE	3	Göllüdağ East	7.8	3.7	215	13	24	82	31	472	557	18	27
SOF 108	K10/1080.85-1080.61	Flake (scraper)	3	Göllüdağ East	4.2	3.7	220	13	24	89	38	449	592	17	26
SOF 124	K10/1080.85-1080.61	Blade	7	Göllüdağ East	2.4	0.4	205	13	22	90	27	383	477	19	23
SOF 021	L10/1077.74-1077.73	Flake	5	Göllüdağ East	3.1	3.1	217	12	22	79	32	437	575	20	26
SOF 040	L10/1077.99-1077.90	Blade	1	Göllüdağ East	3.3	2.6	218	12	26	81	36	516	586	18	21
SOF 059	K10/1077.72-1077.70	Flake (retouched)	1	Göllüdağ East	1.6	0.8	206	12	24	87	29	487	605	16	23
SOF 104	K10/1080.85-1080.61	CTE	2	Göllüdağ East	4.4	1.5	200	12	23	79	31	467	556	15	26
SOF 109	K10/1080.85-1080.61	Flake	1	Göllüdağ East	3.0	3.0	233	12	26	90	38	495	622	21	26
SOF 128	K10/1080.85-1080.61	Blade (microlith)	1	Göllüdağ East	2.1	0.3	168	12	18	72	25	417	521	17	23
SOF 018	L10/1077.38	Flake (retouched)	2	Göllüdağ East	1.6	0.6	175	11	19	67	28	376	518	17	18
SOF 041	L10/1077.99-1077.90	Blade	1	Göllüdağ East	4.5	3.4	193	11	19	76	30	415	512	19	24
SOF 130	K10/1080.85-1080.61	Blade (microlith)	1	Göllüdağ East	2.6	0.8	176	11	19	70	29	432	487	15	22
SOF 076	K10/1077.72-1077.70	Blade	3	Göllüdağ East	3.3	1.0	206	10	23	73	32	467	537	17	22

Tab. 5. Elemental averages (ppm) and ratios of the Central Anatolian obsidians from published literature and the corresponding Sofular Höyük data from this study.* EAAC *East Acıgöl ante-caldera,* EAPC *East Acıgöl post-caldera,* WA *West Acıgöl.

Source	Data	Samples	Method	n	Rb	Sr	Zr	Zr/Rb	Sr/Rb	Zr/Sr
Acıgöl EAAC 1	*Gratuze 1999*	Geological	LA-ICP-MS	6	163	74	140	0.859	0.454	1.892
	Keller, Seifried 1990	Geological	WDXRF	2	166	79.5	153	0.922	0.479	1.925
	Oddone et al. *1997*	Geological	NAA	4	177.5	80.9	152.8	0.861	0.456	1.889
	This study	**Sofular**	pXRF	1*	167	72.3	139	0.832	0.433	1.923
Acıgöl EAAC 2	*Gratuze 1999*	Geological	LA-ICP-MS	11	147	54	92	0.626	0.367	1.704
	Keller, Seifried 1990	Geological	WDXRF	5	176.8	65.4	114.6	0.648	0.370	1.752
	Kobayashi, Mochizuki 2007	Geological	EDXRF	20	177	53	109	0.616	0.299	2.057
	Kobayashi, Mochizuki 2007	Archaeological	EDXRF	1	177	56	108	0.610	0.316	1.929
	Poupeau et al. *2010*	Geological	PIXE	1	180	63	110	0.611	0.350	1.746
	This study	**Sofular**	pXRF	13	235.2	75.7	144.2	0.613	0.322	1.905

Tab. 5. continued

Acıgöl EAPC	*Keller, Seifried 1990*	Geological	WDXRF	7	153.9	106.4	193.9	1.260	0.692	1.821
	Poupeau et al. *2010*	Geological	PIXE	1	165	100	185	1.121	0.606	1.850
Acıgöl WA	*Carter* et al. *2006*	Archaeological	LA-ICP-MS	1	167	1.5	47.1	0.282	0.009	32.041
	Gratuze 1999	Geological	LA-ICP-MS	11	235	1	74	0.315	0.004	74.000
	Keller, Seifried 1990	Geological	WDXRF	9	257.4	4.1	85.9	0.334	0.016	20.892
	Kobayashi, Mochizuki 2007	Geological	EDXRF	19	269	0	76	0.283	0.000	> 76
	Oddone et al. *1997*	Geological	NAA	7	237.1	4	87.6	0.370	0.017	22.168
	Poupeau et al. *2010*	Geological	PIXE	1	266	2	79	0.297	0.008	39.500
	Poupeau et al. *2010*	Geological	EDXRF	1	267	3	87	0.326	0.011	29.000
Göllüdağ East	*Carter* et al. *2006*	Archaeological	ICP-MS	55	181.6	11.7	76.7	0.422	0.065	6.543
	Gratuze 1999	Geological	LA-ICP-MS	22	186.5	11.5	68	0.365	0.062	5.913
	Keller, Seifried 1990	Geological	WDXRF	8	186.5	14	74.9	0.401	0.075	5.348
	Kobayashi, Mochizuki 2007	Geological	EDXRF	20	184	9	71	0.386	0.049	7.889
	Kobayashi, Mochizuki 2007	Archaeological	EDXRF	2	188.5	7	71	0.377	0.037	10.143
	Oddone et al. *1997*	Geological	NAA	3	184.3	16.5	76.3	0.414	0.090	4.621
	*Poidevin 1998****	Geological	LA-ICP-MS	3	185	12.7	81.8	0.442	0.068	6.455
	Poupeau et al. *2010*	Archaeological	EDXRF	26	197.8	13.7	81.3	0.411	0.069	5.922
	Poupeau et al. *2010*	Geological	EDXRF	1	194	17	86	0.443	0.088	5.059
	Poupeau et al. *2010*	Geological	ICP-MS	6	180.7	9.6	70.6	0.391	0.053	7.338
	Poupeau et al. *2010*	Geological	PIXE	12	193.8	11.5	72.6	0.374	0.060	6.287
	This study	**Sofular**	pXRF	48	222.8	14	87.8	0.394	0.063	6.271
Göllüdağ West 1	*Gratuze 1999*	Geological	LA-ICP-MS	8	158	38	75	0.475	0.241	1.974
	Keller, Seifried 1990	Geological	WDXRF	4	163	42.3	81.8	0.502	0.259	1.935
	Oddone et al. *1997*	Geological	NAA	1	172	43.6	79.8	0.464	0.253	1.832
	Poupeau et al. *2010*	Geological	PIXE	1	165	40	74	0.448	0.242	1.850
	*Poidevin 1998****	Geological	LA-ICP-MS	2**	165.2	39	88.4	0.535	0.236	2.265

Tab. 5. continued

Göllüdağ West 2	*Gratuze 1999*	Geological	LA-ICP-MS	6	167	70	119	0.713	0.419	1.700
	Kobayashi, Mochizuki 2007	Geological	EDXRF	25	169	65	118	0.698	0.385	1.815
	*Poidevin 1998****	Geological	LA-ICP-MS	4	173.3	73.5	129.2	0.746	0.424	1.758
	This study	**Sofular**	pXRF	1*	198	80.7	147	0.742	0.408	1.822
Hasan Dağ	*Gratuze 1999*	Geological	LA-ICP-MS	2	100	80	65	0.650	0.800	0.813
	Keller, Seifried 1990	Geological	WDXRF	3	114.7	94.7	76	0.663	0.826	0.803
	Poupeau et al. *2010*	Geological	PIXE	1	122	74	49	0.402	0.607	0.662
Nenezi Dağ	*Carter* et al. *2006*	Archaeological	ICP-MS	45	163.5	95.9	145.8	0.892	0.586	1.520
	Gratuze 1999	Geological	LA-ICP-MS	3	163	106	138	0.847	0.650	1.302
	Keller, Seifried 1990	Geological	WDXRF	3	159.3	98.3	136.7	0.858	0.617	1.390
	Kobayashi, Mochizuki 2007	Geological	EDXRF	19	162	87	130	0.802	0.537	1.494
	Kobayashi, Mochizuki 2007	Archaeological	EDXRF	3	162	85.3	130.3	0.805	0.527	1.527
	Oddone et al. *1997*	Geological	NAA	1	191	99.3	136	0.712	0.520	1.370
	*Poidevin 1998****	Geological	LA-ICP-MS	5	164.4	94.2	136.7	0.832	0.573	1.451
	Poupeau et al. *2010*	Archaeological	EDXRF	8	175.4	100.5	147.3	0.840	0.573	1.465
	Poupeau et al. *2010*	Geological	ICP-MS	3	157.3	93.2	138.1	0.878	0.592	1.482
	Poupeau et al. *2010*	Geological	PIXE	3	184	120.7	152.7	0.830	0.656	1.265
	** Average of three measurements.*									
	*** Pumice samples not included.*									
	**** Results of J.-L. Poidevin and N. Arnaud in Annex 2 ("Poidevin et Arnaud").*									

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Projectile point variability from a biogeographical approach in northwestern Patagonia, Argentina

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ABSTRACT - *Our objective is to analyse the relationship among the availability, selection, and use of raw materials suitable for knapping with projectile points from the Late Holocene of northwestern Patagonia. We analyse differences in the raw material used to make projectile points according to the techno-morphological characteristics. Non-stemmed projectile points predominate in all the biogeographic units. The size and weight of the projectile points in Patagonia duplicate those from Altoandina and Monte. We conclude that there was a coexistence of two weapons systems related to hunting, the bow and arrow, together with the use of darts.*

KEY WORDS – *lithic tools; projectile points; biogeography; rock selection; hunting strategies*

Variabilnost puščičnih osti pri biogeografskem pristopu v severozahodni Patagoniji, Argentina

IZVLEČEK – *Cilj našega dela je analizirati razmerja med dostopnostjo, izbiro in uporabo surovin, primernih za izdelavo puščičnih osti iz poznega holocena severozahodne Patagonije. Analiziramo razlike med surovinami za izdelavo konic glede na njihove tehnomorfološke značilnosti. V vseh biogeografskih enotah prevladujejo osti brez trna. Velikost in teža konic v Patagoniji sta enaki tistim iz Altoandine in Monte. Sklepamo, da sta obstajala dva vzporedna lovna oborožitvena sistema, lok s puščico in uporaba kopja.*

KLJUČNE BESEDE – *kamena orodja; puščične osti; biogeografija; izbor kamnin; strategije lova*

Introduction

Projectile points and their morphological types have been traditionally used as temporal markers to establish a relative chronology in the archaeological record *(Bird 1993; Martínez 2003; Belardi* et al. *2005)*. Projectile points (PP) are an essential part of several weapons systems. Beyond their technological variations and particularities, they are present throughout the Holocene until the Spanish contact. In the Late Holocene, there was an increase in the use of obsidian and tools made of this raw material, mainly with regard to the manufacture of PP (*Durán 1997*; *Gil 2006; Neme 2007*; *Neme, Gil 2008*; *Cortegoso* et al. *2012*). In southern Mendoza, stemmed projectile points named *Fortuna* (*Gambier 1980)* belong to Early and Middle Holocene contexts. Triangular projectile points, called *Morrillos*, are associated with late occu-

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pations (*Gambier 1980*). Both morphologies of projectile points coexisted in the Late Holocene.

In this paper, we present the study of PP from archaeological sites of three biogeographic units from southern Mendoza: Altoandina, Patagonia, and Monte (Fig. 1.a; *Salgán* et al. *2022*). Our objective is to test differences and similarities in the use of raw materials to manufacture PP from their techno-morphological characteristics. In addition, we explore if there was a particular selection of obsidian sources to make PP in each biogeographic unit, specifically during the Final Late Holocene. In this context, changes in hunting strategies generated the need to manufacture PP of smaller size and volume. Therefore the use of obsidian presented advantages compared to other tool stones. Finally, we assess a first approximation to interpret the hunting strategies according to raw material use and PP characteristics in each environment.

Projectile points in the archaeological studies of southern Mendoza

In the Diamante and Atuel rivers *(Franchetti 2019; Pompei 2019*) and El Payén area (Fig. 1.a,b; *Salgán 2013*), we have already characterized the spatial distribution, availability, and properties of raw materials. These studies addressed the use of raw materials in each environment, the possible mobility circuits, as well as changes and continuities in the lithic organization (*Salgán* et al. *2014a*; *Franchetti 2019*; *Pompei 2019*; *Salgán* et al. *2022*).

In the Diamante river (Fig. 1.b), Fernando Franchetti (*2019*) observed a predominant use of basalts in the surface archaeological assemblages, followed by cryptocrystalline rocks, obsidian, and other rocks. Hunter-gatherers acquired basalts from primary and secondary sources. The Diamante valley has localities with cores and flakes with cortex, indicating active access and use of basalts. In addition, all the metric variables for this raw material are larger in the Patagonia unit, in contrast to the sizes in the Altoandina unit. There was direct access to this raw material in the lower zones, with seasonal and year-round posterior conveyance to the highlands. In the Patagonia unit, Franchetti (*2019*) observed a contrast in the abundance of scrapers in the larger sites compared to base camps in the Altoandina unit. In this last environment, we found PP mostly as isolated findings and in secondary base camps related to hunting practices. In the Altoandina unit, there are also localities with cores and evidence of the early stages of reduction in cryptocrystalline rocks. The use of other rocks of lower quality, such as rhyolites and vulcanites, is sporadic and opportunistic. The only non-local raw material is obsidian, registered at a 40km distance or further from the archaeological sites (*Meltzer 1989).* The nearest source is Laguna del Diamante, and this location has the lowest frequency among the known obsidian sources detected in the lithic organization of the Diamante valley (*Franchetti* et al. *2022*). Obsidian predominates in the larger sites, mainly as PP and bifaces (*Franchetti 2019*).

In stratigraphic sites from the Atuel river, María de la Paz Pompei (*2019*) noted a higher use of cryptocrystalline rocks, followed by obsidian, basalt, and other raw materials (Fig. 1.b). Obsidian in the Atuel valley is also non-local, since the known sources are further than 40km away (*Civalero, Franco 2003*). The other raw materials are available along the river in the three biogeographic units as primary and secondary sources (*Pompei 2019*). In the Atuel valley archaeological record, cryptocrystalline rocks predominate in the Patagonia and Monte units, followed by obsidian. In the Altoandina unit, the use of obsidian predominates followed by cryptocrystalline rocks. Therefore, hunter-gatherers selected the best quality raw material available for knapping – both spatially and temporally – in each unit. The Monte sites also show the use of rhyolites and other rocks of lower quality. In the Atuel valley, hunter-gatherers mostly used obsidian to make PP and other bifacial tools. In contrast, hunter-gatherers used cryptocrystalline rocks to make unifacial tools. However, in the Patagonia unit, there are numerous PP made of cryptocrystalline rocks. There is low use of basalts to make tools, but there are some unifacial and bifacial tools. In burials, there is evidence of PP made of rhyolites and vulcanites. Other technological trends observed in the Atuel valley include the scarcity of cores to transport rocks, the low or non-existent presence of cortex, and the scarce proportion of the initial stages of the reduction sequence (*Pompei 2019*). There may be a sample bias in the assemblages, which all belong to large excavated sites and a portion of their stratigraphic record.

In the Payén area, Laura Salgán (*2013*) analysed lithic assemblages from surface and stratigraphic sites. In this location, cryptocrystalline rocks predominate, followed by obsidian, basalts, and other raw materials (Fig. 1.b). The results suggest exploitation of local rocks, such as cryptocrystalline and non-local obsi-

dian, available in the north and centre of the area (*Salgán 2013*). The strategy of cryptocrystalline rock procurement presents scarce preparation techniques, evidence of conveyance of base forms, and, in lower frequency, cores (*Salgán 2013*). Hunter-gatherers used and discarded formal tools without evidence of fractures. In contrast, obsidian appeared as bifacial tools, mostly in fractured states. Salgán (*2013*) considered local raw materials within a range of 40km as local, and thus sources beyond this radius as non-local. The use of local basalts and rhyolites to make tools was occasional. Obsidian can be considered non-local, except for Laguna del Maule 2 and Cerro Huenul, located less than 40km from archaeological sites south of the Payén area (*Salgán 2013*).

Regional lithic resource base in Altoandina, Patagonia, Monte

The characterization of the lithic resources regional base (LRRB), in conjunction with petrographic and geochemical studies on rocks, provides relevant information to advance the comprehension of technological strategies adopted by human societies (*Ericson 1984; Nelson 1991*; *Aragón, Franco 1997*; *Franco, Aragón 2004*; *Berón 2006).* This approach generates a framework for expectations regarding the distribution, availability, accessibility, and abundance of raw materials in a given area or region. This information is crucial to understand the procurement modes, transport, and utilization of rocks – allowing us to discuss mobility patterns, action ranges, and possible interactions with other human populations (*Binford 1979*; *Lyons* et al. *2003; Franco 2004*).

We generated the LRRB of southern Mendoza from three complementary lines of information (*Salgán* et al. *2022*): (1) bibliographic revision of the geologic and lithologic characteristics of the different environmental units, which allowed us to estimate the distribution and localization of potential sources of raw materials suitable for knapping; (2) a targeted survey of geologic formations and sampling of rocks close to water courses, following the geological and archaeological background (*e.g., Gambier 1980*; *Lagiglia 1997; 2002; Durán 2000*; *Gil 2006; Neme 2007*), which made it possible to establish the availability, quality, relative abundance, variability and accessibility of raw materials suitable for knapping (*Torrence 1989*); and (3) petrographic analysis of cryptocrystalline outcrops (*Salgán* et al. *2014b*) and determinations of obsidian nodules from known sources and samples from archaeological sites and collections. This approach improved the knowledge of the genesis of such tools, geological characteristics, and preferred locations (*Giesso* et al. *2011; Cortegoso* et al. *2012*; *Salgán* et al. *2012; 2020*; *Barberena* et al. *2019*).

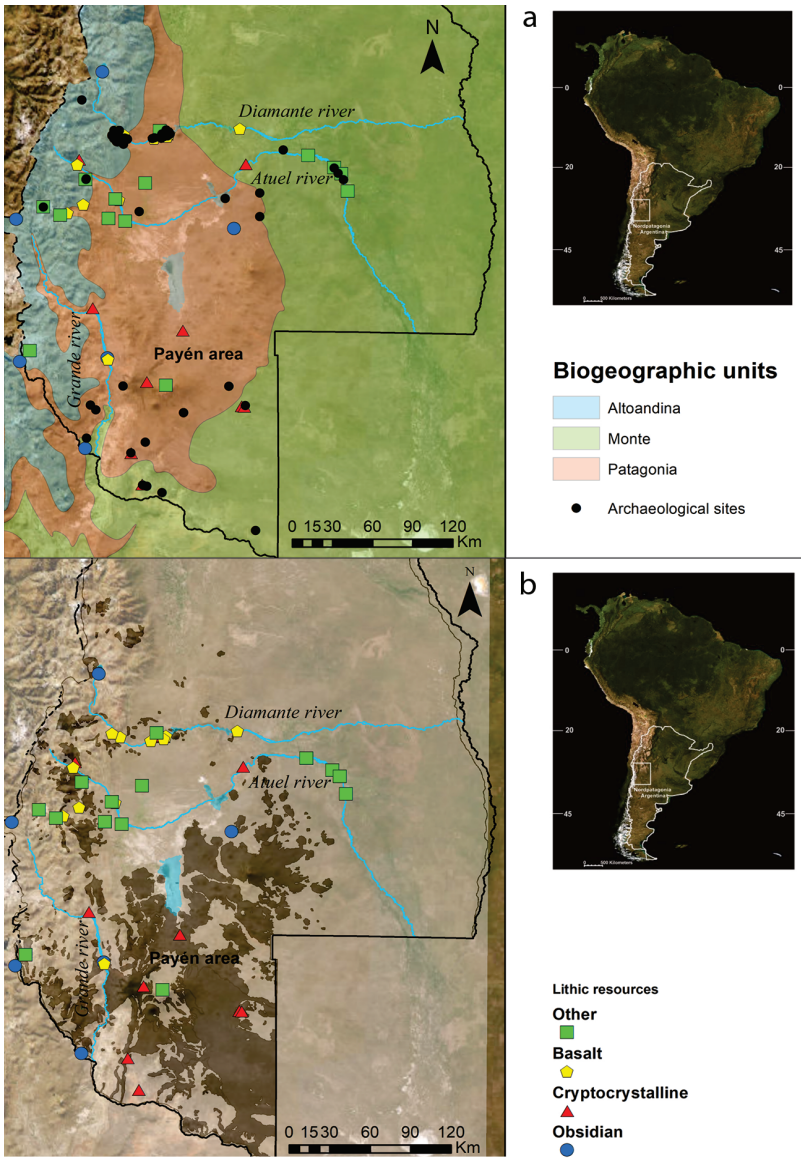

Fig. 1. **a** ***Biogeographic units and archaeological sites with lithic assemblages (black dots).*** **b** ***Lithic resources regional base from southern Mendoza. Basalt formations are in dark grey.***

Salgán *et al.* (*2022*) divided southern Mendoza into three biogeographic units associated with phytogeographic provinces – Altoandina, Patagonia, and Monte (*Cabrera 1976*; *Oyarzabal* et al. *2018*) – to test the use of lithic resources and their possible connectivity among the biogeographic units (*Nelson 1991*). The unit Altoandina includes the Andes cordillera, with altitudes of 2200masl (*Neme, Gil 2012*). Raw materials have seasonal accessibility, and are predominantly sedimentary rocks of marine origin (sandstones, silicified sandstones, and conglomerates, among others) and igneous rocks (basalts, rhyolites, andesites, basandesites, obsidian, and tuffs) (*Nullo* et al. *2005; Sepúlveda* et al. *2007*).

Many of these rocks required transport through the hydric basin that runs west to east, such as along the Diamante, Atuel, Salado, Malargüe, and Grande rivers. Salgán *et al.* (*2022*) documented different obsidian primary sources of excellent quality for knapping with four geochemical signals.

(1,2) Laguna del Diamante and Arroyo Paramillos in the Diamante volcanic complex (34° south latitude) (*De Francesco* et al. *2006*; *Cortegoso* et al. *2020),* present small nodules of variable quality; the radii of use ranges 40–100km in linear distance between the source and the sites, especially towards the west side of the Andes cordillera (*Cortegoso* et al. *2020*).

(3) Las Cargas, next to the volcanic complex Pteroa and El Cura stream (35° south latitude) (*Salgán* et al. *2015*), presents excellent quality for knapping in an area of 1km^2, expanding its availability area downstream due to the action of glaciers. This source presents the highest record of use across central western Argentina in sites at distances of 40 to 100km, with evidence of transport beyond 300km (*Giesso* et al. *2011; Cortegoso* et al. *2012*; *Nami* et al. *2015*).

(4) Laguna del Maule, located in the homonymous volcanic complex (between 36° and 37° south latitude) (*Seelenfreund* et al. *1996*; *Durán* et al. *2004*), presents two geochemical subtypes, Laguna del Maule 1 and Laguna del Maule 2 (LM1 and LM2, respectively) (*Barberena* et al. *2019*). These sources differ in their accessibility and availability, but are of excellent quality for knapping. LM1 outcrops as lava flows and blocks in Altoandina, while LM2 appears as nodules transported through the Barrancas and Colorado rivers in the piedmont. LM1 presents a higher use in the 40–100km distance range to sites, with evidence of transport beyond 200km. In contrast, LM2 presents more substantial evidence of local use within the 0–40km range, and less evidence of transport (*Barberena* et al. *2019*).

The Patagonia unit includes the Andean piedmont (2200 and 1200masl) and the volcanic field La Payunia. The rocks are available annually and present high variability. In the north centre of the unit, between the Diamante and Atuel rivers, sedimentary rocks and deposits predominate (*Sepúlveda* et al. *2007*), with scarce rocks of volcanic origin, mainly olivine basalts and basaltic breccias (*Nullo* et al. *2005*). In the south, there are rocks which are the product of the retro arc volcanic complex La Payunia, integrated with olivine basalts, ignimbrites, tuffs, and trachytes (*Narciso* et al. *2001*), and cryptocrystalline rocks of hydrothermal and sedimentary origin (*Salgán* et al. *2014b*). The sampling of raw materials in the Patagonia unit (*Salgán* et al. *2022*) indicates sources of cryptocrystalline rocks (*Durán 1997*; *Campos* et al. *2006*), the obsidian source Coche Quemado (*Salgán* et al. *2020*), and basalt (*Durán 1997*; *Neme* et al. *2011*; *Salgán* et al. *2022*).

In the south of La Payunia, the geologic information (*González Díaz 1972; Narciso* et al. *2001*) and the petrographic studies on quarries, archaeological materials, and potential sources indicate a high occurrence of cryptocrystalline rocks, as nodules of diagenetic origin (*Salgán 2013; Salgán* et al. *2014b*). In this biogeographic unit, there are two geochemical signals for obsidian sources: El Peceño (with subtypes El Peceño-1 and El Peceño-2), located in the eastern plains, next to the Monte biogeographic unit (*Salgán, Pompei 2017*); and Coche Quemado, registered in the middle course of the Grande river, next to El Payén (*Salgán* et al. *2020*).

The Monte biogeographic unit covers the east of the extra-cordilleran plains, with an altitude below 1200masl (Fig. 1.a). This unit has eolian and alluvial sediments which form the eastern plain (*Sepúlveda* et al. *2007*). Some hills interrupt the landscape, with a lithology composed of andesites, trachyandesites, basalts, rhyolites, obsidian, and dacites (*Sepúlveda* et al. *2007*). In the samplings done in the eastern portion of the Atuel river, there are rhyolites and cryptocrystalline rocks of good to excellent quality for knapping, available as secondary sources (*Pompei 2019*; *Salgán* et al. *2022*). Although these rocks have diverse qualities and are available throughout the

year, there is generally limited access to them. This is likely due to the small nodules and low visibility related to vegetation cover and sediment deposits.

Projectile points from a biogeographical approach

PP present an identifiable morphology and are recurrent in the archaeological record, and offer analytical possibilities that other artefacts do not have (Fig. 2). PP are a complex technology, their design and maintenance were influenced by cultural norms (*Knecht 1997*), the necessity for reliable tools (*Bleed 1986*), functional efficiency (*Smith 2015*), provisioning strategies (*Thomas 2012*), and the quality and availability of raw materials (*Smith 2015*). There are various advantages with regard to using PP in lithic studies: (1) morphological types can provide relative chronology (*Thomas 1981*); (2) they provide indirect evidence of prehistoric subsistence strategies, including when there are no faunal remains (*Hockett, Murphy 2009*); (3) they allow the reconstruction of foraging areas or exchange networks thanks to their link to specific geological sources (*Smith 2015*); (4) they make it possible to infer weapons systems, which combined with other factors such as topography and prey ethology, can generate models of hunting strategies (*Martínez 2003; 2007*).

In central western Argentina, the studies centred on the analysis of PP focused on the interaction between agricultural and hunter-gatherer societies (*Castro* et al. *2018*). In southern Mendoza, the related PP studies examine their use as chronological markers *(Lagiglia 1977; 1997*; *Gambier 1980*), as part of regional studies (*Durán 1997*; *Gil 2006*; *Neme 2007*), or engage in technological analysis from a biogeographic perspective (*Salgán 2013; Franchetti 2019; Pompei 2019*).

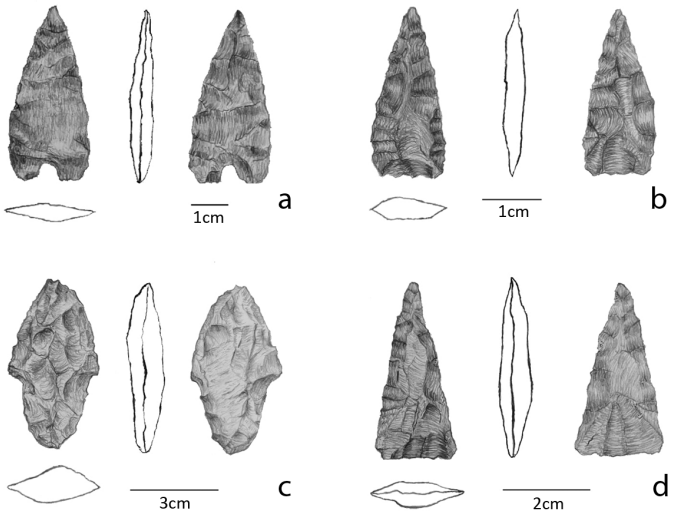

Fig. 2. Projectile points from southern Mendoza. Note: non-stemmed projectile points: **a, b, d*; stemmed projectile points:*** **c,** ***Atuel River:*** **a,** ***91-5CS Lowlands. La Payunia:*** **b,** ***SRALAM14 Piedmont. Diamante River:*** **c,** ***unit 323 Piedmont.*** **d,** ***FS 12 Highlands.***

Materials and methods

The PP analysed in this study belong to samples from the Diamante river (*Franchetti 2019*), the Atuel valley (*Pompei 2019*), and El Payén (*Salgán 2013*) (Figs. 1 and 2). We studied 203 PP from the Altoandina (37%, n=75), Patagonia (51%, n=103) and Monte (12%, n= 25) biogeographic units. The sample includes artefacts from surface recollections (isolated findings and archaeological sites), systematic random sampling of the surface, and excavations of base camps and burials.

The analysis of PP did not include preforms and followed a techno-morphological approach (sensu *Aschero 1975*; *1983)*. The variables selected are: raw material, presence or absence of stem, and state of fragmentation (entire or fractured). For the entire pieces, we measured length, width, and thickness in millimetres, according to the morphological axis (sensu *Aschero 1975*; *1983*), and weight in grams. This last measure avoids the redundancy in the size measures and allows us to estimate the relevance of each raw material. We counted the segments present for the fractured pieces, following these categories: tips, tip-mesial fragments, mesial fragments, basal-mesial fragments, and basal fragments (in both stemmed and non-stemmed PP) (*Martínez 2003; Belardi* et al. *2005)*. We measured the maximum width and thickness for basal-mesial, stem, and basal fragments. In the entire PP, we calculated volume in mm^3, multiplying length, width, and thickness, then dived by 100.

To avoid an oversized sample we calculated the minimum number of PP required for the analysis (*Belardi* et al. *2005*), which considers the frequency of all the PP, summing fragments of basal-mesial and basal fragments. In addition, we calculated the manufacture and replacement index from Daniel S. Amick (*1996*), as obtained by the quotient between basal plus mesial fragments, and tips plus mesial fragments in each unit. This allows us to estimate and compare which biogeographic

unit had more or less discard and replacement of PP. In addition, we calculated the production index, obtained by dividing the total PP by the total number of tools (*Salgán 2013*). We also calculated the functional adscription of the PP, in an exploratory approach, following Michael J. Shott (*1997*) and Jorge G. Martínez (*2003*), which makes it possible to differentiate between the form of propulsion and weapon system present in the archaeological record *(Ratto 1991; Shott 1997*; *Martínez 2003*). In particular, we used the classification for weight from Martínez (*2003*), in which ranges from less than 4 grams for arrows, to between 4 and 20 grams for darts, and between 21 and 70 grams for spears (*Martínez 2003*; *Heider, Rivero 2018*).

Raw Material	Biogeographic unit					
	Altoandino		Patagonia		Monte	
	n	%	n	%	n	%
Cryptocrystalline	1980	43.1	5987	60.9	1771	80.6
Obsidian	651	14.2	1770	18	327	14.9
Basalt	185	40.4	1818	18.5	35	1.6
Others	105	2.3	256	2.6	64	2.9
Total	**2921**	**100**	**9831**	**100**	**2197**	**100**

Tab. 1. Frequencies and percentages of artefacts by raw material in each biogeographic unit.

We complemented these measures with the analysis of the discriminant function, which uses lineal dimensions from PP, calculated through equations to differentiate arrows from darts (*Thomas 1978; Shott 1997; Castro* et al. *2018; Heider, Rivero 2018*). We considered the maximum width to apply the Shott (*1997*) functions. We determined darts using 1.4 multiplied by the maximum width minus of 16.85. On the other hand, we determined arrows using 0.89 multiplied by the maximum width minus of 7.22. We compared the results from both equations and made a functional assignation according to the higher results. When it was possible to distinguish between final and initial Late Holocene samples, we compared the raw materials used to make PP.

Results

Discriminant analysis of lithic projectiles

The results for the raw materials selected to produce stone tools in the Altoandina, Patagonia, and Monte biogeographic units indicate that in all of them the use of cryptocrystalline rocks predominates (Tab. 1). This is most evident in Monte (80.6%), followed by Patagonia (60.9%), and Altoandina (43.1%). The second type of rock with the highest use for stone tools varies among the biogeographic units: in Altoandina and Patagonia it is basalt (37.1% and 18.5%, respectively), while in Monte it is obsidian (14.8%). The results for raw materials selected to produce PP show that in Altoandina and Patagonia the use of obsidian to make PP predominates, followed by basalt in Altoandina, and cryptocrystalline rocks in Patagonia (Tab. 2). Figure 1 highlights the presence of basalt in southern Mendoza. However, sampling in the field showed differences in the quality for knapping among the biogeographic units (*Salgán* et al. *2022*). In Altoandina the samples presented very good to moderate quality, while in Patagonia and Monte they were mainly of lower quality, being good to regular (*Salgán* et al. *2022*). In Monte, the use of obsidian as the second common raw material occurs due to the scarcity of knapping rocks in the landscape. In this area, we observed 2.9% of other raw materials and 1.6% of basalt use (Tab. 1).

In Altoandina and Patagonia, the third raw material used is obsidian, available in both environments as primary sources, and in Patagonia also found as a secondary source. This indicates a significant influence of the LRRB in the selection of rocks to make PP. In Altoandina and Patagonia the best rocks available are the most used. In contrast, in Monte, with a lack of quality rocks, the lithic resources recorded as the second most used are the best raw material available in the neighbouring areas. An example is the obsidian from El Peceño located in Patagonia, seen in the assemblages of Monte (*Salgán, Pompei 2017*; *Pompei 2019*). In addition, Monte shows the highest variety of rocks used to manufacture tools.

Raw Material	Biogeographic unit					
	Altoandino		Patagonia		Monte	
	n	%	n	%	n	%
Cryptocrystalline	18	24	22	21.4	13	52
Obsidian	30	40	71	68.9	9	36
Basalt	27	36	10	9.7	1	4
Others	-	-	-	-	2	8
Total	**75**	**100**	**103**	**100**	**25**	**100**

Tab. 2. Frequencies and percentages of projectile points by raw material in each biogeographic unit.

Table 3 shows PP by biogeographic units, raw material and state of fragmentation (entire or fractured). The PP are either fractured (62%) and entire (38%). The tips, mesial fragments, and tips-mesial fragments have higher frequencies in Altoandina and Patagonia compared to Monte. We calculated the minimum number of PP from the available fragments, which is 139, 68% of the PP (Tab. 3).

The main raw material used for PP in Altoandina and Patagonia is obsidian, and for Monte it is cryptocrystalline rocks (Fig. 3.a). In Altoandina, basalts and cryptocrystalline rocks are used equally to make PP as the second most common raw materials. In Patagonia, cryptocrystalline rocks and basalts were the second and third most common raw materials used to make PP, respectively. In Monte, cryptocrystalline rocks were the most often used to make PP, followed by obsidian, basalts, and other raw materials (vulcanites and rhyolites).

The analysis of entire PP and fragments with a base allowed us to separate the sample according to the hafting area, in non-stemmed PP or bases without a stem (n=98) and stemmed PP (n=41). In Figure 4, we observed a more significant frequency of non-stemmed PP in Altoandina (n=50), especially those made of obsidian, basalt, and cryptocrystalline rocks. In Patagonia, we observed non-stemmed PP made of obsidian, basalt, and cryptocrystalline rocks (n=36). In Monte, we observed non-stemmed PP made of cryptocrystalline rocks, obsidian, basalt, and other raw materials (vulcanite and rhyolite) (n=12). In contrast, we observed a higher frequency of stemmed PP in Patagonia (n=33), made of obsidian, cryptocrystalline rocks, and basalt (Figs. 2 and 4). In Monte, there is a low frequency of stemmed PP (n=7) made of cryptocrystalline rocks and obsidian (Figs. 2 and 4). In Altoandina there is only one stemmed PP made of obsidian (Figs. 2 and 4). The discard and replacement index (*Amick 1996*), indicates that there was more replacement of pieces in Monte (1,7), followed by Patagonia (1,3), and Altoandina (1,2).

Table 4 shows the averages for length, width, and thickness that were used in the volume calculation. In the three biogeographic units, the averages for this variable indicate lower values for PP made of obsidian. In Patagonia and Monte, the PP made of basalt have a higher volume, while in Altoandina the PP made of cryptocrystalline rocks have a higher volume. In Patagonia, the PP of all raw materials have a higher volume compared to those from the other biogeographic units. We observed a similar trend with regard to the weight. Figure 3.b compares the average weight of PP by biogeographic unit, showing a large difference with regard to Patagonia (4.2 ± 1.1g) compared to Altoandina (2.7± 0.5g) and Monte (2.7± 0.7g) at an 80% confidence level. There are no significant differences in the weight averages between Altoandina and Monte.

To explore changes over time, we selected 32 PP from seven stratigraphic sites (three from Patagonia and Monte, one from Altoandina) from the Atuel river and El Payén area. We aimed to test changes in the use of raw materials between the Initial Late Holocene (ILH) 4000–2000 years BP, and the Final Late Holocene (FLH) 2000–200 years BP (*Pompei 2019*). Figure 5 shows that in both periods of the Late Holocene PP were mostly made of obsidian, followed by cryptocrystalline rocks. In the FLH there was a higher variety in the rocks used to make PP, with the incorporation of basalt, rhyolite, and vulcanite. In

	Biogeographic units													
	Altoandina				**Patagonia**				**Monte**					
	Cc	Obs	Bas	**Tot**	Cc	Obs	Bas	**Tot**	Cc	Obs	Bas	Others	**Tot**	Total
Tips	2	6	4	**12**	9	8		**17**	1	3			**4**	33
Tips + mesial		1	4	**5**		3	1	**4**		1			**1**	10
Mesial	3	4		**7**	2	11		**13**	1				**1**	21
Mesial+ base	5	3	5	**13**	2	4	1	**7**	2			1	**3**	23
Base	1	5	2	**8**	2	22	1	**25**	2	4			**6**	39
Entire	10	11	9	**30**	7	23	7	**37**	7	1	1	1	**10**	77
Total	21	30	24	**75**	22	71	10	**103**	13	9	1	2	**25**	203
MNPP	16	19	16	**51**	11	49	9	**69**	11	5	2	2	**19**	139

Tab. 3. Section of projectile points by raw material and biogeographic unit: **Cc** ***cryptocrystalline rocks;*** **Obs** ***obsidian;*** **Bas** ***basalt;*** **MNPP** ***minimal number of PP.***

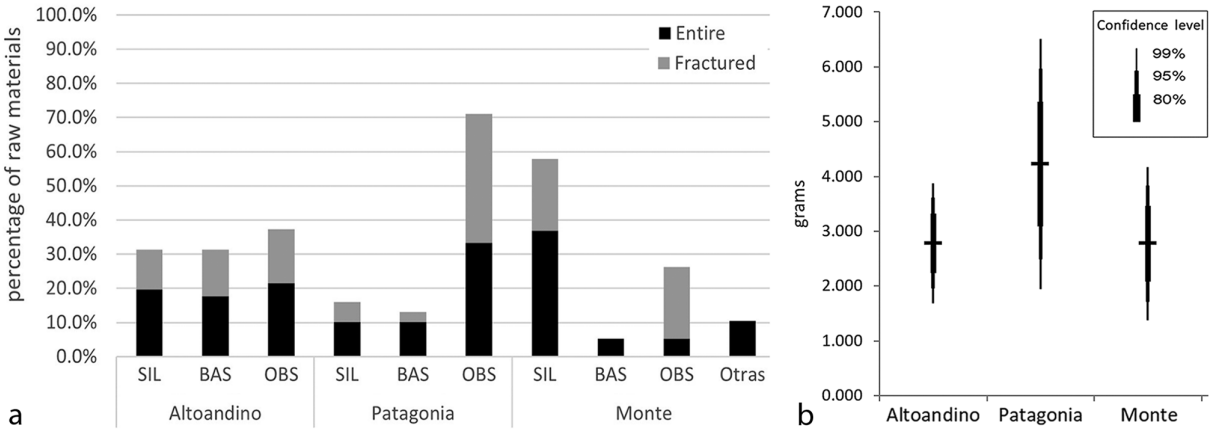

Fig. 3. **a** ***Percentages of raw materials and fracture state of projectile points by geographic unit.*** **b** ***Weight in grams of projectile points.***

both temporal blocks, non-stemmed PP predominate. There was only one stemmed PP in the cryptocrystalline rocks for the HTF.

We also explored the possibility of distinguishing between arrows and darts (*Shott 1997; Martínez 2007*). To apply this approach the samples must have a measure for the maximum width of the base and chronological context with radiocarbon dates. We explored this analysis in the Atuel valley samples in which 32 pieces met these criteria. The results showed that 87% (n=28) of the samples could be classified as arrows, and 13% (n=4) as darts. In the ILH, we observed only arrows made of obsidian and cryptocrystalline rocks. In the FLH, we observed arrows made of obsidian, cryptocrystalline rocks, basalts, rhyolites, and vulcanites. In contrast, in the same period we also found darts made of cryptocrystalline rocks (Fig. 5).

Discussion and conclusions

Technological studies in the biogeographical models of southern Mendoza

The variability in the availability and access to good quality raw materials for knapping at a large spatial scale has a marked influence on the production of PP (*Salgán* et al. *2022*). In Altoandina and Patagonia, the most commonly used raw material was obsidian, and in Monte it was cryptocrystalline rocks. This predominance of obsidian PP might be due to its knapping characteristics, penetration attributes, and high fragility inside the prey (*Belardi* et al. *2005*). In addition, there is specific evidence of conveyance by hunter-gatherers using highland routes to transport obsidian PP and bifaces from the Las Cargas source to highland villages, and then to intermediate valleys and the Piedmont (*Franchetti* et al. *2022*).

In the three biogeographic units the non-stemmed PP morphology predominates. In Altoandina, non-stemmed PP are made of obsidian and basalt, with a lower average size than in Patagonia and Monte. In Patagonia the non-stemmed PP also predominates. However, in sharp contrast, Patagonia has a higher proportion of stemmed PP (51%). Hunter-gatherers used obsidian and cryptocrystalline rocks to make both morphologies, and the size and weight of the PP are roughly the same in Altoandina and Monte. Despite the small sample size in Monte, we can observe some non-stemmed PP made of cryptocrystalline rocks and other raw materials, and very few stemmed PP.

Humberto Antonio Lagiglia (*1974*) and Mariano Gambier (*1980*) observed this spatial difference for the Early Holocene in the PP morphology: non-stemmed PP in Altoandina, and the coexistence of stemmed and non-stemmed PP in Patagonia and Monte (Figs. 2 and 4). In this paper, we observed the same pattern for the Late Holocene. This corresponds to standardized hunting practices in Altoandina, which require a specific weapon, such as the bow and arrow. In contrast, in Monte and Patagonia various hunting strategies would lead to the production and use of both hafting techniques.

The presence of non-stemmed PP in Altoandina, made of obsidian, is probably related to the bow and arrow weapon system associated with individual hunting or small hunting groups chasing prey of various sizes. This high frequency of obsidian non-stemmed PP may also be related to the discarding of entire pieces and replacement in quarry areas, or other spaces different from the occupation sites, given the low replacement index (*Amick 1996*). The tips and tip-mesial

fragments in Altoandina may be due to the fact that they entered the sites with the prey after the animals had been processed, suggesting that the PP were not lost on killing grounds. The low number of basal fragments may indicate the difficulty of recovering hafts on steep terrain and the related difficult access, and thus the PP were not discarded at residential camps (sensu *Amick 1996*).

ALTOANDINO						
Raw Material	**n**	**Lenght mm**	**Width mm**	**Thickness mm**	**Volumen mm³**	**Weight gr**
Cryptocrystalline	10	30,9	19,9	6,1	37,51	3,6
Basalt	9	31,4	19,8	5,8	36,06	4,1
Obsidian	11	21,9	13,7	3,8	11,40	1
Total	**30**	**27,7**	**17,6**	**5,2**	**25,35**	**2,8**
PATAGONIA						
Cryptocrystalline	7	39,1	23,4	6,4	58,56	7
Basalt	7	42	25,3	7,7	81,82	8,7
Obsidian	23	24,3	15,1	4,2	15,41	2
Total	**37**	**30,4**	**18,6**	**5,3**	**29,97**	**4,2**
MONTE						
Cryptocrystalline	7	32,2	15,4	5	24,79	2,6
Basalt	1	47	15	6	42,30	3,5
Obsidian	1	13,7	8,9	2,9	3,54	0,3
Others	1	46,5	16	6	44,64	4,4
Total	**10**	**34,5**	**14,9**	**5,1**	**26,22**	**2,8**

Tab. 4. Projectile points metric variables by raw material and biogeographic unit.

We observe a different situation in Patagonia and Monte, where there are both weapons systems (bow and arrow, and darts). In these areas, there was more emphasis on collective hunting, with ambush hunting for big game prey in open areas. This led to a higher replacement rate on certain sites, especially in Monte. The higher discard and replacement index of PP on Monte may also be related to the quality of cryptocrystalline rocks, and to the topographic characteristics of the plains, which could require collective hunting.

Carlos A. Aschero and Jorge G. Martínez (*2001*) considered topographic resources as important for hunting strategies. In Altoandina, the steep slope of the terrain could facilitate the ambush of the fauna toward areas of confinement with the use of a bow and arrow. In contrast, Patagonia and Monte demand other techniques and strategies with the participation of a higher number of hunters, which would minimize the possibility of losing prey (*Ratto 1993*).

In the context of Argentinean Patagonia, Juan Bautista Belardi *et al.* (*2021*) proposed that different ambush tactics may have involved individual and collective hunting events, which could reflect the complementary seasonal use of terrain at different altitudes. In southern Mendoza, we observe a similar pattern related to the annual seasonal round, prey availability, weapons systems used for hunting, and the construction of stone structures, such as parapets. Patagonia and Monte could have been used intensively across the year, with access to a broader range of prey. In Altoandina, the seasonal availability of the area and a higher focus on guanaco

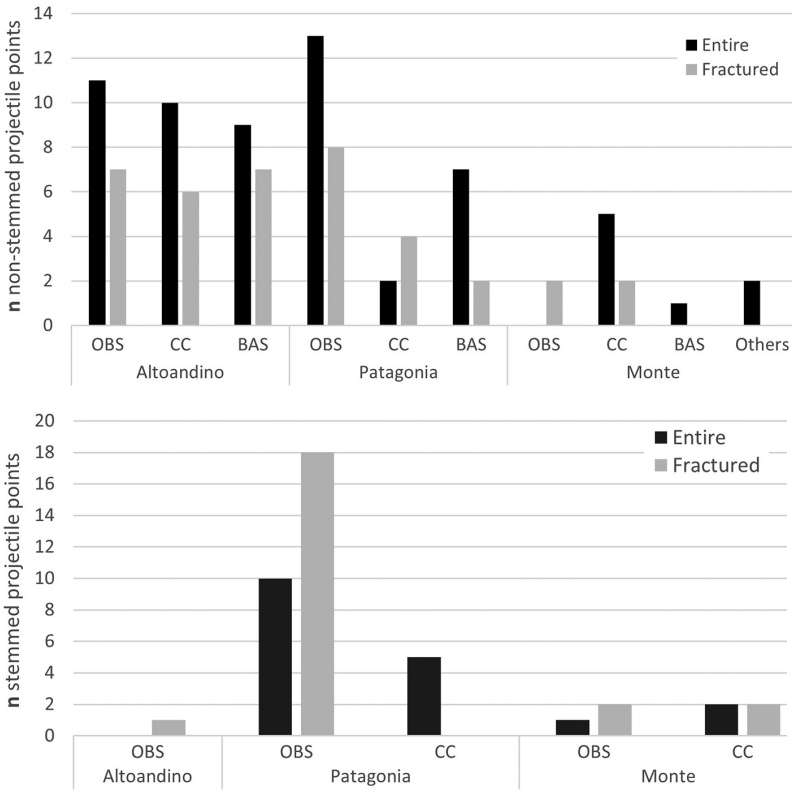

Fig. 4. Frequencies of stemmed and non-stemmed projectile points in the biogeographic units.

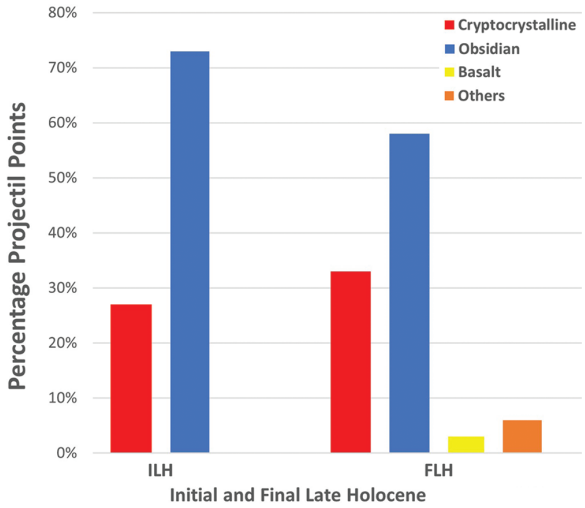

Fig. 5. Raw materials of projectile points in the Late Holocene.* ILH *Initial Late Holocene;* FLH *Final Late Holocene.

at specific locations (*Otaola* et al. *2019*) challenged hunter-gatherers to use more reliable PP (*Bleed 1986*). Here it is notable that Ratto (*2003*) suggested the bow and arrow is a more flexible technology that allows both individual and collective hunting. At the same time, hunter-gatherers used it for large and small prey, with a size range between 23 to 230kg.

We observed small differences in PP weight between Altoandina and Monte, but a much higher weight in Patagonia. Obsidian PP present the lower values for length, width, and thickness, while basalt PP present the higher values. This may imply specific raw material selection for each weapon or hunting strategy. A similar pattern occurs at lower latitudes of Argentinean Patagonia, where stemmed obsidian PP are smaller and more homogeneous in their dimensions compared to PP made of cryptocrystalline rocks (*Belardi* et al. *2005*; *Cassiodoro* et al. *2020*). In contrast, non-stemmed PP show more variability in their sizes.

In the temporal exploration of the sample from the Atuel valley, we found that PP were mostly made of obsidian during the ILH and FLH, followed by cryptocrystalline rocks. In the exploratory analysis of metric differences between arrows and darts, we found differences in comparison to the results of Silvina Celeste Castro *et al.* (*2018*) for northwest San Juan and central Mendoza. These earlier authors suggested that the bow and arrow replaced the weapons systems based on darts and spears in the Late Holocene due to the diffusion of this cultural trait from north to south (*Castro* et al. *2018*). Our results indicate the coexistence of both systems during the Late Holocene of southern Mendoza. In Patagonia and Monte during the FLH, there is evidence of the use of both hunting practices, bow and arrow, and darts with the atlatl. These findings must be considered preliminary, but do suggest the use of both weapons systems during the Late Holocene. The choice of system relates to prey size, the topographic characteristics of the environment, and the hunting strategies used by human groups (*Martínez 2007*).

Guillermo Heider and Diego Rivero (*2018*) mentioned that for the central pampean area of Argentina, the use of both stemmed and non-stemmed PP is related to functional requirements, which would vary according to the open or narrow locations in the landscape. Their results show that the morphological variations in PP are not related to different weapons systems.

Finally, Gustavo Neme, and Adolfo F. Gil (*2008*) proposed that the occupation of marginal environments, such as Altoandina and Monte, was due to a demographic increase, or when the technology necessary to secure subsistence in such areas was available. The coexistence of stemmed and non-stemmed PP in Patagonia, and non-stemmed PP in Altoandina, could indicate that the technological innovation of the bow and arrow made the effective occupation of such environments successful.

Conclusions and future directions

This work constitutes a starting point to integrating the lithic record in the focal areas, and particularly the projectile points registered in each biogeographic unit. In future works we aim to integrate a more significant number of sites and incorporate other temporal variables that would help us understand changes and continuities in the identified trends.

In the future, it would be helpful to explore elements associated with strategies and hunting techniques in open-air sites in southern Mendoza. We also need to integrate information from the identification of parapets, sighting places, interception, and ambush locations of prey, linked to the information available on butchering sites and changes in the size of prey.

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Technological transformation of the bone at the Eneolithic tell settlement of Vitănești, southern Romania (Gumelnița B1 level)

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ABSTRACT - *This paper discusses the technological exploitation of bone at the tell settlement of Vitănești (southern Romania). A total of 307 artefacts from the Gumelnița B1 level were analysed for this study, which can be assigned to four product and sub-product categories (waste, blanks, preforms, finished pieces). At the level of determined bones, the most numerous are those belonging to large species, both domestic and wild mammals. We also note the use of bones belonging to species rarely found in the Eneolithic bone industry (*Bos primigenius, Equus ferus, Canis familiaris*) in the Lower Danube. At the typological level, bevelled tools predominate, along with pointed tools and projectile points. A varied range of other typological categories includes spatulas, abraded astragalus, spindle whorls, burins, needles, and figurines, among others. The large quantity of preforms proves that the production of the assemblage was carried out* in situ*. It is an interesting assemblage which proves that the bone pieces were involved in various activities within the Vitănești community that lived at the end of the 5th millennium BC, from the processing of hides or vegetable fibres to hunting. This assemblage could serve as a reference for future studies, as there are not many comparable assemblages for the same period in Southern Romania.*

KEY WORDS – *Eneolithic; Gumelnița B1 level; Romania; bone; tools and weapons; technological analysis; functional hypotheses*

Tehnološko preoblikovanje kosti na eneolitskem tell naselju Vitănești, južna Romunija (nivo Gumelnița B1)

IZVLEČEK – *V članku obravnavamo tehnologije izkoriščanja kosti na naselbini tipa tell Vitănești (južna Romunija). Analizirali smo 307 artefaktov iz plasti Gumelnița B1, ki jih je mogoče razvrstiti v štiri kategorije izdelkov in polizdelkov (odpadki, surovci, predoblike, končni izdelki). Med determiniranimi kostmi jih največ pripada velikim vrstam, tako udomačenih kot divjih sesalcev. Opažamo tudi uporabo kosti živalskih vrst, ki jih sicer redko najdemo v eneolitski kostni industriji v Spodnjem Podonavju (*Bos primigenius, Equus ferus, Canis familiaris*). Med tipološko določenimi orodji prevladujejo poševna in koničasta orodja ter puščične osti. Med ostalimi so pogoste lopatice, obrabljeni astragali, predilna vretenca, vbadala in igle ter figurice. Veliko število predoblik dokazuje, da so bile izdelane v naselju. Gre za zanimiv skupek, ki dokazuje, da so bili koščeni izdelki vključeni v različne dejavnosti v skupnosti, ki je v Vitănești živela na koncu 5. tisočletja pr. n. št. (od predelave kož in rastlinskih vlaken do lova). Skupek lahko služi kot referenca za prihodnje študije, saj v južni Romuniji ni veliko primerljivih zbirov za to obdobje.*

KLJUČNE BESEDE – *eneolitik; Gumelnița nivo B1; Romunija; kosti; orodje in orožje; tehnološka analiza; funkcionalne hipoteze*

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Introduction

The analyses of the faunistic remains and osseous industry found at the Vitănești site are made on representative assemblages, comprising the whole inventory of each habitation level as a result of the large scale excavations of the tell settlement. The complete excavation of the upper-most habitation level belonging to the last phase (B1) of the Gumelnița culture offered the basis for the analysis of the worked antler (*Mărgărit* et al. *2022*) and bone assemblages presented in this article. A total of 307 artefacts were analysed for this study, representing an important assemblage as a reference for future studies, as there are not many comparable examples for the same period in Southern Romania.

Chronological and cultural context

The Vitănești archaeological site is located in Teleorman County, 7km east of the city of Alexandria and about 80km south-west of Bucharest. Vitănești-*Măgurice* is a tell settlement located in Teleorman River Valley, with a relatively round shape, having a 40–45m diameter at its upper part, 90–95m at its lower part and a 6m height. It is situated near the Teleorman River's north-eastern terrace, which slowly descends to the floodplain, being protected by the terrace on its east and north sides. The Teleorman River flood plain opens to its west and south, having about 1km width (Fig. 1).

The settlement belongs to the Gumelnița culture, which is chronologically placed in the last half of the 5th millennium BCE. After 28 excavation seasons, the two upper-most habitation levels were almost completely researched, revealing a very rich settlement. To mention just two of the most precious artefacts, a gold pendant and a Thinker type clay figurine with shell eyes were discovered at the site (*Andreescu* et al. *2003. 75; 2009. 75–76*; for a comprehensive review of the literature on the research at Vitănești see *Andreescu* et al. *2022. 457–478*).

In 1993, archaeological research began in the Vitănești settlement, as part of a partnership between the National History Museum of Romania and the Teleorman County Museum. The archaeological excavations were led by Radian Romus Andreescu.[1] The general aim of research was the investigation of the main characteristics of the Neolithic and Eneolithic habitation from the Teleorman area. The research had several specific objectives. One of them regarded the genesis and evolution of the tell settlement and its relation with the environment. Two sedimentological sondages were made on the tell slope, and a large area (10x30m) for stratigraphic control was started in order to achieve this objective.

Fig. 1.* a, b *Vitănești-Măgurice tell-settlement, aerial photos by Ion Torcică, October 2022 (the white arrow indicates the site location near the Teleorman River terrace).

1 This paper was written in loving memory of Dr. Radian Romus Andreescu (1958–2022).

The second objective was to explore the dynamics of habitation in the tell settlement and surrounding area of the Teleorman River. To this end, archaeological research was carried out on a large scale in order to reveal, one by one, the various habitation levels and at the same time identify details regarding the spatial organisation of the settlements that later arose on the tell. The components of the living space investigated so far are several buildings and their interior features, among which the hearths are best preserved. Looking around the tell, the evaluation of the habitation dynamics lead to the discovery of a secondary flat settlement, named Vitănești II. For a wider view, the Vitănești settlement was integrated into the larger area of the Teleorman River, with a special attention to the relation with other tell-settlements.

The third specific objective was establishing the local characteristics of the Gumelnița culture by studying the different categories of artefacts made of clay, bone, stone, flint, copper, gold and other materials. Considering the very rich inventory discovered at Vitănești, most of the studies were dedicated to certain categories of artefacts, as follows: vessels and ceramic technology, anthropomorphic and zoomorphic figurines, anthropomorphic vessels, loom weights, flint tools, house models, consecration horns, and adornments (pendants) (*e.g., Andreescu, Mirea 2000; Andreescu 2006; 2009; 2012; Andreescu* et al. *2003; 2009; 2022; Moldoveanu 2008; 2012; Andreescu, Moldoveanu 2017; Torcică 2012; 2017; 2018a; 2018b; 2019; 2022; Crandell* et al. *2016; Bîrzu 2019*).

Vitănești settlement is rich not only in artefacts, but also in ecofacts/osteological materials. The identification of the different aspects of the paleo-economy is thus an important aim of the research. In this respect, a series of studies aimed at analysing both different assemblages of faunal remains and worked bones/antlers were carried out and are reported here.

Methodology

In the first phase, an analysis chart was drawn for each artefact, with observations on raw material (species, skeletal element), the type of object, and morphology; then followed investigations into the manufacturing technique (both main operations: debitage and shaping) and, finally, proposing a hypothetical function, based on from identified use-wear.

The artefacts were subdivided following their degree of finishing, resulting in four categories (waste, blank, preform, finished object). The presence of all the constitutive elements of an operational sequence offered clues regarding the *in situ* processing of the necessary toolkit for the community. The definition of typological categories was based upon the *Fiches typologiques de l'industrie osseuse préhistorique* (*e.g., Camp-Fabrer 1988; 1990; 1998; Ramseyer 2001; Patou-Mathis 2002 etc.*), starting from their morphology. Analytical criteria for the technological and functional interpretation of micro-marks were also established based upon the comparison with recent publications on the osseous industries in prehistory (*e.g., Choyke, O'Connor 2013; Vitezović 2018; 2020; Altamirano Garcia, Alarcón Garcia 2019; Orłowska, Osipowicz 2022*).

When the degree of preservation permitted, the objects were examined with a Keyence VHX-600 digital microscope, between 30x and 150x magnification. The images were focused with the aid of a camera incorporated within the microscope.

Archaeological assemblage

The osseous industry from the Vitănești site can be assigned to the four product and sub-product categories (Tab. 1). Their distribution is uneven, favouring finished products, which total 229 items (75% of the total products), whereas 16 objects (8%) were undergoing processing and there were 13 (4%) blanks and waste items. The archaeological assemblage is completed by an important category of 'undetermined objects' that includes 39 artefacts (13%). Such a substantial amount of preforms is rare in sites' inventories, and points to *in situ* manufacture and an interest for achieving a manufacturing stock. The result is a reserve for the immediate replacement of fractured objects and the strict management of raw materials.

Bevelled tools (n=54). Nine bevelled tools were made on blanks preserving the anatomical volume. No less than seven of these are processed ulna of *Bos taurus* (n=6) and *Sus domesticus* (n=1). From a technological point of view, we can observe a great unity of the bevelled tools made from ulna (Fig. 2.a,d,g,j), given the fact that is the same type of bone. The technological investment is minimal, using the natural shape of the bone, and thus it can be seen that the proximal epiphysis was removed by percussion without regularization of the debitage edges. Then a new percussion blow was given at the distal part, and the

Technological stage	Typological category	No of pieces
Finished piece	Bevelled tool	54
	Pointed tool	50
	Projectile point	44
	Rectangular plate	39
	Spatula	14
	Abraded astragalus	11
	Spindle whorls	5
	Burin	3
	Needle	2
	Figurine	2
	Mandible	1
	Knife	1
	Perforated phalanx	1
	Abraded phalanx	1
	Adornment	1
Preform		26
Blank		9
Waste		4
Undetermined object		39
TOTAL		307

Tab. 1. Typological categories present in the archaeological assemblage from the Vitănești site.

regularization of the plane was achieved by bifacial abrasion (Fig. 2.c,f,l).

Other types of bone were also used for bevelled tools on blanks in volume. Thus, a right tibia of *Canis familiaris* (Fig. 2.m) underwent a process of burning. The epiphysis was removed by percussion, without regularization of the debitage edges. The arrangement of the active end was initiated by percussion followed by the rigorous shaping of the debitage edges (Fig. 2.n). Being heavily burned, the use-wear fine striations have disappeared. The femur was another bone used from this species (Fig. 2.o). Intervention was done at the distal level, where percussion was applied, followed by abrasion of the debitage edges. This abrasion (Fig. 2.r) also extended on the upper face at the level of the extremity.

More numerous is the category of bevelled tools made on flat blanks (n=45). A first variant of bipartition involved percussion (Fig. 3.a,d). On some of the items, after applying percussion, the arrangement of the debitage edges took place by abrasion. This abrasion was also applied bifacially, at the level of the active end (Fig. 3.c,f). There is a less common procedure of shaping (Fig. 3.g), with diffuse indirect percussion (Fig. 3.i) which created the specific morphology, visible on the inferior side. There are specimens where the debitage edges (Fig. 3.j) remained unshaped. The active end was created by bifacial abrasion (Fig. 3.l) applied at the extremity.

Within the bipartition method, we have specimens with rectilinear extremity (Fig. 3.p). The active end was shaped by abrasion on both sides, applied on variable surfaces, depending on the specimen (Fig. 3.s). On the superior side, there was periodic intervention for the re-arrangement of the active end (Fig. 3.r). For this reason, the extremity shows lustre only on the *fil du tranchant*, the use-wear area being covered by the abrasion marks.

An interesting blank is a *Bos taurus/Cervus elaphus* humerus (Fig. 4.a). The epiphysis was removed without shaping the fracture edges. The bipartition of the bone was done by indirect percussion with the abrasion of the fracture edges (Fig. 4.c) only towards the distal level. This abrasion was also applied to create the active end, on both sides, at the extremity. As the abrasion is very obvious and the use-wear is not extended on the surface (Fig. 4.b), we consider it to be a reshaping of the active front.

Another bevelled tool was made on a longitudinally cut blank (Fig. 4.d), with the shaping of the debitage edges by abrasion (Fig. 4.f). Abrasion was also applied to both extremities. Starting from the fracturing, we think that it was used in indirect percussion. The same use in indirect percussion is attested for another piece (Fig. 4.h), obtained by *quadri*-partition by percussion where abrasion was applied only at the level of the active end (Fig. 4.i).

The longitudinal debitage by the *quadri*-partition method (Fig. 4.j) resulted in obtaining an irregular blank, and the proximal end was regularized by abrasion (Fig. 4.l). The inferior and superior sides were also regularized, both on a median area, probably to flatten out the convexity of the bone. Another specimen (Fig. 4.m) is made on a blank cut longitudinally by percussion with the abrasion of the debitage edges (Fig. 4.o), but not on the entire surface. The arrangement of the active end was achieved by abrasion, only from the inferior side. On the superior side, the active edge was formed only from use.

Finally, a splinter from the diaphyseal wall (Fig. 4.p) has the active end arranged laterally. The blank was obtained by percussion with the proximal end shaped

by abrasion. The active end was created by bifacial abrasion (Fig. 4.s).

Pointed tools (no=50). Similar to the category of bevelled tools, when we talk about pointed tools we are actually referring to various pieces that have as a common element the presence of a pointed active end. A few pieces are on blanks in volume (n=3). In the case of a *Sus* sp. fibula (Fig. 5.a), the unmodified bone shape was used through abrasion at the distal level (Fig. 5.c), especially on one of the sides. The extremity is fractured *en languette* (Fig. 5.b), possibly from use. A lateral metapod of *Equus ferus* (Fig. 5.d) was abraded distally, around the entire circumference (Fig. 5.e). Otherwise, the anatomical shape of the bone was preserved.

A fragment of the scapula (Fig. 5.f) was detached by percussion, as illustrated by the irregular fracture edges along its entire length. The active end was formed by abrasion only at the distal level (Fig. 5.h), around the entire circumference.

Most of the pointed tools are on flat blanks (n=47). Thus, in the case of a *Cervus elaphus* metapod (Fig. 5.i), the longitudinal bipartition was performed by double grooving (Fig. 5.k), still visible because the abrasion was applied only towards the distal end, on both sides and debitage edges, to shape the active end. At the proximal area, on the superior side, several irregular incisions appear.

Another variant of longitudinal debitage is the *quadri*-partition (Fig. 5.l,o) which also involved double grooving (Fig. 5.r). The debitage edges as well as both sides were abraded (Fig. 5.n), destroying the marks of the previous action.

Other specimens were obtained by *quadri*-partition by percussion (Fig. 6.a) with the arrangement of the debitage edges only at the distal level by abrasion (Fig. 6.c) or scraping. This abrasion also affected the inferior side at the distal level.

Another specimen (Fig. 6.d) shows that it was most likely used in indirect percussion, as an intermediate piece. The bone was fractured longitudinally, but we can no longer reconstruct the techniques. It is certain that at the distal level the shaping was achieved by abrasion (Fig. 6.f).

A specimen (Fig. 6.g) was made of a rib fractured longitudinally by percussion to shape the active end. At the distal level, longitudinal scraping was applied (Fig. 6.i) to create the convergence of the edges.

For a metapodial of a large mammal (Fig. 6.j), the epiphysis was removed by segmentation, without being able to identify the technique, because the debitage plane was rigorously shaped. Longitudinally, bipartition of the bone occurred. We also cannot identify the technique because the debitage edges and inferior side have been rigorously abraded. Only on one of the debitage edges, towards the distal end, can longitudinal scraping be identified (Fig. 6.l), intended to ensure the convergence of the edges and the pointed end.

A shaping procedure was used for another pointed tool (Fig. 6.m) that was less common in prehistoric assemblages, which also appears at several other specimens from this site. It is a quarter of the diameter of a bone, obtained by longitudinal debitage by percussion. At the proximal end, the area was arranged by diffuse percussion, with specific marks (Fig. 6.o), after which the proximal end, as well the debitage edges, at the distal level, were regularized by abrasion.

A few specimens (Fig. 6.p) are splinters from the diaphyseal wall of large bones obtained by percussion, perhaps recovered from culinary waste. Moreover, they were used with a minimal technological intervention, in the sense that towards the distal end an abrasion was applied (Fig. 6.s).

Projectile points (n=44). Under this generic name, we have brought together morphologically different pieces which seem to have fulfilled the function of projectile points. For this category, a study was already published that provided both a morphological classification of the pieces and experimental reconstructions of the operational scheme (*Torcică 2022*).

A unique point was obtained (Fig. 7.a) from the diaphyseal wall of a long bone from a large mammal. We do not know the debitage procedures because the entire surface was arranged by longitudinal scraping and then in a coarse abrasion (Fig. 7.d). The proximal end was abraded and peripheral incisions were made along the entire circumference by bifacial cutting (Fig. 7.c).

A very interesting example is that of the points provided with wings and perforations (no=3). We have identified three such pieces (Fig. 7.e), two of them fragmented. The blank is a splinter from the diaphyseal

wall of the bone, where we can no longer identify the debitage techniques due to subsequent interventions. The rhomboidal section at the end was created by longitudinal scraping (Fig. 7.g,k). Proximally, the glove system was performed by a bifacial rotation perforation (Fig. 7.h), the two wings were then created by longitudinal scraping (Fig. 7.l). There are also examples with wings without perforation (Fig. 7.i) where the technological procedures are similar, except those related to the making of the perforation.

Points with a straight base and a hole constitute another category (no=4) (Fig. 7.m), and these were created with the same splintering from the diaphyseal wall. We can no longer identify the debitage marks. At the proximal end, the items were segmented by sawing with the shaping of the segmentation edges by abrasion (Fig. 7.p). Inside, a cavity was created, through rotation that allowed a handle to be inserted. The convergence of the sides and the end were created by longitudinal scraping, applied to four sides, hence the rectangular cross-section of the pieces (only at the proximal level the cross-section is circular) (Fig. 7.o). Towards the distal end, over the scraping, abrasion was applied to finish the items.

Stemmed arrow points are more numerous (no=18) (Fig. 8.a,e). The proximal end was initially carried out through a delineation procedure by sawing applied around the entire circumference (Fig. 8.d,h), followed by the arrangement through longitudinal scraping creating the circular cross-section. The distal end was also shaped by longitudinal scraping (Fig. 8.c,g), but applied to four sides (hence the rectangular cross-section of some specimens) or continuously around the circumference (hence the circular cross-section), overlapping, towards the distal end of abrasion. The assemblage presents a series of variables, mainly related to the ratio between the distal and proximal section, of the diameter or the length of the items.

There is also a variant of these stemmed arrow points (Fig. 8.i), in the sense that the distal area is not separated from the proximal one by delineation in sawing. The only difference is that the proximal section is thinner. The same technological formula (as in the previous variant) is followed: the surface of the piece was covered by longitudinal scraping (Fig. 8.k). At the level of the distal end, the extremity was prepared by abrasion on small facets.

Another category of projectile points have a rectangular morphology obtained from the diaphyseal wall (n=3) of some long bones (Fig. 8.l). A longitudinal debitage was applied by percussion (no=1), combined grooving/percussion (no=1) or double grooving (n=1) (Fig. 8.n). The shaping operation consisted of applying abrasion around the entire circumference at the distal level or on the entire surface.

Next comes a category of proximally fractured points (n=13) (Fig. 8.o). We do not exclude the possibility that they belonged to one of the other categories (due to fracturing we do not know the morphology of the proximal area). We can thus say that they are fragments of the diaphysis, illustrating a surface arrangement by means of longitudinal scraping around the circumference – creating the circular section – to ensure the convergence of the sides.

Plates (no=39). These specimens have a rectangular morphology (Fig. 9.a,d). The blank is flat, obtained by longitudinal bipartition of long bones. At most of the specimens, we cannot identify the bipartition procedures because the debitage edges were generally regularized by abrasion (Fig. 9.j) or scraping (Fig. 9.f). For a few specimens, on one of the long edges, we can identify a bipartition by diffuse percussion (according to the morphology of the edges and the type of marks). Sawing was applied transversally (Fig. 9.b,h), with abrasion of the segmentation edge (Fig. 9.e,i). The superior side was regularized on some specimens (Fig. 9.g), at the median level by abrasion, becoming slightly rectilinear.

One of these plates (Fig. 9.l) was rigorously abraded on the inferior side (Fig. 9.n), edges (Fig. 9.m,o) and extremities, after applying the longitudinal debitage. In addition, on the edges, five and four small transverse incisions (1.2mm), respectively, were made by sawing (Fig. 9.p). Their purpose can only be decorative. The piece has undergone a burning process to blacken it, but not over the entire surface.

Spatulas (no=14). According to the morphology of the active end, we identified three types of spatulas: straight, convex and pointed. To obtain the straight spatulas (n=6) (Fig. 10.a), the longitudinal debitage by percussion was applied. The debitage edges and the inferior side have been regularized by scraping (Fig. 10.b-c), or by abrasion, applied to various surfaces.

In another specimen (Fig. 10.f), we do not know the bipartition procedure of the rib due to subsequent technological interventions. The proximal end was prepared by percussion followed by the abrasion

of the end (Fig. 10.h), the debitage edges (Fig. 10.g) and the inferior side – until the spongy tissue was removed. The active end was also created by transverse abrasion on both sides, applied only at the distal level.

On a third piece (Fig. 10.k), the longitudinal bipartition of the bone took place without us being able to identify the technique, because the debitage edges were completely shaped by abrasion. The active end was prepared by a bifacial abrasion (Fig. 10.l) that involved the entire superior side and the distal end on the inferior side.

For the convex spatulas (n=5) (Fig. 10.n), the bone was sectioned longitudinally by bipartition. The debitage edges and the entire inferior side were rigorously abraded (Fig. 10.o). Abrasion appears to have also been applied to the superior side at the distal level but is largely covered by use-wear, more extensive on the inferior side (Fig. 10.p).

On another piece (Fig. 11.a) the blank was cut longitudinally, with the shaping by scaping of the edges (Fig. 11.b). Then, the entire surface of the item (both sides) was rigorously prepared by abrasion (Fig. 11.c). Two other items represent a quarter of a *Bos/Cervus* rib cut longitudinally by percussion, without setting up the fracture edges. The active end was created by bifacial abrasion applied only at the extremity.

For the pointed spatulas (n=3) (Fig. 11.f), the blank was obtained by longitudinal debitage, with the shaping of the edges by abrasion (Fig. 11.g).

Another variant (Fig. 11.i) consists of obtaining a splinter from the diaphyseal wall, but we do not know the debitage procedures since the entire surface was prepared by abrasion (Fig. 11.k). Only at the level of the proximal end are percussion marks still preserved. At the distal level, the convergence of the edges was achieved by scraping applied bilaterally (Fig. 11.j).

There is also a spatula on a blank in a volume (Fig. 11.n) made on scapula. The end was pointed, being prepared bifacially by abrasion (Fig. 11.o) applied only to the distal level.

Abraded astragals (no=11). Five specimens are shaped on *Ovis aries/Capra hircus* astragals. They underwent an abrasion procedure on the lateral and medial sides, with the aim of flattening and removing the protrusions. One of the pieces (Fig. 12.a) shows extremely interesting marks illustrating pronounced abrasion on both sides, extended also towards the periphery, a process that greatly narrowed the piece (Fig. 12.b). In addition, on one of the sides perforations were initiated by rotation (Fig. 12.c), an unfinished procedure. The pronounced abrasion makes us wonder if, after it was exhausted as an abrasive piece, in the sense that it could no longer be held between the fingers, it was not intended to be transformed into a piece with another purpose, by creating the perforations. Another specimen (Fig. 12.d) is heavily burned, with colour variations from black to white. It shows a pronounced abrasion on the sides (Fig. 12.e), with an extensive abrasion on the dorsal face as well. On one side there is the beginning of a perforation by rotation (Fig. 12.f).

Other astragals come from the *Bos primigenius* species. The first specimen (Fig. 12.g) shows an abrasion (Fig. 12.h), not very rigorous, of the dorsal, lateral and medial sides, as well as a perforation (Fig. 12.i), performed by bifacial rotation, from the dorsal and plantar sides. The second specimen shows a very rigorous abrasion starting from the medial side and extending to the dorsal side.

Two astragals of the *Bos taurus* species were also abraded. In one case, both the lateral and medial sides were regularized. For the second specimen, a recent fracture does not allow us to determine whether both sides were abraded. The preserved side is intensely abraded, with flattening.

An astragalus of *Sus domesticus* species and another of *Cervus elaphus* species (Fig. 12.j) were abraded (Fig. 12.k-l) on the lateral and medial faces, acquiring a rectilinear morphology.

Spindle whorls (n=5). Most of the specimens (n=4) (Fig. 12.m) were made from the femoral head of *Bos taurus/Cervus elaphus* species. The detachment from the bone was achieved by indirect percussion, because the fracture plane is smoothed, preserving the negative of the extremity of the intermediate piece. The debitage edge has not been regularized for any item. Centrally, a rotation perforation was performed (however, the marks are not very visible due to the internal spongy tissue), from both sides, because their profile is biconical (Fig. 12.n).

One specimen (Fig. 12.o) was made from a flat bone (scapula) of a large mammal. The piece is fractured and heavily weathered on the surface. The sides of the fracture are rough with no traces of shaping, but we cannot identify the cutting technique. A perforation made by unifacial rotation can be observed at its centre.

Burins (n=3). We assigned the related items this nomenclature because the morphology of the active end seems similar to flint burins. The items have irregular sides, a convex-concave section, towards the extremity convergent edges and a pointed end, located laterally in relation to the longitudinal axis. The first specimen was made from a *Bos taurus* tibia (Fig. 13.a). The epiphysis was removed by percussion without shaping the debitage plan. Moreover, the bipartition of the bone was achieved by indirect percussion. The arrangement of the debitage edges was done by means of a few blows in diffuse percussion. Then, at the distal level, abrasion was applied on both sides (Fig. 13.c), to ensure their convergence. The wear developed laterally as the item was used in a longitudinal action, alternately on the two sides. Longitudinal use-wear striations are apparent (Fig. 13.b).

For the second item, a rib of large mammal was used. The piece is fractured proximally *en languette*, probably from use. The bone was cut longitudinally, apparently by percussion after which the edges of the debitage were quite rigorously abraded. The active end shows pronounced wear developed exclusively at the end, without extension on the surface, hence the conclusion that the piece was used at a 90 degrees position.

The last piece of this category, also fractured proximally, comes from the diaphysis of a long bone (Fig. 13.d). The debitage procedure included the longitudinal partition of the bone by percussion. For the shaping of the laterally located active end, only one of the sides was prepared by abrasion (Fig. 13.f). The active front shows off-centre wear with longitudinal striations (Fig. 13.e).

Needles (no=2). Two pointed tools with perforations were identified. The flat blank (Fig. 13.g) was obtained through a procedure of longitudinal *quadri*-partition where the grooving (Fig. 13.h) also intervened, hardly identifiable, because the entire surface of the piece was subjected to rigorous abrasion (Fig. 13.i) that destroyed most of the marks of the previous actions. At the proximal end, a perforation was made by rotation (Fig. 13.k) towards both sides without too intense wear. Meso-distally, the piece has a strong macroscopic polish and a pronounced blunting of the extremity with loss of raw material indicating long use. Although fractured, the active end illustrates an intense blunting being rounded with the disappearance of technological marks (Fig 13.j).

For another specimen (Fig. 13.l) double grooving occurred (Fig. 13.m) during the longitudinal debitage procedure, hardly identifiable because the whole surface of the bone and especially the debitage edges were rigorously abraded (Fig. 13.n). At the proximal level, a bifacial rotation perforation was performed (Fig. 13.p). The piece was certainly used for perforation and sewing, although it was not use by rotation but by indirect percussion, which is proven by the longitudinal, peripheral fracture type, at the proximal end. Additionally, at the end of the extremity the functional striations are not transversal but longitudinal, creating a rectilinear plane, with small fractures on the upper side. Internally, the perforation shows the disappearance of the rotational marks.

Flat figurines (no=2). Both specimens are fragmented, being made from diaphyseal walls of long bones from large mammals. The first is a proximal fragment (Fig. 14.a), with a convex extremity, roughly rectangular section, and sides – one convex, the other fractured. In the first phase, the longitudinal bipartition of the bone took place without being able to identify the procedure because the debitage edges were rigorously abraded (Fig. 14.b). On both sides, more insistently on the upper one – probably to regularize the convexity of the bone – a rather irregular longitudinal scraping was applied (Fig. 14.c). On the lower side, the pattern consists of two points made by rotation and placed towards the proximal end. The same two points are also found on the upper side but the model is completed by the schematic representation of the legs by grooving (Fig. 14.e), while the pubic triangle is made by sawing. The decoration is completed by three horizontal series of dots and another series of dots following the line of the pubic triangle, made by rotation (Fig. 14.d).

From the second figurine only the distal fragment is preserved (Fig. 14.f). The lower side, as well as the debitage edges, have been rigorously abraded. The upper side was also abraded at the median level (Fig. 14.g). The neck was released by sawing (Fig. 14.h),

applied bifacially. On the upper side there are six perforations (Fig. 14.i) and another six dots, probably decorative elements. The perforations are made by bifacial rotation, and the unfractured ones draw attention to the very pronounced wear towards the periphery, with depression and fading of the technological marks (Fig. 14.j).

Mandible (no=1). It is a *Canis familiaris* mandible (Fig. 14.k). The contour of the mandible was arranged at the level of the coronoid process and the alveoli by abrasion (Fig. 14.l). The active area was developed at the level of the coronoid process, moreover it was apparently resharpened, so we have no functional traces. Instead, we can see a smoothed area with a strong polish (Fig. 14.m-n). Mesially, on both sides, an area characterized by flattening of the surface with macroscopic polish developed from hand rubbing (Fig. 14.o).

Knife (no=1). A *Cervus elaphus* ulna (Fig. 15.a) has been technologically arranged and used as a knife or scraper, in the sense that the active edge evolves laterally, showing use-wear (Fig. 15.b). Obviously, the natural shape of the ulna was used and the distal end was regularized by a bifacial abrasion (Fig. 15.c).

A perforated phalanx (no=1) (Fig. 15.d) of *Sus scrofa* species was flattened on the plantar side by abrasion. Towards one of the proximal ends a perforation (Fig. 15.e) was made by indirect percussion, with a subrectangular morphology. We do not know what the function of the item was.

Adornment (no=1). Only one piece was integrated into this typological category. It is (Fig. 15.f) made of a *Silurius glanis* vertebra. The vertebral apophyses were detached by bending (Fig. 15.g) and the central perforation was achieved by indirect percussion (Fig. 15.h).

Preforms (no=26). Most of the pieces undergoing processing were to be turned into bevelled tools (no=12). One item – in the early processing phase (Fig. 15.i) – was obtained by longitudinal percussion. Transversely, the segmentation was done by percussion. We consider it a preform, because on one of the edges and one of the ends diffuse percussion was applied, creating an extremity well adapted for a future bevelled tool. In another case, a femur was bipartitioned longitudinally (Fig. 15.j), without us being able to identify the procedure because the debitage edges were rigorously shaped by abrasion. Extremities were segmented by percussion. Other pieces were in an advanced stage of processing (Fig. 15.k). We consider that these items were undergoing processing because the abrasion of the active end is very pronounced and a use-wear area is not detected (Fig. 15.l). They were made on longitudinally cut bone, but we cannot identify the sequence of procedures, because the debitage edges (Fig. 15.m), as well as variable surfaces, were regularized by abrasion.

Three specimens from the same category (Fig. 15.n) could be both preforms for bevelled tools and flat figurines. Most likely a stock of such preforms was produced, which were then transformed into finished pieces. Initially, the bipartition of the bone was carried out but the identification of the procedure in the debitage operation is not possible because the entire surface of the piece was subjected to a rigorous abrasion (Fig. 15.o-p). One of these specimens (Fig. 16.a) has a pointed distal end, with converging rectilinear edges. The longitudinal bipartition of the bone was achieved by grooving (Fig. 16.c), hardly identifiable on one of the edges, because they were completely shaped by abrasion. The segmentation at the proximal level was achieved by sawing. The segmentation edge was regularized by abrasion (Fig. 16.d). The same abrasion was applied entirely on the lower side and to the upper side in a median longitudinal area, probably to blur the convexity of the bone. At the distal level, the active end was created by sawing applied bilaterally, superimposed by abrasion (Fig. 16.b).

Two other pieces undergoing processing were to be turned into bevelled tools of smaller dimensions (Fig. 16.e). We do not know the debitage techniques used longitudinally and transversely, because the edges were regularized by scraping (long ones) (Fig. 16.g) or abrasion (short ones). On the lower side, an oblique facet was created at both extremities, by longitudinal abrasion. (Fig. 16.f,h).

A few preforms were to be turned into arrowheads (n=4), and thus a blank (Fig. 16.i) was obtained from the diaphyseal wall of a long bone. For the longitudinal debitage, grooving was used (the marks are preserved on a small area at the proximal end) (Fig. 16.k). We do not know the segmentation technique in the transversal direction, because at both ends the debitage edge has been regularized by abrasion (Fig. 16.l). The entire surface of the blank was regularized by longitudinal scraping (still visible in some areas)

(Fig. 16.j), superimposed by abrasion. At the distal level, on one of the facets, the setting up of the active end had begun, through the convergence of the edges what was achieved by scraping. Another example is a splinter from the diaphyseal wall (Fig. 16.m). At the level of the proximal end, it was segmented by sawing (Fig. 16.p). The convergence of the edges and the pointed end were created by longitudinal scraping (Fig. 16.n-o), applied from four sides, hence the rectangular section of the piece. The piece is not finished, you can clearly see that it has been worked on, but it should be an arrowhead with a stem.

We have included another six pieces in this category (Fig. 17.a), five shaped on long bone diaphysis, one on rib. They are on flat blanks and appear to have been obtained by a longitudinal debitage apparently by percussion followed by the integral abrasion of the lower side. In the transversal sense, it seems to be a segmentation by percussion followed by the abrasion of the debitage edge. The pieces were left at this technological phase. We cannot say precisely what type of pieces they were to be transformed into.

Most likely, an ornament was to be obtained from the processing of a scapula (Fig. 17.b) of a large mammal. Extraction from the bone appears to have been done by indirect percussion. The fracture edges then began to be regularized by abrasion, to give it a circular shape (Fig. 17.c).

The last piece in this category (Fig. 17.d) seems to be in the process of recycling/repair. It was originally a finished piece that fractured. We do not know the debitage procedures because both edges of the piece, as well as the preserved fracture edge, underwent a shaping procedure by abrasion (Fig. 17.e-f), creating flat sides. At one of the ends a perforation was made by unifacial rotation (Fig. 17.g). The piece fractured longitudinally, so we can no longer reconstruct its original morphology and function. A procedure of restoring its shape began by longitudinal scraping (Fig. 17.h), but we do not know if the action was completed.

Blanks (no=9). A rib fragment (Fig. 17.i) was cut longitudinally by the abrasion of one of the edges (Fig. 17.j) followed by indirect percussion. Then, in the transversal direction, through a delineation procedure, grooves were drawn with sawing (Fig. 17.k) to mark the dimensions of the future items. Another blank was also obtained from a *Bos* sp. rib. It is a flat blank obtained by a bipartition by percussion, applied on both edges. At one end the transversal segmentation was also done by percussion, at the other end the piece is fractured. It remains in its raw state, with no traces of shaping.

Two *Cervus elaphus* metacarpus (Fig. 17.l) underwent a process of bipartition by double grooving (Fig. 17.m-n). We consider them as blanks since we do not record a shaping stage.

Two blanks (Fig. 18.a), in fact *Cervus elaphus* metacarpus, illustrate a bipartition procedure by double grooving. The halving process has not been completed, remaining in this stage, but they could have been transformed into finished pieces. In the same series (Fig. 18.b), a *Cervus elaphus* metatarsus was bipartitioned in longitudinal percussion, after which a new bipartition was initiated by grooving. The groove was deepened on both the upper and lower sides. The presence of striations on the lower side proves that bipartition by percussion was attempted. Two blanks could thus be obtained, but the action was not completed.

A *quadri*-partition debitage procedure is evident at a *Cervus elaphus* metatarsus (Fig. 18.c) and a large mammal long bone diaphysis. Double grooving was applied. The detachment was completed by indirect percussion.

Finally, the last piece (Fig. 18.d) could have been a blank for the plates specific to this assemblage. In the transversal direction there was a segmentation made by sawing (Fig. 18.e) at both ends, with very visible marks. In the longitudinal axis direction, the bipartition was achieved by indirect percussion, the active end of the intermediate piece being visible. The shaping operation was not carried out, so it can be considered a blank.

Waste (no=4). Four pieces can be considered waste of abandoned bones as a result of accidental fractures, which no longer allowed processing and transformation into a blank. Traces of the debitage operation are evident on their surface, but accidents occurred and they could no longer be processed. Three of them are bones (metacarpus/metatarsus/metapodial) coming from the *Cervus elaphus* species.

A *Cervus elaphus* metacarpus (Fig. 18.f) is a recently strongly fractured piece, but one of the sides pre-

serves the marks of two converging grooves, which do not exclude the possibility of an extraction procedure (needle, arrowhead?). The same method of debitage by extraction (Fig. 18.g) is evident for an *Equus ferus* epiphyses distal metapodial. Most likely, the transversal fracture led to its abandonment. We can see a procedure of extracting narrow blanks (such as for arrowheads) through parallel grooves. The extracted blank would have been about 6mm wide and 8mm thick, another 10mm wide and 8mm thick.

Another piece, a *Cervus elaphus* metatarsus, illustrates (Fig. 18.h) a bipartition procedure by double grooving. We assume that the process of separating the two halves was prematurely initiated, when the wall was not thin enough, so the bone fractured. The last piece of this category also illustrates a longitudinal bipartition of the bone through grooving, combined with percussion. The bipartition procedure is completed, but the piece has broken transversely.

Undetermined pieces (no=27). This category includes atypical pieces, generally represented by a single specimen, whose function could not be established. We have also added here fragments with traces of processing, whose final morphology could not be reconstructed. The processing marks consist of shaping procedures by scraping or abrasion, which prove that they were at least preforms.

A distal fragment, heavily burned to black with three lobes and with a circular cross-section (Fig.18.i), could be a fragment from an ornament. We have no indication of the techniques used in the debitage operation, since the obtained preform was fully subjected to abrasion shaping, including the preserved extremity. The lobes were created by peripheral sawing (Fig. 18.j-k), turning the item around the entire circumference.

A fragment of bone (Fig. 18.l) does not give us many clues related to the technological procedures, but both extremities show several grooves made by sawing (Fig. 18.m). It seems to be a decoration, given their rhythmicity.

A fragment of a *Sus* sp. mandible (Fig. 18.n) preserves an edge characterized by abrasion (Fig. 18.o). We do not know if this is an extraction method or direct shaping.

An *Ovis aries/Capra hircus* proximal metacarpus and metapodial were bipartitioned, apparently by grooving, which can hardly be identified due to subsequent interventions. Peripheral scraping was applied on one specimen to create the convergence of the sides (it was most likely a pointed tool), after which the entire surface was subjected to rigorous abrasion. The piece shows a strong macroscopically identified lustre, probably from hand rubbing. Four other *Bos taurus/Cervus elaphus* metapodial fragments illustrate the process of *quadri*-partition by double grooving. The debitage edges were abraded on variable surfaces. The pieces are broken at the mesial level and we do not know the morphology of the active end.

Discussion

Management of the raw materials

As shown in Table 2, 78% of blanks could not be identified with regard to the raw materials, being passed to the category of undetermined species, the most numerous are those belonging to large species, both domestic and wild mammals. We also note the use of bones belonging to species rarely found in the Eneolithic bone industry (*Bos primigenius, Equus ferus, Canis familiaris*) in the Lower Danube. Obviously, the source of acquisition remains a local one, in the sense that the blanks were obtained from the recycling of waste from animal slaughter activities. The only difference is the source of origin of these animals: breeding (*Bos taurus; Ovis aries/Capra hircus; Canis familiaris*) or hunting (*Cervus elaphus; Bos primigenius; Equus ferus*).

Table 2, despite the incomplete data, overlaps that of the faunal remains in the sense that in the Gumelnița B1 phase the bones of wild mammals reach a significant percentage of 48%. Moreover, cervids rank first in the Gumelnița B1 level (16.7%) (*Bălășescu, Mărgărit 2014*). Regarding domestic species, *Bos taurus* is in first place (*Bălășescu, Radu 2003*), at 23% of the total. The situation of *Ovis aries/Capra hircus*, whose bones are usually well represented in prehistoric bone industries, regardless of culture, is interesting. This time, the species is represented by a few pieces (the astragals predominate), while in the faunal spectrum the situation is similar, with a presence of only 4% (*Bălășescu, Mărgărit 2014*). We can conclude that there is a close connection between the paleoeconomy and the raw materials used to process the artefacts.

Skeleton elements	*Bos taurus*	*Ovis/ Capra*	*Sus domesticus*	*Canis familiaris*	*Cervus elaphus*	*Bos primigenius*	*Equus ferus*	*Sus domesticus/ Sus scrofa*	*Bos taurus/ Cervus elaphus*	*Silurius glanis*	Undetermined sp. (mammals)
Astragalus	2	5	1		1	2					
Mandible				1				1			
Rib	2								3		50
Radius											1
Humerus			1						2		
Ulna	4		1		1				1		1
Metacarpus		1			5						
Metapodialus		1			4		2		8		
Femur				1					4		1
Tibia	2			1					1		
Metatarsus					4			1			
Fibula								1			
Scapula									1		3
Phalanx			1								
Vertebra										1	
Long bone diaphysis											183
TOTAL	**10**	**7**	**4**	**3**	**15**	**2**	**2**	**3**	**20**	**1**	**239**

Tab. 2. Numerical distribution of the different types of raw materials and their selection by species and skeletal elements at the settlement of Vitănești.

Technology management

The study of the above-mentioned categories led to the identification of the following detachment procedures: a transversal debitage, to which a transformation scheme by segmentation corresponds, and a longitudinal debitage, to which transformation schemes by *quadri*-partition, bipartition and successive partitions are subordinated. A transformation scheme can be added by direct shaping, identified in the case of the processed astragals.

The debitage resulted in two blank types: in volume and flat. Excluding the heavily fractured pieces, we may state a preference for the use of flattened blanks (longitudinal debitage – 237 objects), followed by those that preserved their anatomical volume (25 objects). It is clear that the productivity of the assemblage was high because the transformation schemes based on *quadri*-partition or bipartition allow obtaining two/four similar blanks that can be transformed into finished objects. Longitudinal debitage was achieved in most cases by percussion, and in a few specimens a combination of grooving and percussion or double grooving was found. Transversal segmentation was applied by sawing (especially in the case of rectangular plates) and percussion.

For surface modification, abrasion was the most used technique, followed by scraping and diffuse percussion. Abrasion and scraping are combined on different artefacts to shape the debitage edges, or surface and diffuse percussion were used exclusively to regularize these. Sawing, grooving and rotation were also used to modify the surface, mainly to create a delineation procedure or decoration on different pieces. The only technique used to change the volume was perforation, mainly by rotation and, although in only two cases, by indirect percussion.

Functional hypotheses

Within the studied assemblage, the most important typological category is that of bevelled tools. Numerous tool types carry the generic name of bevelled tools as their common element is the development of their active end through the intersection of two convergent edges. The main question we considered was whether those tools had an identical function since – as we could see from the study that we carried out on the present set – they prove a different use-wear evolution. For some pieces (Fig. 2.d) on blank sin volume, the distal end shows wear on a narrow area, only on *fil du tranchant*, otherwise the abrasion marks are accentuated, hence the hypothesis of reshaping by abrasion (Fig. 2.e). The use is proven by the morphology of the active end that acquired a concavity arranged in the middle (Fig. 2.d-f), as a result of material loss and repeated resharpening. There are also specimens that attest to long use (Fig. 2.b), but whose functional end has not been remodelled. They have a very blunt extremity, with significant loss of material (Fig. 2.i) resulting in a concave *fil du tranchant*, with a bifacial use-wear lustre, extended about 15mm from the end of the tool and with longitudinal functional striations (Fig. 2.h). Another specimen (Fig. 2.j) has an atypically narrow extremity and shows pronounced use-wear with the disappearance of abrasion marks and loss of matter in the form of depressions superimposed by use-wear. The use-wear lustre extends for about 5mm and longitudinal functional striations are visible (Fig. 2.k). For another specimen the extremity is smoothed, with a strong lustre only on the active end (Fig. 2.p), hence our conclusion that it was resharpened on the lower side. Materials with variable hardness were processed, as evidenced especially by the morphology of the active end.

For the bevelled tools made on a flat blank obtained by bipartition or *quadri*-partition, the use-wear is quite uniform in the sense that the end is blunt with extensive macroscopic use-wear on the upper side (4–5mm), longitudinal marks thus leads to the conclusion that it was worked under an open angle (Figs. 3.b,e,h,k; 4.k,n,r). Most likely, a soft material was processed, therefore the active end remained uniform/smoothed, without the appearance of small concavities on the cutting edge.

An interesting mode of use-wear evolution appears on one of the pieces (Fig. 3.m). The functional end is lacy, with splinters over which use-wear is superimposed. The wear is extensive on both sides with longitudinal functional striations, hence the question as to whether both sides were not used alternately (on the lower side the wear extends over 6mm) (Fig. 3.n-o). In this case, a hard, abrasive material seems to have been processed.

A few pieces were used as intermediate tools with indirect percussion (Fig. 4.d,g). The evidence is especially the fractures at the level of the active end (Fig. 4.e,h), accompanied by functional longitudinal striations. On one specimen (Fig. 4.e) the extremity is fractured but intense macroscopic use-wear can be seen, extended into the surface. The peripheral fracturing mode, developed longitudinally for the proximal end and the distal fracture, also poses the problem of use as an intermediate piece.

In the case of pointed tools on a flat blank, the use-wear is more varied, proving different functionalities. We think that the different hardnesses of the processed materials is also reflected in the different appearances of the active extremity wear. In the case of one specimen the point was blunted, becoming too wide. The lustre is evident, developing a series of functional striations (Fig. 5.j). On other specimens the functional end is either strongly blunted with small fractures, over which the lustre is superimposed (Fig. 5.m), or strongly rounded, with lustre and transverse functional striations, hence the hypothesis of use in a rotational action (Figs. 5.p; 6.k,n). On some specimens the end is strongly blunted, flattened and becoming almost straight (Fig. 6.b,h,r) as a result of the pressure exerted by the processed material. We may consider that they belong to the transformation tool category, destined for processing soft materials (*i.e.* skin, *Christidou, Legrand 2005; Rašková Zelinková 2010*; skin or wood, *Maigrot 2000*; skin perforation or textile fibre knitting, *Campana 1989; LeMoine 1991*).

For the pointed tools on the blanks in volume, the end is strongly smoothed, up to roundness, with an invading lustre on the surface (17mm) (Fig. 5.e,g) and with transversely arranged functional striations and depressions, hence the hypothesis that they were used for perforation. In the case of perforating thick skin, these points may have also been used in indirect percussion (as seems to be the case with one needle) – as already stated by other specialists (*Christidou, Legrand 2005*).

Equally, there is a very important category of projectile points. The traces of use-wear are quite uniform for these, in the sense that the distal end is strongly rounded with a macroscopic lustre and with few functional longitudinal striations (Figs. 7.b,f,j,n; 8.f). Rarely, small fractures appear that are superimposed by use-wear, which proves that the item continued to be used (Fig. 8.b,j), or a strongly worn rectilinear plane is formed, most likely caused by an initial fracture with continued use of the item (Fig. 8.m). A few specimens (n=6) (Fig. 8.e,o,r) are fractured proximally *en dents de scie*, generally a type of fracture of a functional nature.

The presence of rectangular plates, rigorously shaped, some perforated, raises the question of their functionality. We can assume they were preforms for small bevelled tools or for future beads (however, we do not have finished pieces of this type). In addition, some show use-wear, which means that they were used. The wear is visible especially on the upper side, and limited in the flattened part at the median level, with the development of a macroscopic lustre, while longitudinal striations, arranged in quite a disorganized way, are visible under the microscope (Fig. 9.c,k).

Spatulas seem to correspond to a functionality characterized by a prolonged movement on soft materials, such as skins (*Averbouh, Buisson 2003; Rašková Zelinková 2010*). However, other studies suggest the use of these objects in processing clay pots (*Struckmeyer 2011; Mărgărit 2017*). The use-wear evolution on the straight spatulas shows that different materials were processed in terms of intensity. On one specimen the end also has small fractures on the *fil du tranchant* (Fig. 10.d). The piece was used to clean a hard material, in a longitudinal movement, as evidenced by the direction of development of the functional striations (Fig. 10.e).

Other specimens seem to have processed softer materials. On one of the pieces the end is blunt, with an irregular distal end overlapped by use-wear with macroscopic lustre on both sides, extended over 3mm (Fig. 10.m). On one of the spatulas, use-wear can be seen on the *fil du tranchant* (Fig. 10.i) consisting of a macroscopic lustre and fine longitudinal striations that proves a soft material was worked. However, the abrasion is very pronounced (Fig. 10.j), hence the conclusion of resharpening, in order to maintain the effective active end.

For the convex specimens, the active end is smoothed with use-wear lustre (Fig. 11.d) and deep striations, arranged obliquely (Fig. 11.e). At the pointed spatulas, use-wear, developed at the medial level, is evident, probably from friction, characterized by macroscopic lustre and irregularly arranged long striations (Fig. 11.m). The end is strongly smoothed, laterally worn and with rather rare but deep longitudinal striations (Fig. 11.l). At another pointed spatula, the wear develops not at the median level, but towards one of the sides, hence the conclusion of use in an oblique position (Fig. 11.p).

For the astragals category processed by abrasion, we may posit, as a first functional hypothesis, a domestic use; the result of intense friction against another resistant abrasive body could be aimed, for example, at finishing ceramics (*e.g., Meier 2013; Mărgărit 2017*). Another hypothesis is trying to prove the use of those astragals in different games, as there are testimonies in this sense throughout the time and in the faraway parts of the world (Neolithic, Bronze Age, Rome, modern Iran and Mongolia *or aboriginals in Australia) (e.g., Eisenberg 1989; Gilmour 1997; Elster 2003; Minniti, Peyronel 2005; Dandoy 2006; Choyke 2010; Korzakova 2010; Carè 2013)*. Moreover, we cannot ignore the possibility that they may have been used in different rituals, for example in divination (*Zidarov 2005*).

The use of the *Canis familiaris* mandible through a minimal technological intervention, and thus using its natural shape, is also interesting. The direction of the use-wear marks shows that the piece was used in a back-and-forth movement on a soft material (leather/vegetable cleaning). Moreover, the use of the *Canis familiaris* mandible in a similar way is also attested at other Gumelnița communities, such as Căscioarele-*Ostrovel* (*Radu* et al. *2019*).

Conclusion

This archaeological assemblage proves that the worked bone pieces were involved in various activities within the Vitănești community that lived at the end of the 5th millennium BC, from the processing of hides or vegetable fibres to hunting. All of these artefacts were made *in situ*, as evidenced by the preforms, blanks and waste. The importance of the assemblage cannot be questioned since we still do not have many comparable studies for the B1 phase of the Gumelnița culture, and can only invoke the osseous

industry from the Mărițua site (*Mărgărit* et al. *2014*). The same categories of tools for domestic activities are present (pointed tools, bevelled tools, spatulas with the three variants, needles, burins, spindles, flat figurines), while spear points are almost absent. As such, for both sites we can assume similar domestic activities but varied ways of hunting.

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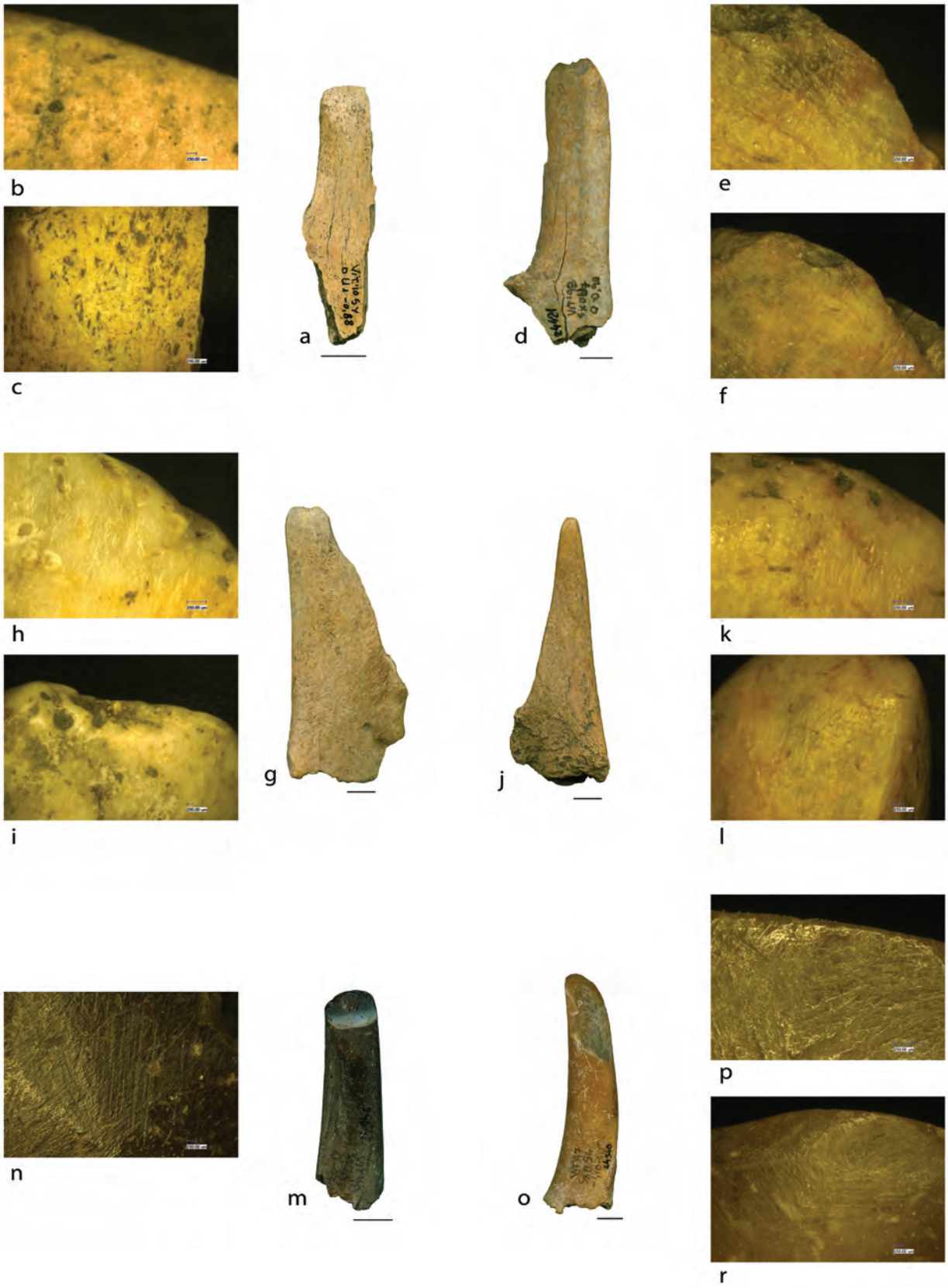

Fig. 2. **a, d, g, j, m, o *bevelled tools;* b, e, h, i, k, p *details of the distal ends;* c, f, l, n, r *abrasion marks.***

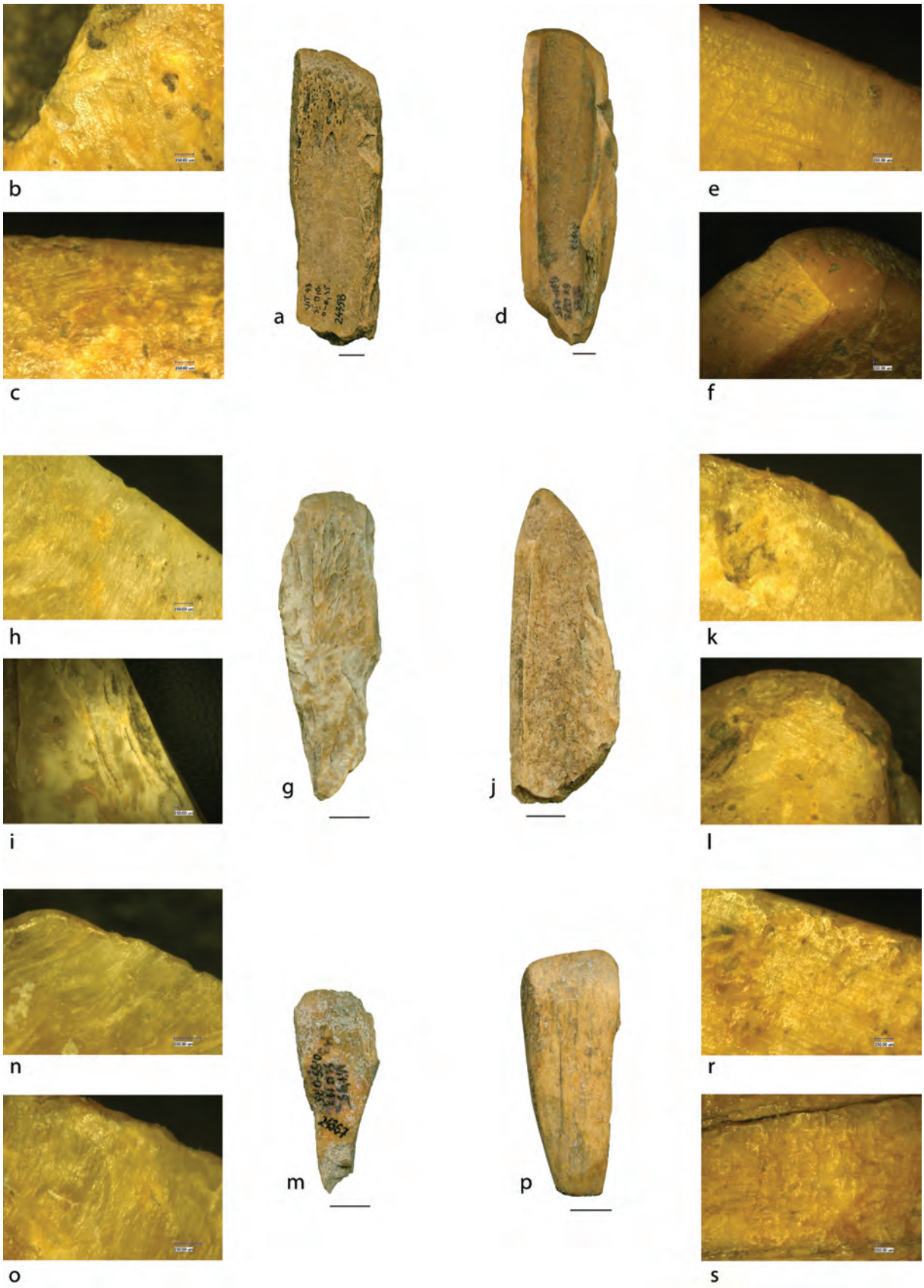

Fig. 3. **a, d, g, j, m, p** ***bevelled tools;*** **b, e, h, k, n-o, r** ***details of the distal ends;*** **c, f, l, s** ***abrasion marks;*** **i** ***diffuse indirect percussion marks.***

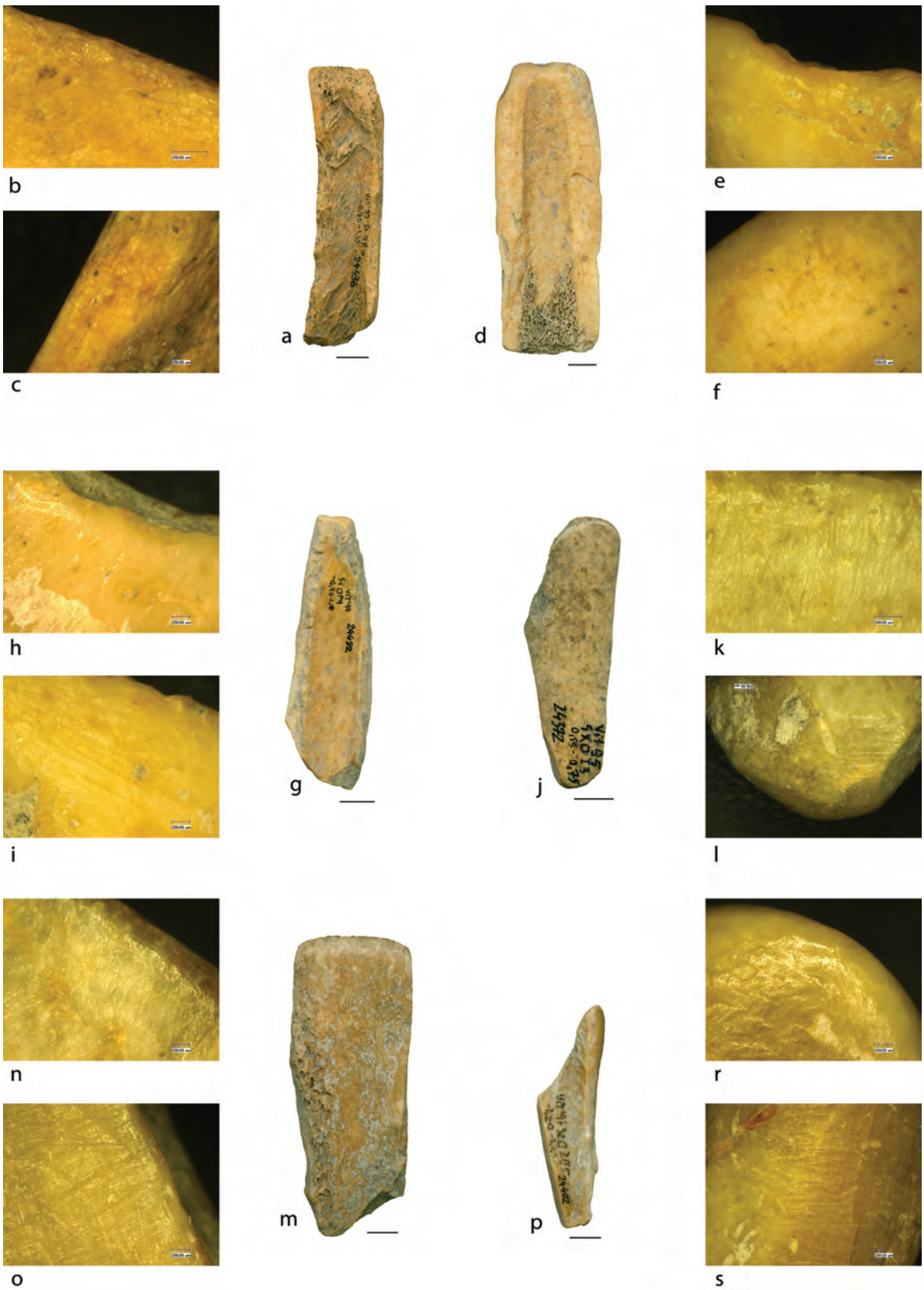

Fig. 4. **a, d, g, j, m, p** ***bevelled tools;*** **b, e, h, k, n, r** ***details of the distal ends;*** **c, f, i, l, o, s** ***abrasion marks.***

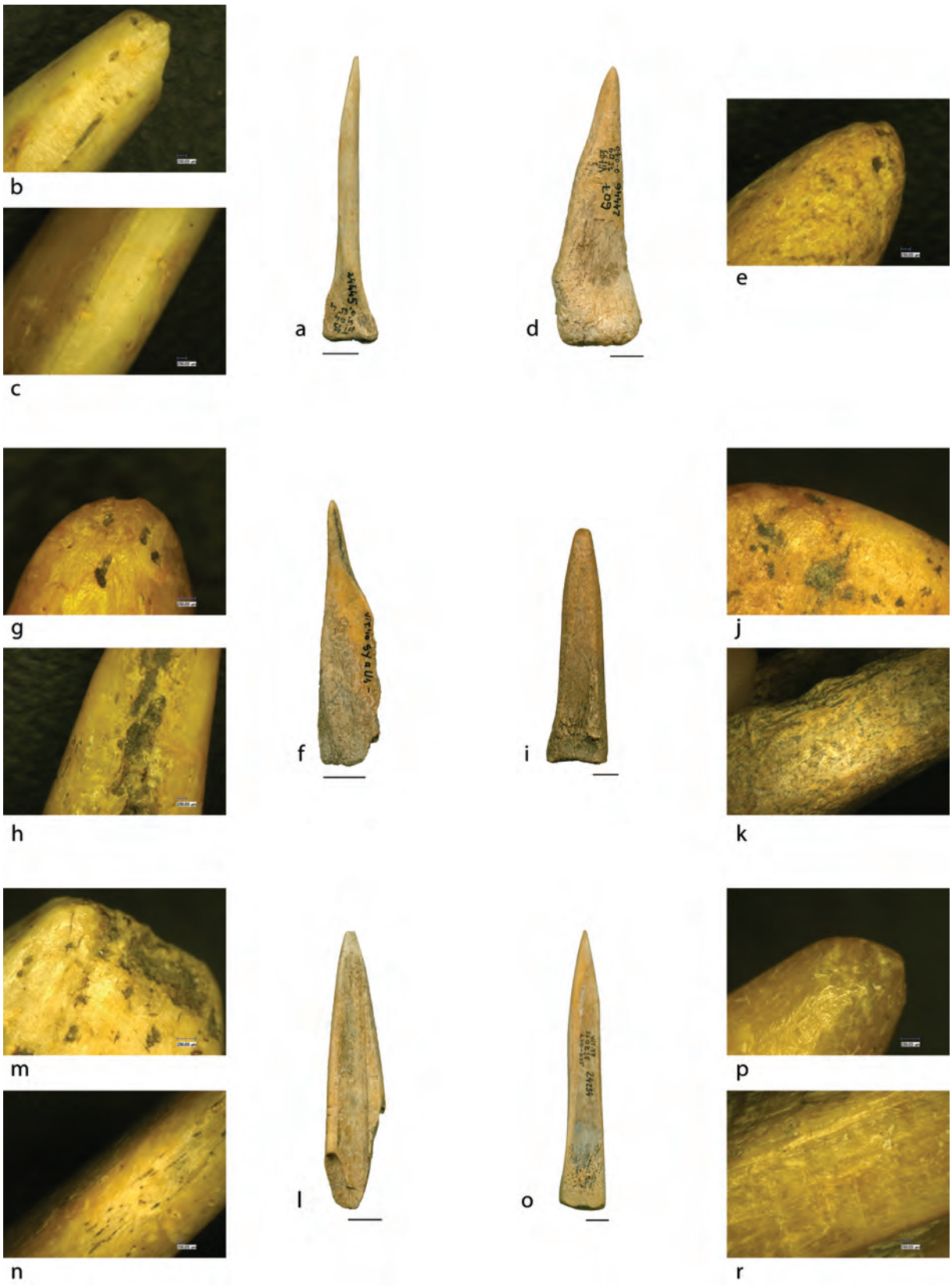

Fig. 5. **a, d, f, i, l, o** ***pointed tools;*** **b, e, g, j, m, p** ***details of the distal ends;*** **c, h, n** ***abrasion marks;*** **k, r** ***grooving marks.***

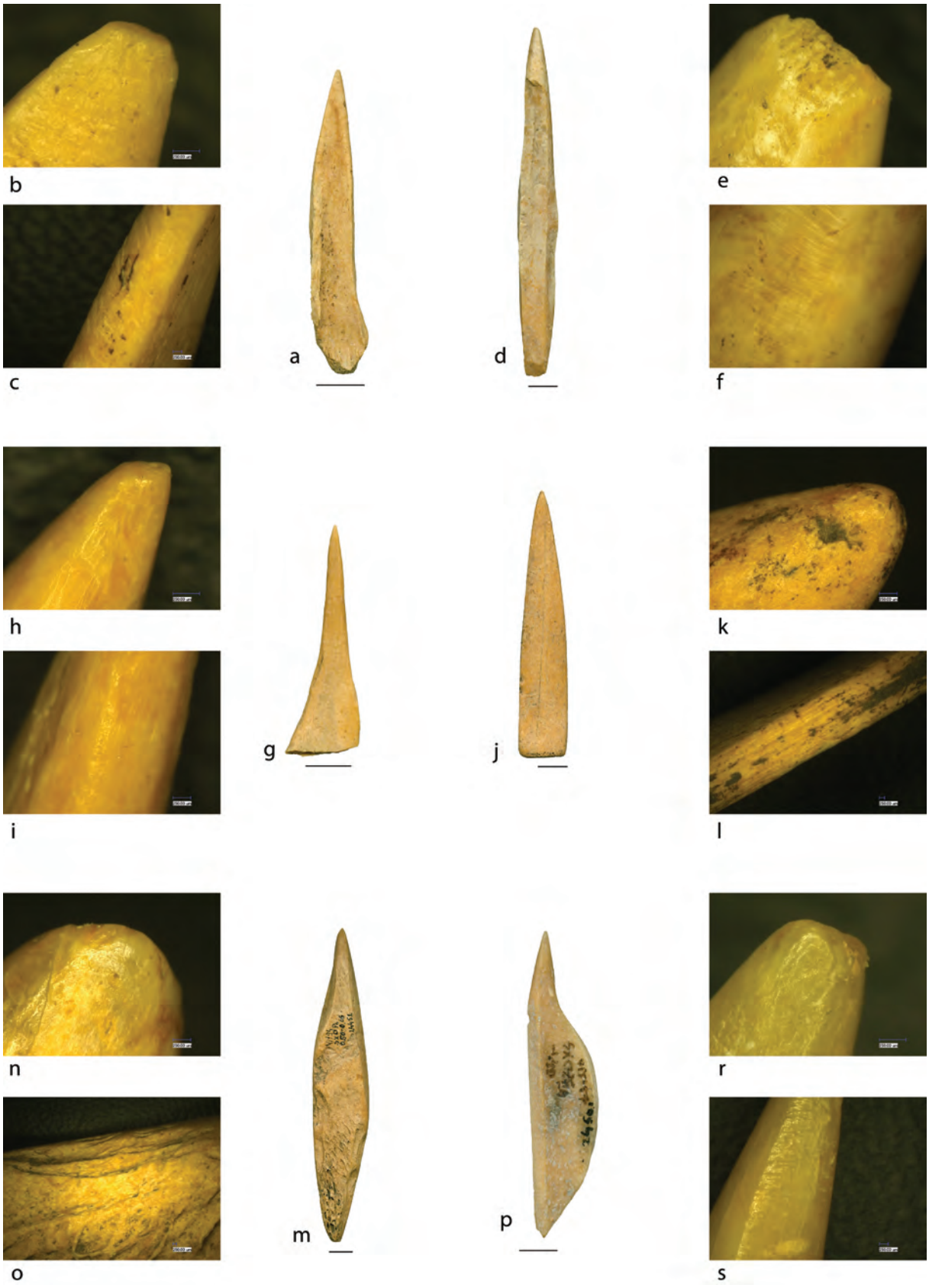

Fig. 6. **a, d, g, j, m, p** ***pointed tools;*** **b, e, h, k, n, r** ***details of the distal ends;*** **c, f, s** ***abrasion marks;*** **i, l** ***scraping marks;*** **o** ***diffuse indirect percussion marks.***

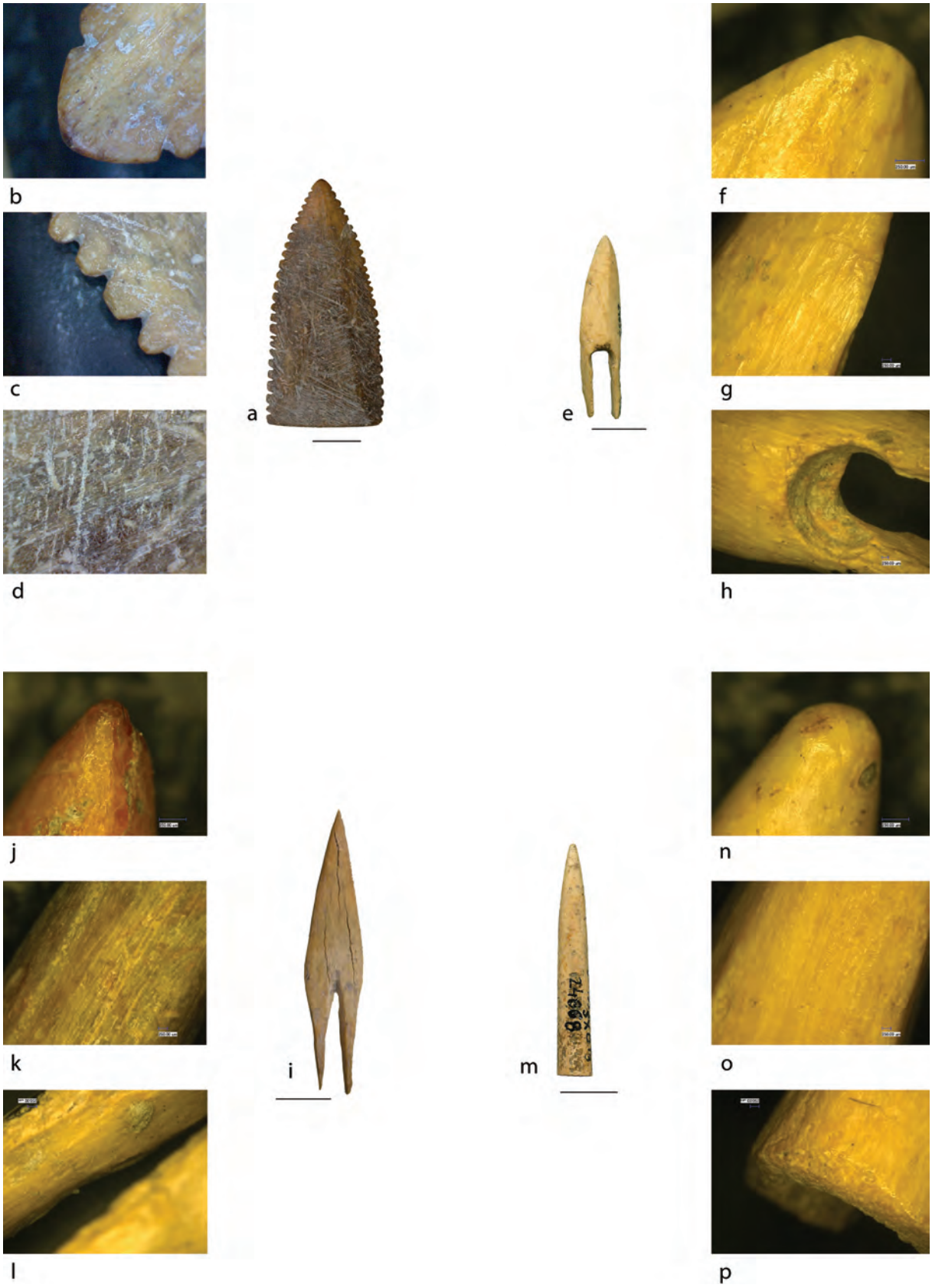

Fig. 7. **a, e, i, m** ***projectile points;*** **b, f, j, n** ***details of the distal ends;*** **c** ***incisions detail;*** **d, p** ***abrasion marks;*** **g, k, l, o** ***scraping marks;*** **h** ***perforation detail.***

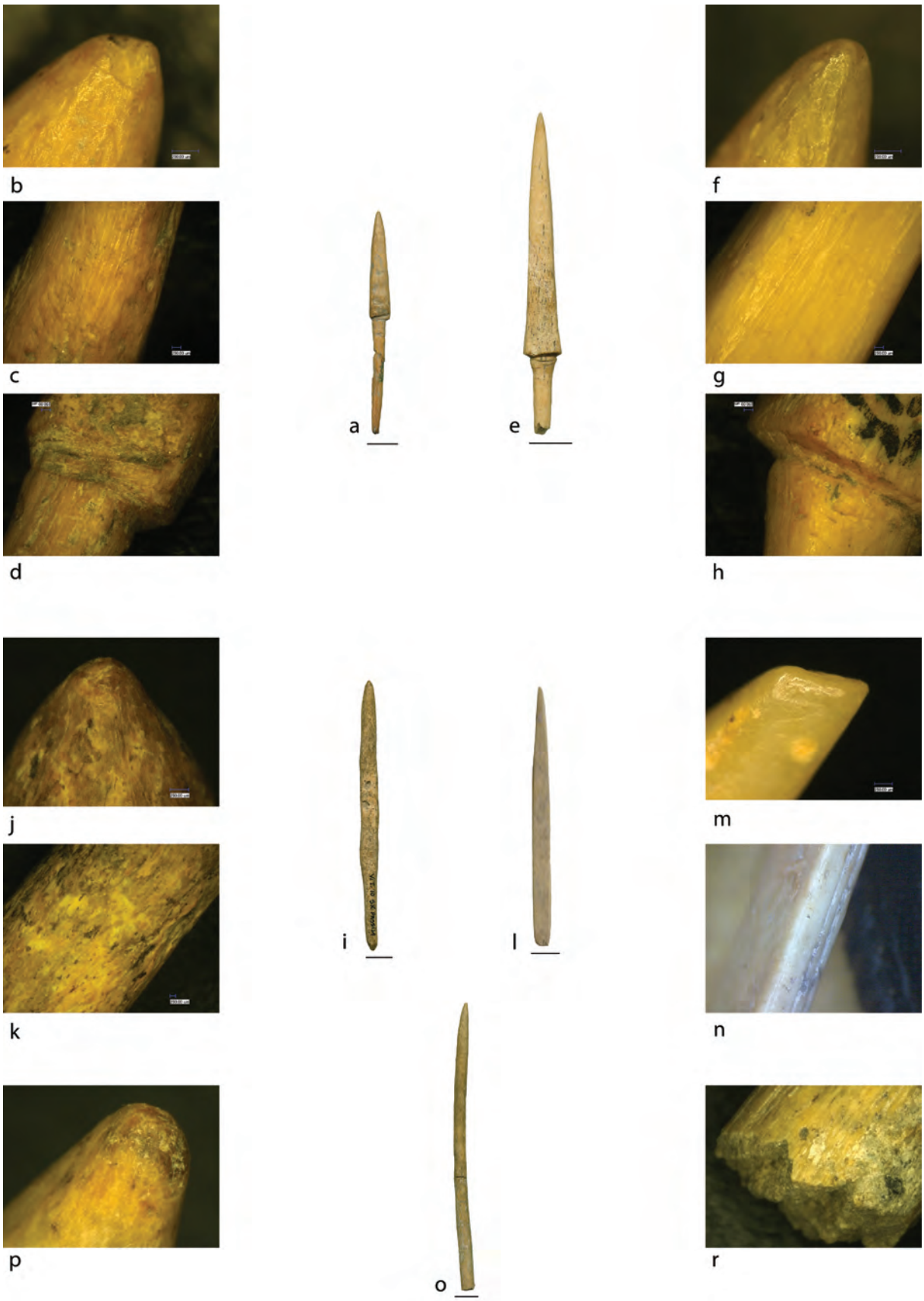

Fig. 8. **a, e, i, l, o** ***projectile points;*** **b, f, j, m, p** ***details of the distal ends;*** **d, h** ***sawing marks;*** **c, g, k** ***scraping marks;*** **n** ***grooving marks;*** **r** ***fractured proximal end.***

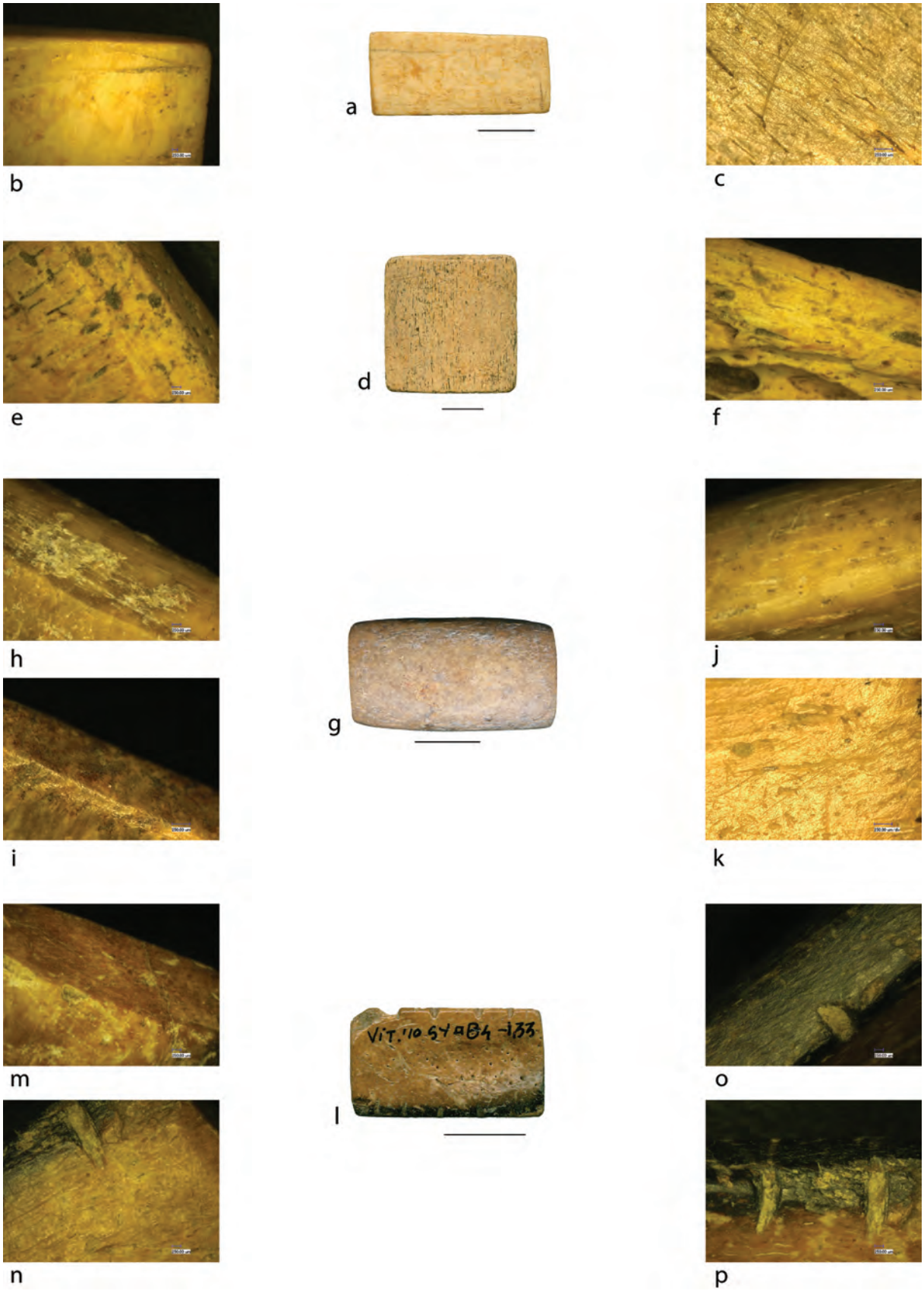

Fig. 9. **a, d, g, l** ***rectangular plates;*** **b, h** ***sawing marks;*** **e, i, j, m-o** ***abrasion marks;*** **f** ***scraping marks;*** **p** ***incisions.***

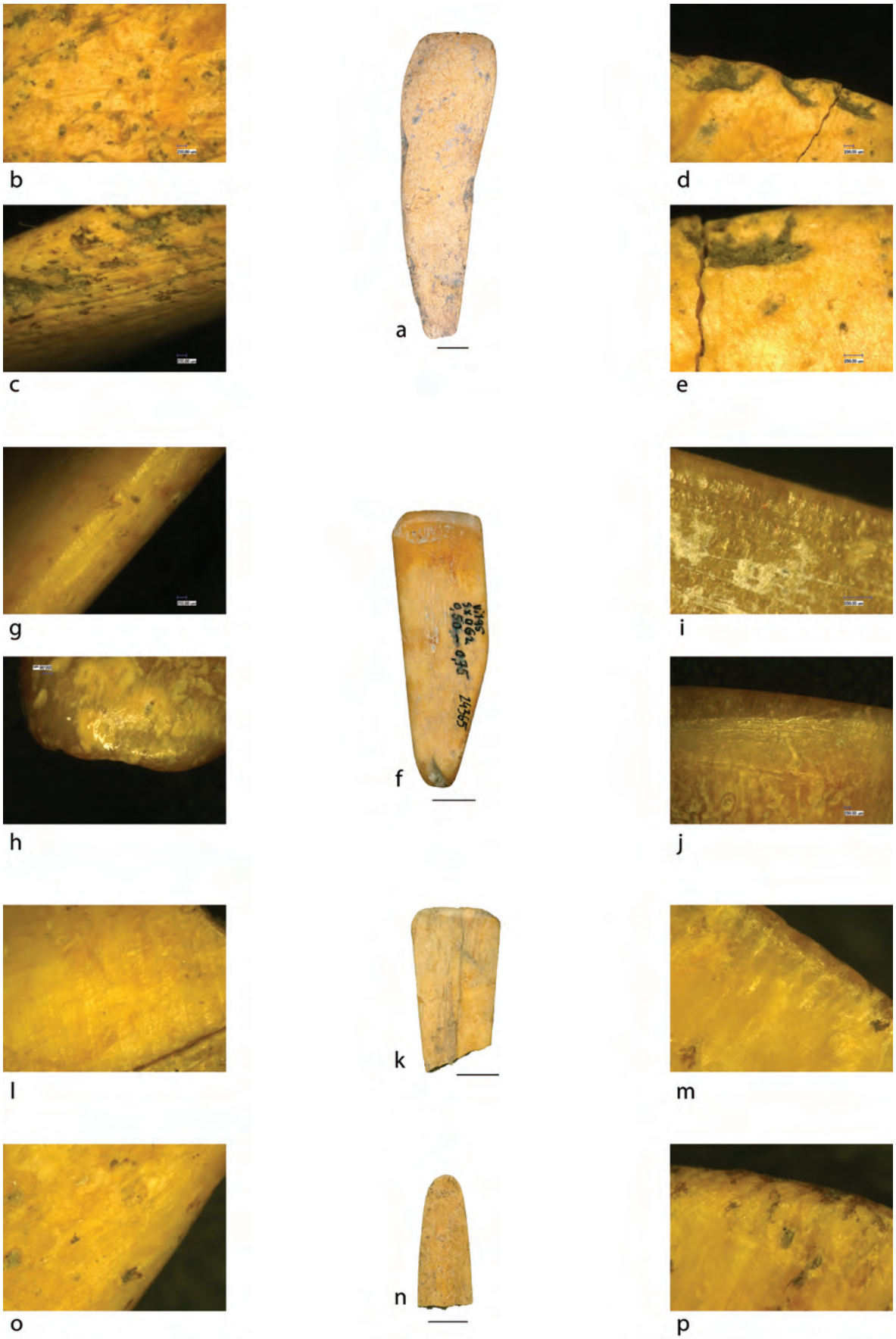

Fig. 10. **a, f, k, n *spatulas;* b-c *scraping marks;* d-e, i-j, m, p *details of the distal ends;* g-h, l, o *abrasion marks.***

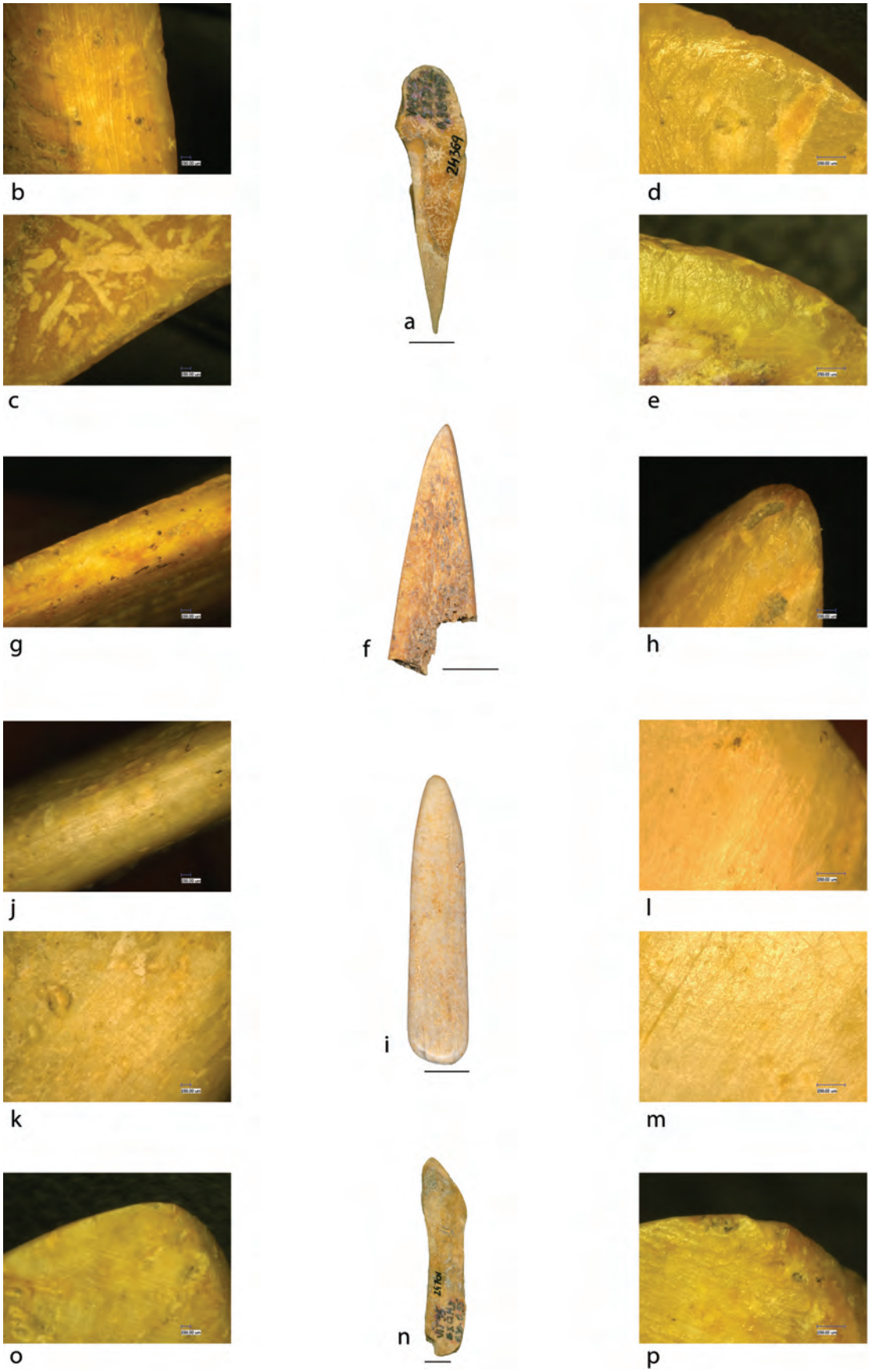

Fig. 11. **a, f, i n *spatulas;* b, j *scraping marks;* c, g, k, o *abrasion marks;* d-e, h, l-m, p *details of the distal ends.***

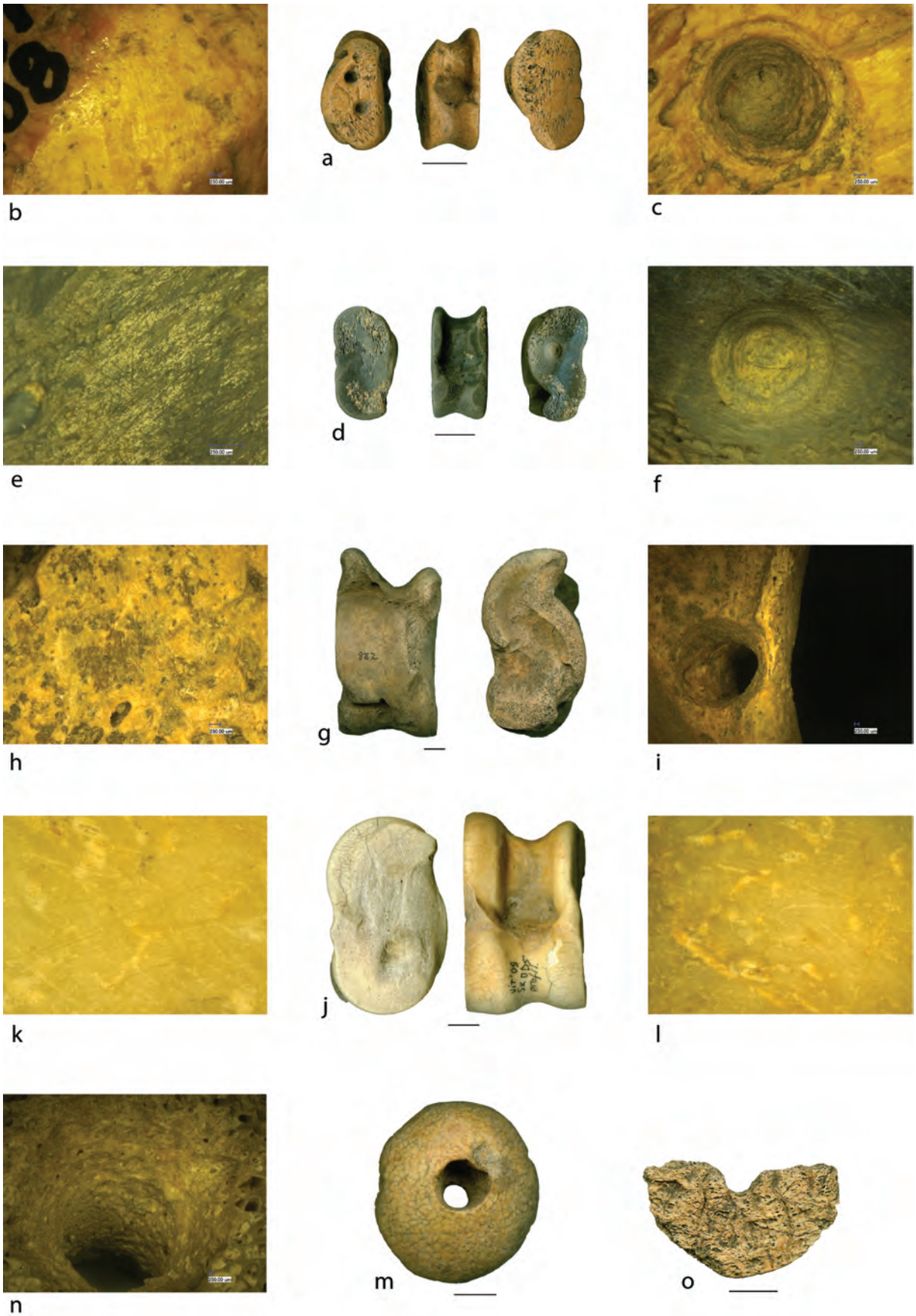

Fig. 12. **a, d, g, j** ***processed astragalus;*** **b, e, h, k-l** ***abrasion marks;*** **c, f, i** ***perforation details;*** **m, o** ***spindle whorls;*** **n** ***perforation detail.***

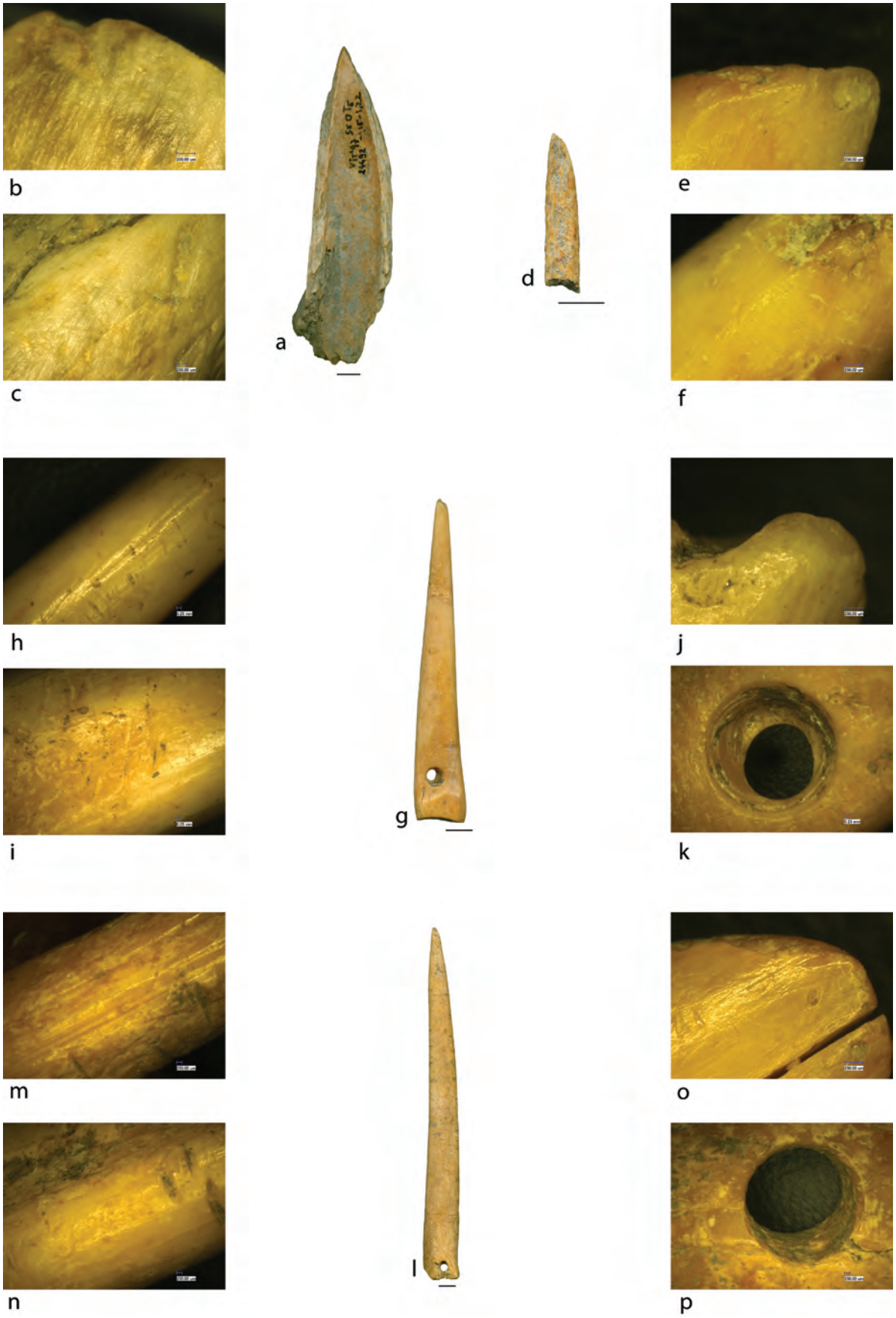

Fig. 13. **a, d *burins;* b, j, o *details of the distal ends;* c, f, i, n *abrasion marks;* g, l *needles;* h, m *grooving marks;* k, p *perforation details.***

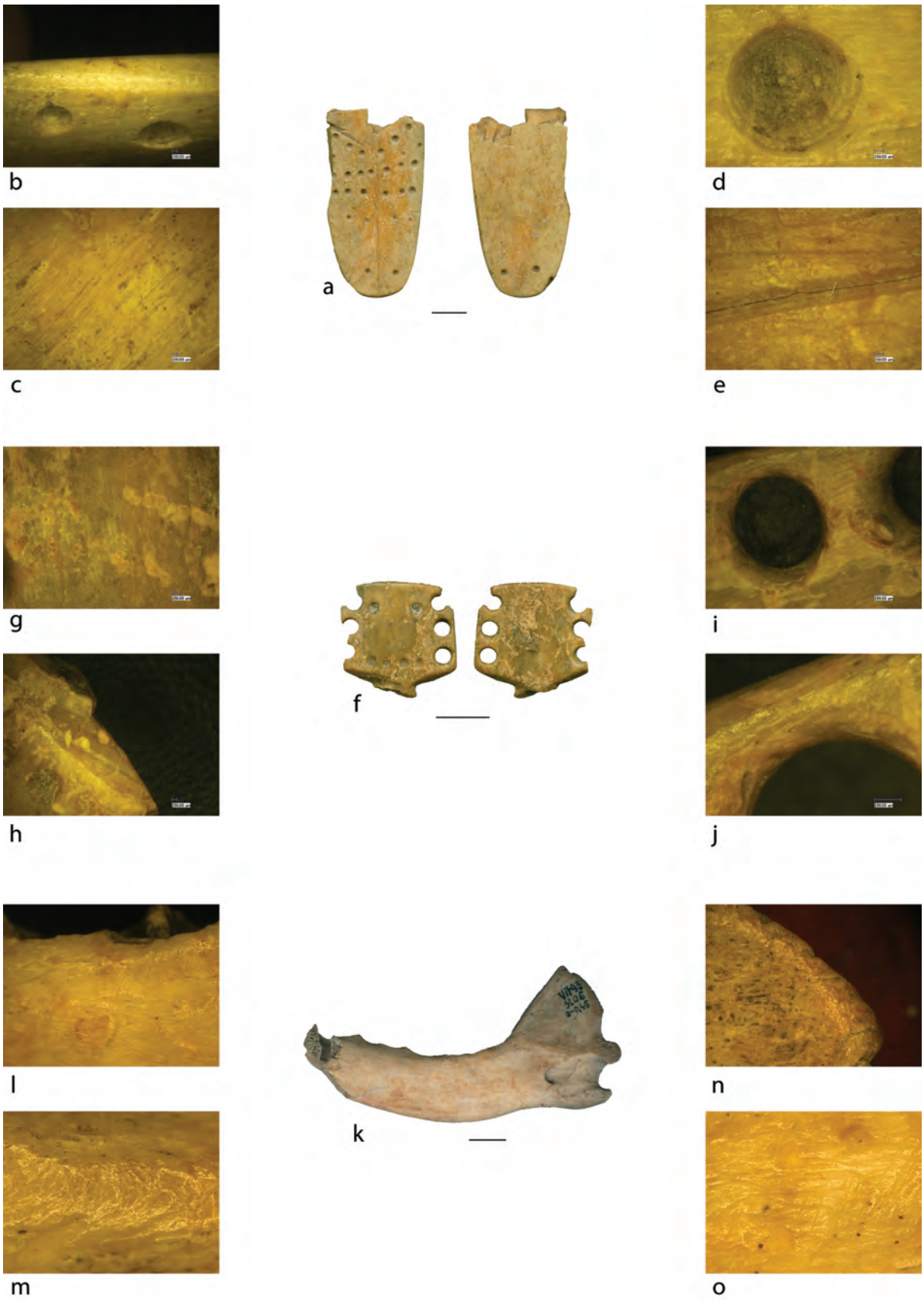

Fig. 14. **a, f *flat figurines;* b, g, l *abrasion marks;* c *scraping marks;* d *dot detail;* e *grooving marks;* h *sawing marks;* i, j *perforations details;* k Canis familiaris *mandible;* m-o *use-wear areas.***

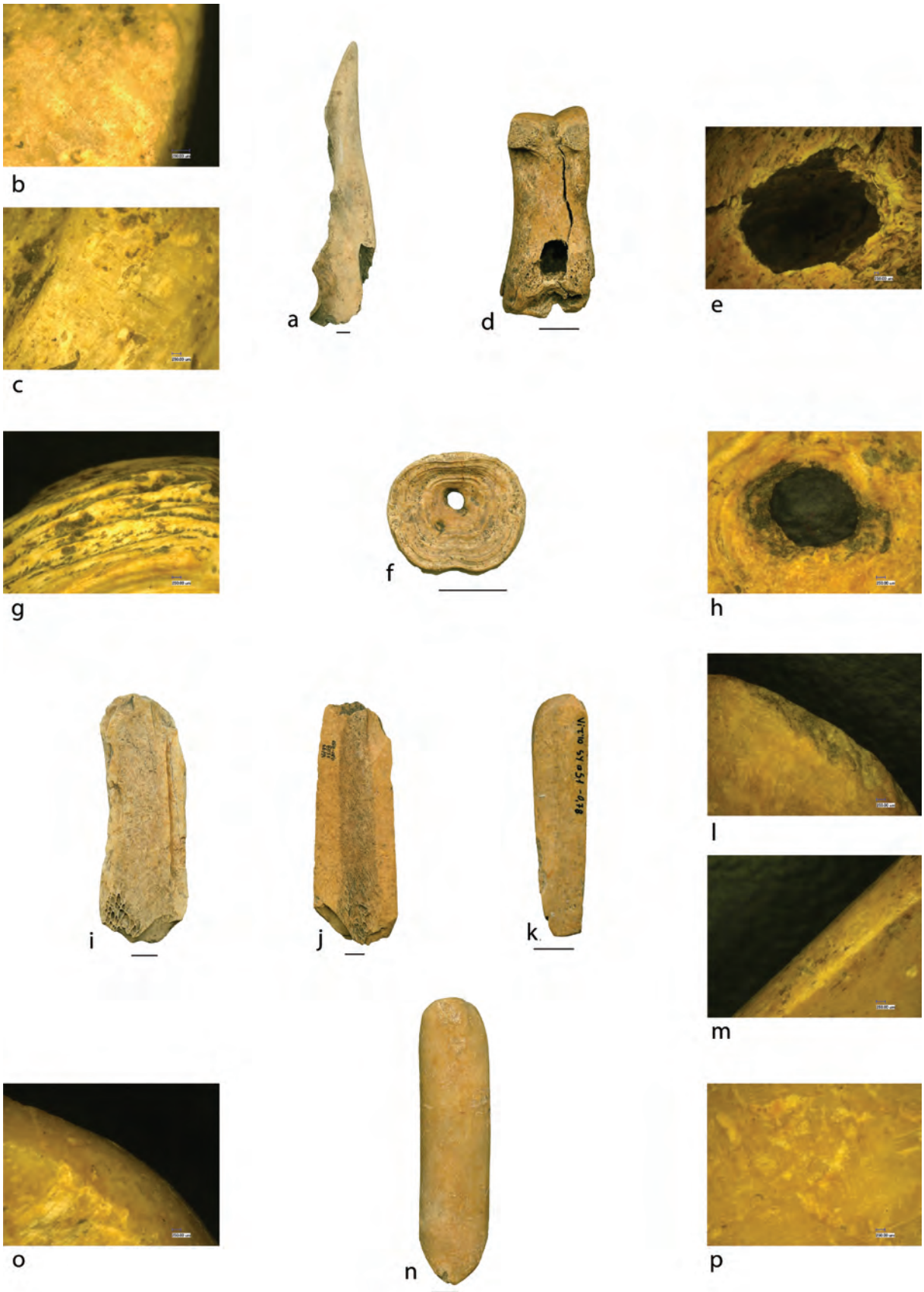

Fig. 15. **a** ***knife;*** **b** ***use-wear area;*** **c, l-m, o-p** ***abrasion marks;*** **d** ***perforated phalanx;*** **e, h** ***perforation details;*** **f** ***perforated vertebra;*** **g** ***edge detail;*** **i-k, n** ***preforms.***

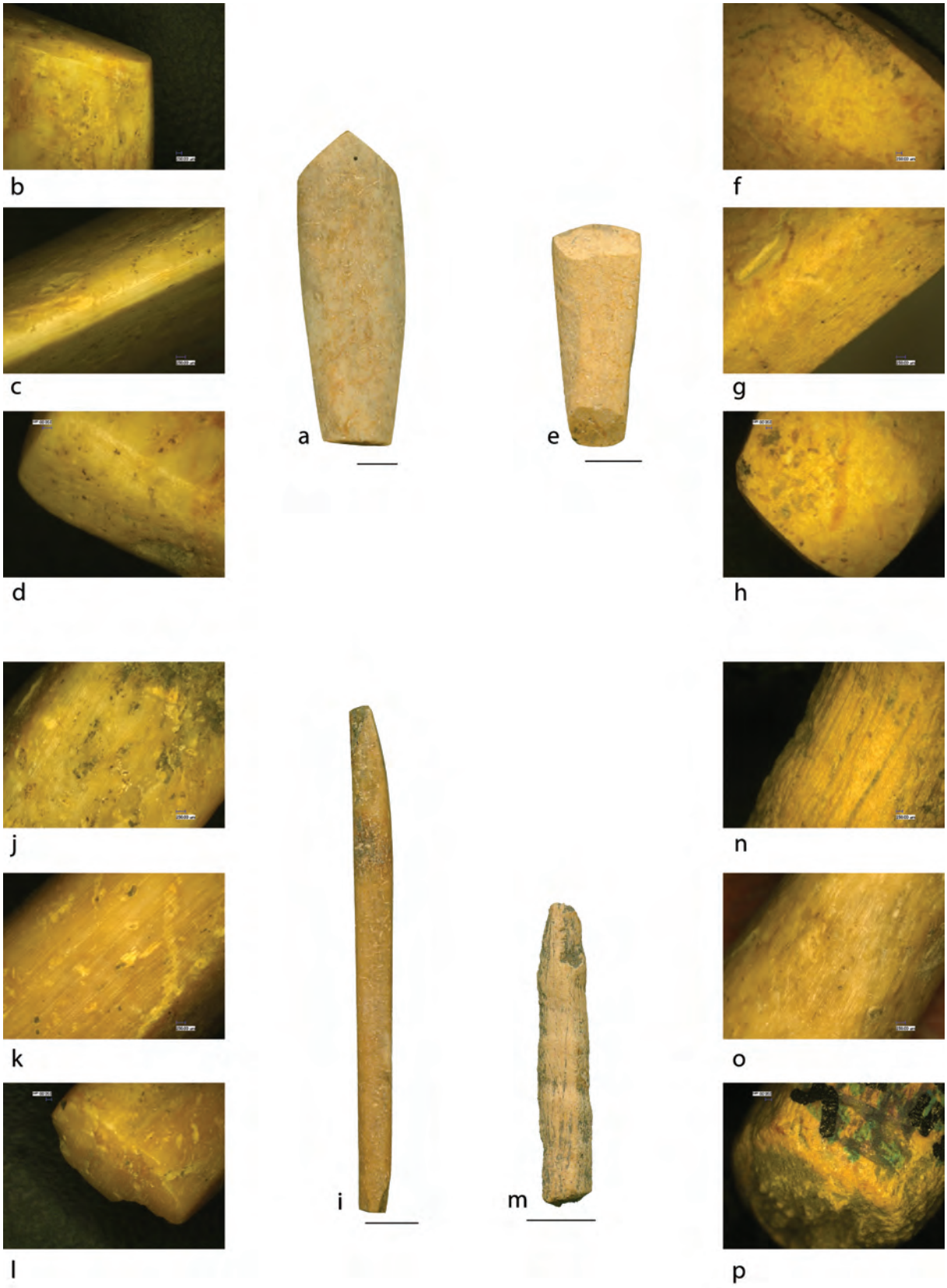

Fig. 16. **a, e, i, m** ***preforms;*** **b, p** ***sawing marks;*** **c, k** ***grooving marks;*** **d, f, h, l** ***abrasion marks;*** **g, j, n-o** ***scraping marks.***

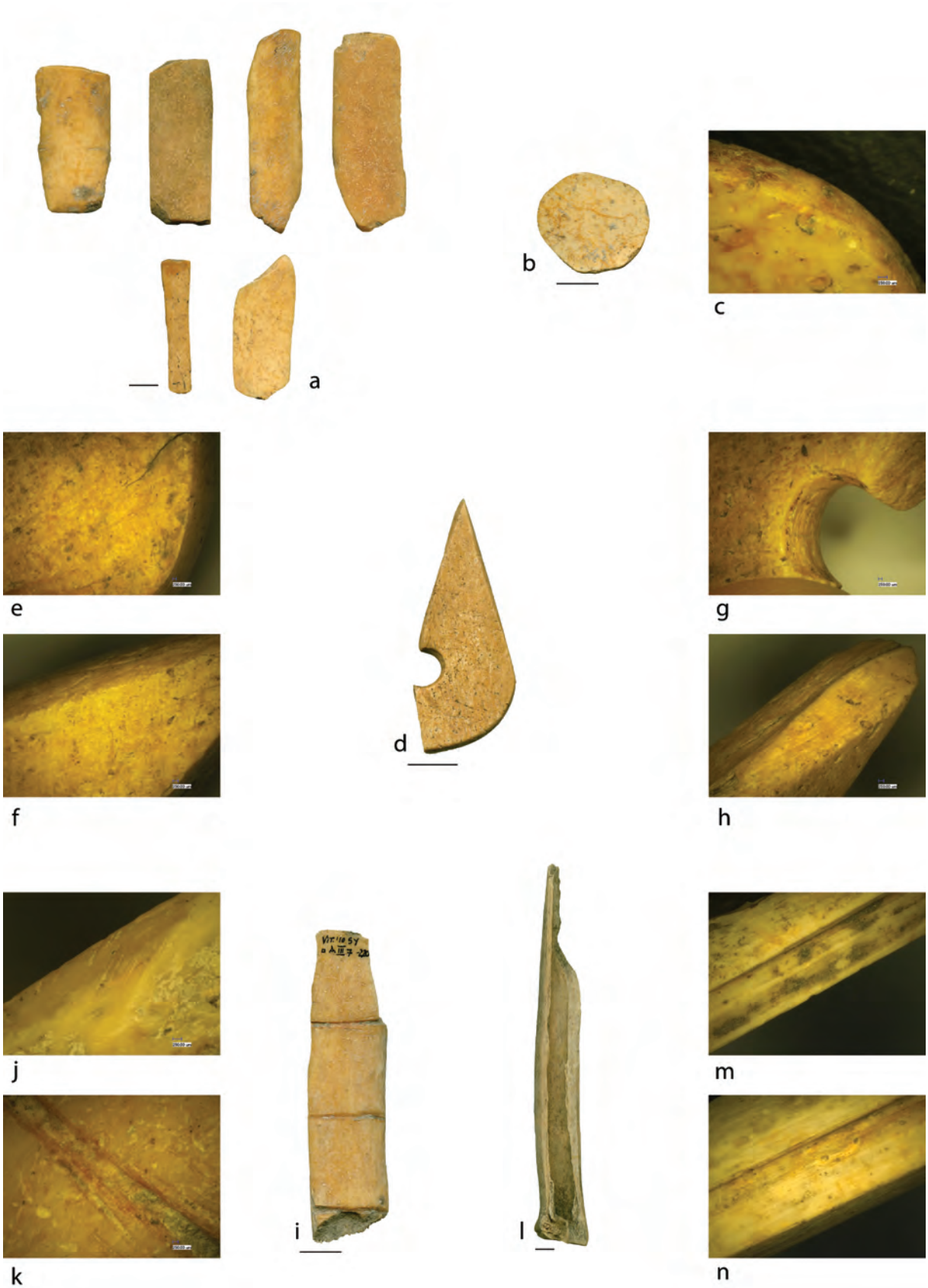

Fig. 17. **a**, **b**, **d** ***preforms;*** **c**, **e-f**, **j** ***abrasion marks;*** **g** ***perforation detail;*** **h** ***scraping marks;*** **i**, **l** ***blanks;*** **k** ***sawing marks;*** **m-n** ***grooving marks.***

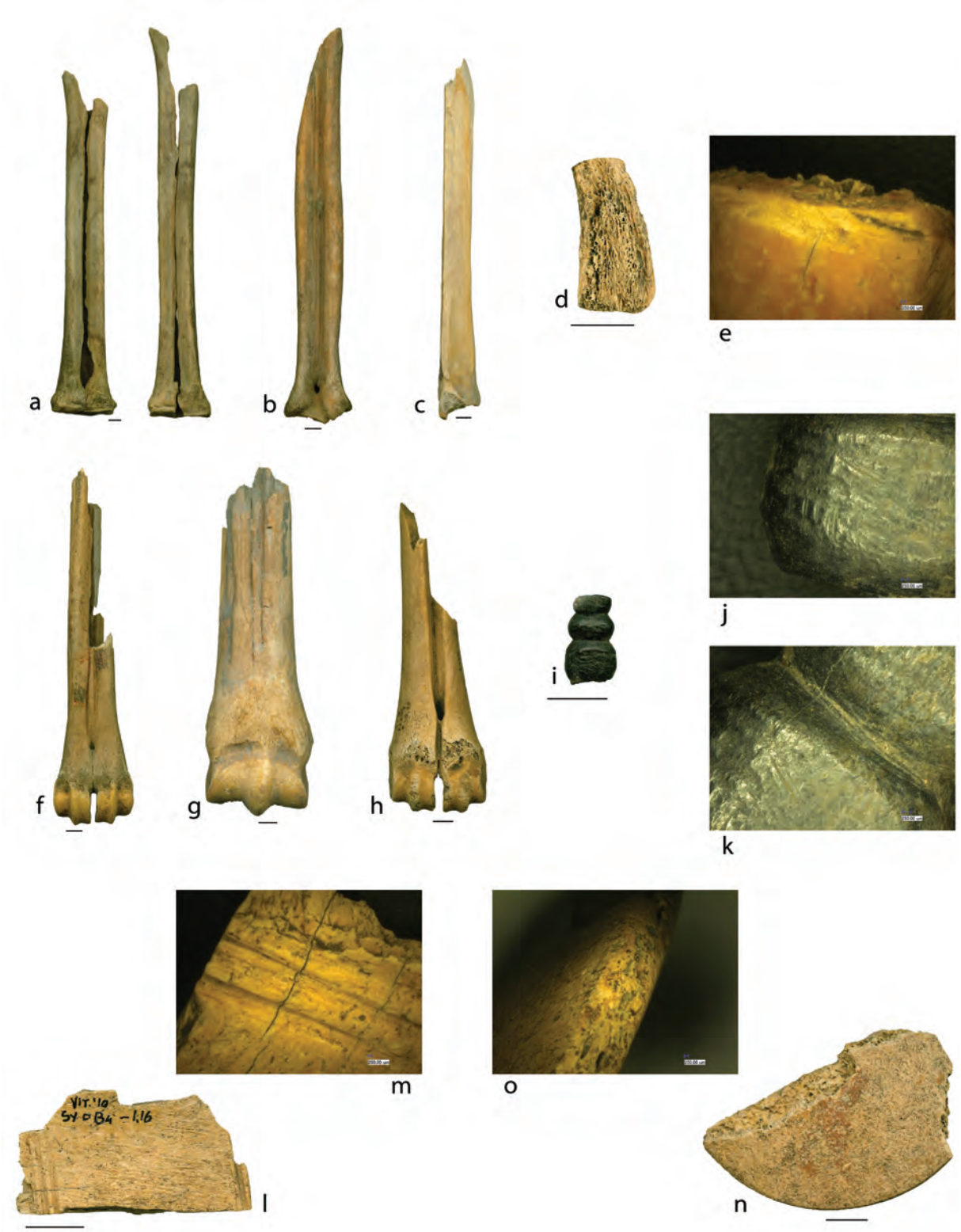

Fig. 18. **a-d** ***blanks;*** **e, j-k, m** ***sawing marks;*** **f-h** ***waste;*** **i, l, n** ***undetermined pieces;*** **o** ***abrasion marks.***

Red Ladies of Clay: identifying colour in Neolithic figurines from Knossos using non-invasive methods

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ABSTRACT - *Colour and decoration were prominent features of Neolithic figurines. However, many such details and colours have faded over time, and it is only on close inspection that traces of colour are visible. This paper presents the innovative application to figurines of a technique based on the treatment of images with DStretch, a valuable tool for recovering the visualization of fainted pigments in clay figurines examined from Knossos. The method has the potential to illuminate aspects such as gender, age, status, identity or group affiliation through the study of colour in Prehistoric figurines.*

KEY WORDS – *Neolithic figurines; Greece; pigment detection; colour*

Rdeče dame iz gline: določanje barv na neolitskih figuricah s Knososa s pomočjo neinvazivnih metod

IZVLEČEK – *Barva in okras sta bili pomembni značilnosti neolitskih figurin. Številni detajli in barve so sčasoma zbledeli in le ob natančnem pregledu so sledi barve še vidne. V članku predstavljamo inovativno uporabo tehnike, ki temelji na obdelavi slik z DStretch orodjem za obnovitev vidnosti obledelih pigmentov na glinenih figurinah s Knososa. Metoda s pomočjo preučevanja barv na prazgodovinskih figurinah pomaga pri pojasnjevanju različnih vidikov, kot so spol, starost, status, identiteta ali skupinska pripadnost.*

KLJUČNE BESEDE – *neolitske figurice; Grčija; odkrivanje pigmentov; barva*

Introduction

Colour and decoration were prominent features of Neolithic figurines. However, too often we are robbed of that perception since most publications consist of black and white photos or simplified drawings that usually fail to convey essential decorative details. Although many such details and colours have also faded over time, we know, for instance, that many marble Bronze Age Cycladic figurines or Classical Greek sculptures were painted with bright colours, and it is only on close inspection that traces of these are visible (*Birtacha 2017*). From a visual perspective, such painting made figurines radically different from the pure white Cycladic figurines that we have in our imaginary. This probably also occurs with figurines in clay from Neolithic Knossos, Crete, on which the paint has faded. Colour and decoration tell us about different aesthetics and, importantly, about past identities too. Colour and decoration must thus be an integral part of any archaeological study of Prehistoric figurines since they may reflect aspects such as gender, age,

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status, identity or group affiliation. More specifically, the study of colour on figurines from Neolithic Greece may help us understand ancient clothing and body ornamentation, elements that could not be studied otherwise as no such archaeological remains are preserved.

The use of colour for the decoration of figurines is known from Prehistoric so-called 'Venus' figurines painted with red ochre or hematite, for instance, the 'Venuses' from Mauern, the Grimaldi Caves, Willendorf and Laussel *(Petru 2006.206*). However, the topic of colour has been understudied and undertheorized in Neolithic figurine research, mainly due to the difficulty of identifying colour traces on the figurines but also the consideration of colour as simply having a decorative purpose (*Ucko 1968; Hourmouziadis 1973; Talalay 1993*), and the problematic classification and objective interpretation of any decoration (*Ucko 1968.329–333; Talalay 1993.70*). Therefore, decoration and colour are commonly interpreted as 'decorative' with no other purposes, forgetting that they may have other meanings beyond the purely aesthetic, perhaps expressing cultural conceptions and practices involving gender and age identities. Colour in itself has not been widely studied in Aegean Neolithic figurines and those studies that have been carried out (*Talalay 1993; Mina 2008; 2014*) have addressed the use of the same colour palette to decorate Neolithic pottery and figurines in the Peloponnese, which may attest to a similar symbolic use of colour (*Talalay 1993.35*), and the relationship between gender, colour and symbolism in Neolithic figurines from the Aegean (*Mina 2008; 2014*). Body marks on figurine's bodies may reproduce real marks and have been mainly interpreted as depicting: body painting, tattooing or scarification, clothing, and jewellery (*Ucko 1968; Talalay 1993; Mina 2008; 2014*).

The known repertoire of pigments used to decorate figurines throughout the Aegean Neolithic are black, white, red, purple, yellow, red-on-white, white-on-red, brown, brown-on-buff, pink and grey; and, additionally, blue and green from the Final Neolithic (*Mina 2008.126*). In the assemblage of figurines from Neolithic Crete, the most widely used pigments are red, yellow, white paste and red-on-white. Black is only reported for rendering hair in a figurine from Knossos (*Mina 2008.126*), but not for bodily decoration. According to Peter Ucko (*1968*) and Mina (*2008. 126*), the figurine makers preferred white paint over red paint on the figurines from Knossos. However, during my study of the Ashmolean Museum material, slight traces of red paint were found on some figurines undetected in previous studies, and more may be identified in the future.

The techniques used so far for the identification of pigments on figurines, particularly on Cycladic ones, are low-power magnification, computer-enhanced photographs to heighten the contrast between painted and unpainted areas and ultraviolet-reflectance photography (*Hendrix 1998; 2003*). This article presents the examination of paint and decoration on figurines from Neolithic Crete, focusing on the site of Knossos, by analysing high-resolution photography of the figurines processed with DStretch (https://www.dstretch.com/), a tool that has been widely used for rock art but not for figurines. These results are then compared with personal inspection of the originals.

Neolithic figurines from Knossos, Crete

The site of Knossos is located 8km inland from the northern coast of the island of Crete. It was first excavated between 1900 and 1905 by Sir Arthur Evans, assisted by Duncan Mackenzie. The published corpus of Neolithic anthropomorphic figurines from Knossos consists of 113 examples, of which 63 were found during A. Evans' excavations (*Evans 1904; 1921; 1928; 1939*). The figurines from A. Evans' excavations were published succinctly without precise contextual data. In the later excavations directed by John D. Evans (*1964*) between 1958 and 1970, another 50 figurines were found, as published in a detailed monograph by Ucko (*1968*). The contextual information in this excavation is well documented, although not all the material recovered from excavations at Knossos has been published. For instance, a few figurines from A. Evans' early excavations at Knossos kept in the Stratigraphical Museum are not yet published and could not be studied. Nikos Efstratiou *et al.* (*2013.43*) also mention the finding of figurines in their excavation at Knossos, but there were not many of these due to the limited extent of the excavation, and unfortunately, they have yet to be published.

It is noteworthy that most figurines found in Crete come from Knossos (Fig. 1), which is the main and most long-settled Neolithic site known on the island, covering the whole sequence of the Neolithic period from the Aceramic or Initial Neolithic to the Final Neolithic (*c.* 7000–3500 BC). Other Cretan sites with figurines are Kato Ierapetra, Phaistos, Gortyna, Ge-

rani cave and Spelaio Pelekiton (Fig. 1), while three further figurines come from unknown sites. Unfortunately, the contextual data at Neolithic Knossos is scarce regarding the figurines' findspots and other associated objects from A. Evans' excavations, as he noted only some of the figurines found in his excavation diaries and divided the strata mainly into Neolithic and Sub-Neolithic phases (Final Neolithic/Early Minoan transition). However, J. D. Evans' (*1964. 60, 238*) excavations suggest that the Late Neolithic was the period with most figurine production, and their deposition in pits and contexts was interpreted by J. D. Evans as habitation debris. In Middle Neolithic contexts, figurines are particularly associated with broken bowls smashed *in situ* or with the base missing, which may suggest that the figurines were associated with feasting and drinking rituals (*Ramirez-Valiente 2022*). In Late Neolithic contexts, figurines are associated with polished and chipped stone tools: maces, axes, chisels, obsidian and chert tools, animal figurines, bone implements and clay objects, suggesting a change in their symbolism and use (*Ramirez-Valiente 2022*).

Of those found on Crete, 31 figurines are decorated or painted (22%), including five clay fragments that cannot be securely identified as parts of figurines (*Evans 1964.Fig. 60,2–3,5–6,14*). Most decorated figurines were found at Knossos, except for one figurine found in Ierapetra (Accession Number AMH.249). Paint mainly survives as the filling of incisions and impressions in 13 examples. In three figurines, white paste and red pigment did not accompany incisions or impressions, and only colour decoration was applied.

Methodology

To assess the presence of painting requires careful handling of the figurines and high-resolution photographs. The use of specific techniques like Multispectral Photography (MP), which uses different light spectra (*e.g.*, daylight, infrared and ultraviolet) and the Decorrelation stretch (DStretch®) enhancement plug-in are helpful tools to bring out the remains of any pigment.

DStretch can bring out faint pigments on surfaces that are invisible to the naked eye. This plug-in was developed by Jon Harman in 2005, and it is a widely used tool for the study of rock art to enhance the visualization of colour in images taken from a digital camera. The enhancement of the images works by increasing differences in hue on photographs using the DStretch plug-in in the program ImageJ®. This method involves breaking down the original image into RGB bands and the application of a series of mathematical operations (using a decorrelation algorithm) on the quantitative information that the image contains (*Quesada-Martínez 2008–2010*). Harman warns that the enhanced image is a false colour one, meaning that the resulting colours may be radically different from the original (www.dstretch.com/AlgorithmDescription.html). Despite this, the resulting image enables the visualization of motifs that were otherwise impossible or very difficult to notice with the human eye, and it also allows the distinction between different superimpositions and types of pigments used (*Fraile* et al. *2016*). However, this tool also includes ways of manipulating false colour images. Therefore, this enhancement technique proves more useful than the traditional computer-enhanced modification of the hue and saturation of the images.

DStretch may also prove helpful for visualizing preserved pigments that are not visible or very faint in figurines, pottery and other surfaces, and has produced some excellent results. However, this tool has not been applied to figurines, except for three examples from Koutroulou Magoula in Costas Papadopoulos *et al.* (*2019*). This paper will demonstrate the usefulness of this technique for identifying the remaining pigments in a group of figurines from Knossos, Crete, for which high-resolution images were available, in order to enhance the perception of pigments present on the figurines that are barely visible to the naked eye.

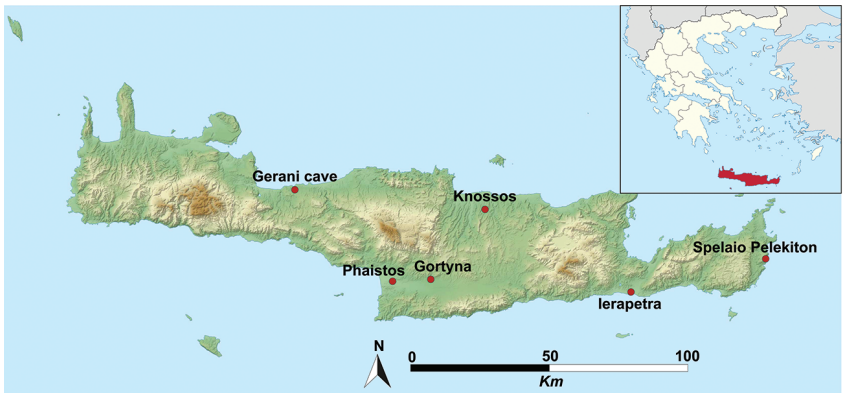

Fig. 1. Map of Crete and sites with Neolithic figurines.

In order to accurately identify pigments, the plug-in requires high-quality images for the analysis, as low-quality photographs may produce errors in the form of false colours. A collection of 16 Neolithic figurines from A. Evans' excavations at Knossos in the Ashmolean Museum at Oxford were available to be handled, studied and photographed personally by the author of the current study. Other high-quality photographs that were used to prove the effectiveness of the method were obtained from those available online showing the British Museum figurines from Knossos.

The photographs from the Ashmolean Museum were taken by the author with a Canon® EOS 1000D with an EF 100mm f/2.8 USM macro lens in the Photo Studio Light Box Foldio2® Plus. The images were processed using the DStretch plug-in for ImageJ to emphasize otherwise imperceptible details in the originals. The examination process involved a great focus on the identification of traces of painting on clay figurines. Some figurines only reveal those traces under specific lighting conditions and are particularly enhanced with the DStretch plug-in. The photographs selected to be processed with DStretch are in their original state, taken under controlled lighting conditions but without any computer-enhanced modifications that could impact the results by simulating false colour traces. Six figurines with indications of paint are discussed in detail below.

Discussion of colour and DStretch results

The surface treatment of Neolithic figurines from Knossos has not attracted much attention and remains widely understudied, although it is important to better understand the final colour results. Similar to ceramic vessels, the surface of such figures was either polished or slipped, resulting in a thin compacted layer (*Tomkins 2001.53–54*). According to Peter Tomkins (*L.c.*), sometimes the addition of a slip layer was intentional to manipulate the colour and ensure a dark polished surface. The firing techniques ranged from mixed oxidizing/reducing to reducing and firing temperatures, from those seen with clay that is not vitrified (750–800°C) to estimates of more than 1000°C in the vitrified examples. The dark burnished ware required surface vitrification, which is observed in specific figurines and pottery found in Knossos. To achieve the highly burnished black wares (*e.g.*, AE.731, Fig. 3) required considerable firing skills and the use of completely reducing firing conditions. This technique differentiates black burnished wares from other medium or dark grey and brown wares, also common in Neolithic figurines from Knossos. Black burnished figurines achieved a lustrous black produced by the ceramic surface's vitrification at very high temperatures. The aesthetic result of this technical achievement was an attractive object with a shining, almost obsidian-like surface (*Gaydarska, Chapman 2008).* Bisserka Gaydarska and John Chapman (*O.c.*) suggest that the colour symbolism and aesthetic appeal of dark and especially black burnished and polished wares were of major significance for their gradual emergence as the preferred fine ware over wide areas of Anatolia, the Aegean, and the Balkans in the late 6th and early 5th millennia cal BC. Equally, the use of this surface treatment for figurines from Knossos

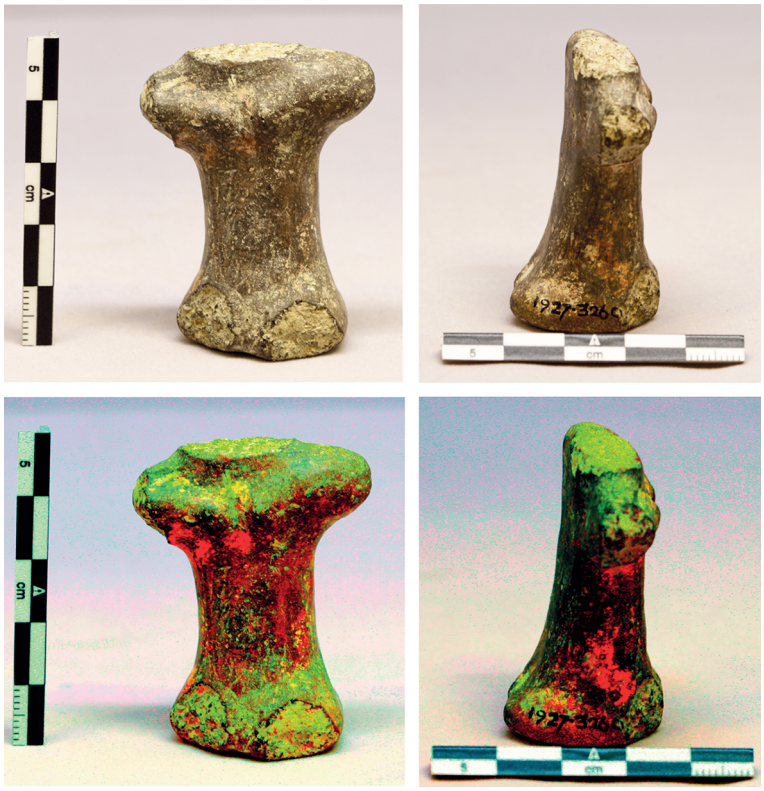

Fig. 2. Top: Figurine 1927–3260 front and side with faint traces of red-on-white paste on a dark brown burnished surface. Bottom: DStretch images in colourspace LAB, highlighting red pigment traces (Photographs by the author, reproduced with permission of the Ashmolean Museum).

may have had a similar effect to that seen with the pottery. The black background of these shiny objects easily created colour contrasts, which may explain why red and white colour paste was applied to decorate some dark burnished figurines, *e.g.*, AE.731 (Fig. 3).

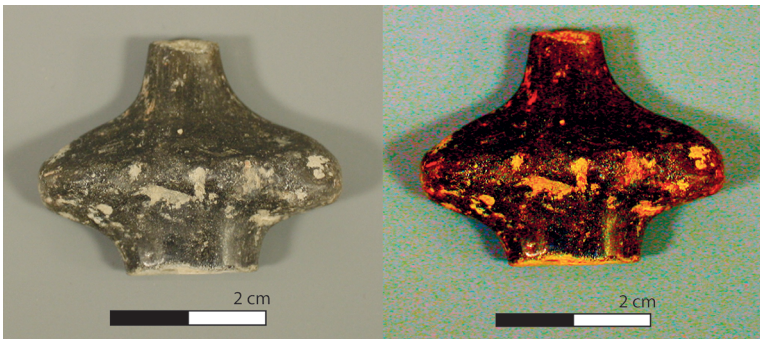

Fig. 3. Left: Front of figurine AE.731 with almost imperceptible traces of red-on-white paste on a black burnished surface. Right: DStretch image in colourspace LAB, highlighting red pigment traces. The red colour on the broken area of the neck represents false colour as no traces could be identified through personal inspection (Photograph by the author, reproduced with permission of the Ashmolean Museum).

Colour and brightness must have been important in categorizing material culture, based upon the striking colours and brilliance of fine painted, slipped and burnished clay figurines. These surface treatments may have had symbolic properties that were imbued in the figurines and manifested in distinctive colours and polished textures. These aesthetic and symbolic properties may thus explain the preference in Late Neolithic clay figurines at Knossos for a dark-colour canvas, ranging from dark brown to black.

In the Ashmolean Museum collection, traces of red paint applied on at least five figurines from Knossos have been identified (1927–3260, AE.731, 1938.661, 1938.660, 1938.662 Figs. 2–6). Another figurine with painting has been identified in the British Museum collection: 1934,0115.3 (Fig. 7). The motifs depicted are not always identifiable because of the poor preservation of the pigment, with red paint being especially poorly preserved. As such, red pigment mainly survives when white paste was applied beforehand. The wide application of red-on-white paste at Knossos might be a way to apply red onto a white canvas so that the pigment adhered better to the surface, perhaps to render the pigment more durable or to make it stand out. The pigments were probably applied after the firing of the figurines, which would result in a much brighter colour but also in the poor preservation of the pigment in the long run.

Figurine 1927–3260 (Fig. 2) from Late Neolithic Knossos (*c.* 5300–*c.* 4400) represents a sitting individual with the head missing and the arms to the chest touching or covering the breasts, and therefore probably depicting a female. Very faint traces of red paint have been detected between its breasts or arms, below its arms or elbows, possibly along its sides on the lower torso and on its right side starting below its arm to the buttocks area. The photographs processed with DStretch colourspace LAB visually enhance the red pigment traces and may be identified with those areas with a deep, bright red colour. This paint could have indicated different motifs, although perhaps all the figurine's body was covered in red given that similar pigment was also visible on its back.

Figurine AE.731 from Late Neolithic Knossos represents a fragment of a torso with the neck partially broken and the hands to the chest touching or covering the breasts. DStretch in colourspace LAB reveals traces of red-on-white paste on its right neck, left hand or breast, and elbows (Fig. 3), while similar traces are visible on the elbows on its back. Unfortunately, the remaining paint is so scarce that it does not show any clear motifs.

Figurine 1938.660 from Late Neolithic Knossos (Fig. 4) depicts a fragment of a torso with the head missing and arms to the chest below the breasts, thus representing a female. At close inspection, remains of paint can be seen with the unaided eye in the chest area between the hands. With DStretch, the pigments become more noticeable, revealing other traces of red paint on the figurine's chest between the left hand and left breast, on the breast area, on its elbows, between its hands at the centre of its chest, along its sides on the lower torso and below its belly. Although paint seems to cover most of the figurine's torso, without any particular pattern, a central motif between the figurine's hands appears to be a lozenge in a turned position compared to the incised lozenge on its abdomen.

The red paint on these three figurines (Figs. 2–4) is thus applied to the same areas: left breast or hand, elbows, between hands or breasts, and left and right

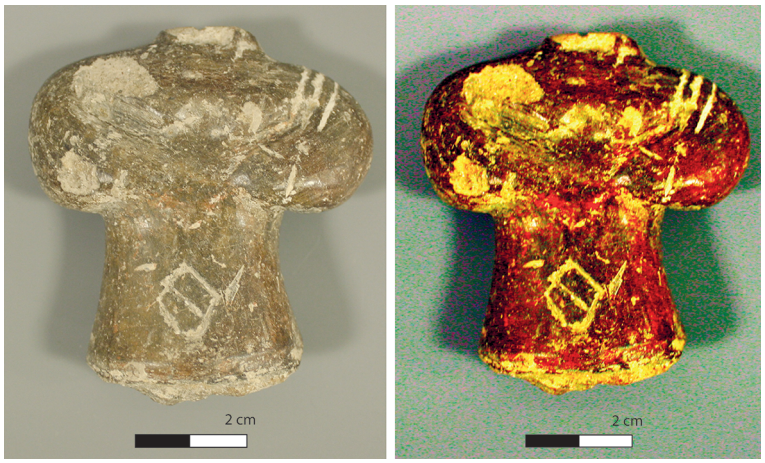

Fig. 4. Left: Figurine 1938.660 with incised motifs filled with white paste and the remains of red paint on a dark brown burnished surface. Right: DStretch image in colourspace LAB, enhancing traces of red pigment (Photograph by the author, reproduced with permission of the Ashmolean Museum).

side of the body in figurines 1938.660 and 1927.3260. However, rather than revealing a pattern, the remaining pigment is probably due to normal wear and tear and the deterioration of figurines with time. Presumably these figurines were coloured almost entirely in red, which is only preserved in some areas of their bodies.

The Late Neolithic figurine 1938.661 (Fig. 5) from Knossos also represents a fragment of torso with the head and part of the right arm missing. The figurine depicts small breasts indicative of a female individual. It is decorated with with two concentric lozenges on the back and, on the shoulders, a pattern that combines hatched-lozenges, triangles, and lines. All the decoration has white and red-on-white paste filling. The concentric lozenges are a common design pattern that probably represents the decoration of the dress. Another figurine from Knossos bears a motif depicting a similar lozenge at the back, hatched into three partitions, but unfortunately, this figurine is only partially published (see *Mina 2009.Fig. 7*).

Figurine 1938.662 (Fig. 6) from Late Neolithic Knossos depicts a fragment of torso with the head missing and arms to the chest touching the breasts, indicating a female. The decoration is composed of roughly parallel lines of impressed dots at the front and back. The dotted decoration covers its remaining torso with white and red-on-white pigments applied to the impressions. Although white and red pigments are visible, enhancement with DStretch highlights the areas with the most paint remaining at the back on the dotted decoration and the elbows. The pigments are more poorly preserved on the front but are faintly visible on the arms as well as some dots, which may depict beads sewn onto the garment. Parallels may be found, although much later in date, in the 'Veiled Girl' from the Late Minoan 'Adorants' fresco from Thera. In this fresco, the figure of a girl has a mantle covered in red dots, possibly representing carnelian shell beads sewn to it, probably to symbolize drops of blood (*Gallou 2018.69, Fig. 2*). A similar garment might also be represented on a figurine from Neolithic Corinth with red painted dots covering the fragmented leg (MF.70-24, *Talalay 1993*).

Figurine 1934.0115.3 (Fig. 7) has only the lower torso and legs remaining and is represented in a squatting posture. This fragment is richly ornated with an incised zigzag, slanting and linear lines, impressed dotted lines, and a 'railway track' motif formed by a

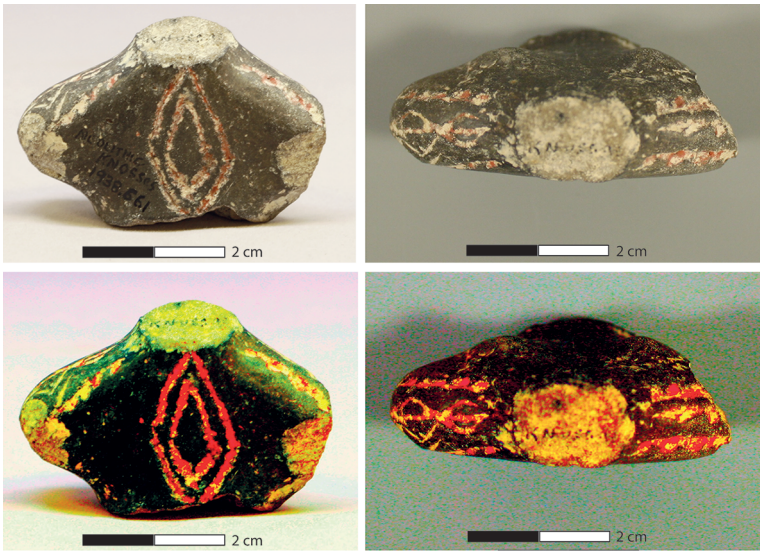

Fig. 5. Top: Back and top views of figurine 1938.661 with incised motifs filled with white paste and the remains of red paint on a black burnished surface. Bottom: The same photographs viewed with DStretch in colourspace LAB, enhancing traces of red pigment (Photographs by the author, reproduced with permission of the Ashmolean Museum).

long straight line crossed by a series of perpendicular lines on the back of the hips. All the decoration is filled with white and red-on-white paste. However, the red paste seems to be applied all over the figurine, as traces of it are found that do not only fill incisions. Analysis of the images with DStretch confirms the wide application of red colour on this figurine (Fig. 7). The red pigment is especially visible on the top and bottom sides of the figurine. The incised and impressed motifs and the paint covering most of the remaining body suggest that this figurine was probably depicted wearing a richly ornate attire.

Interpretation of colour and decoration

In Neolithic Knossos, complex decorative patterns covering most of the figurines' bodies may represent elements of attire. The ornamentation includes zigzag and parallel incised lines, sometimes accompanied by impressed dotted lines and generally painted with white or red paste. This decoration concentrates mainly on the shoulders, arms, back, belly, hips, and legs. Marianna Nikolaidou (*2007.195*) considers it very likely that Neolithic Aegean textiles were beaded or decorated with bone and shell appliqués, as has been attested in Neolithic and Bronze Age Europe and Anatolia (*Barber 1991*). Garments were probably quite ornate from the Late Neolithic onwards. Perhaps tiny beads were sewn onto clothing as it may be the case in figurine 1938.662 from Knossos and in examples from Sitagroi, as suggested by Nikolaidou (*2007.195*).

The colour reconstruction with DStretch illustrates that the preserved traces of red pigment frequently correspond to incisions or impressions, particularly in figurines 1938.661, 1938.662 and 1934.0115.3 (Figs. 5–7). However, red pigment not accompanying incisions or impressions also appears on figurines 1927.3260, AE.731 and 1938.660 (Figs. 2–4). Therefore, some figurines were covered with strong and bright colours and bore motifs and patterns, which are often not clear nowadays. The results suggest that different colourspaces applied with the DStretch plug-in provide different outcomes. Colourspace LAB is extremely useful to enhance red pigment. While RGB, YBR and LRE also bring out reds, for our figurine collection they are less successful and may induce false colour errors. YDS and LDS colourspaces provide good results with white and yellow pigments. However, when present, these tend to be more visible to the naked eye in our assemblage. Clay figurines from Neolithic Knossos were mostly given a dark burnished finish to which paint could not easily adhere, explaining the deteriorated state of pigment preservation.

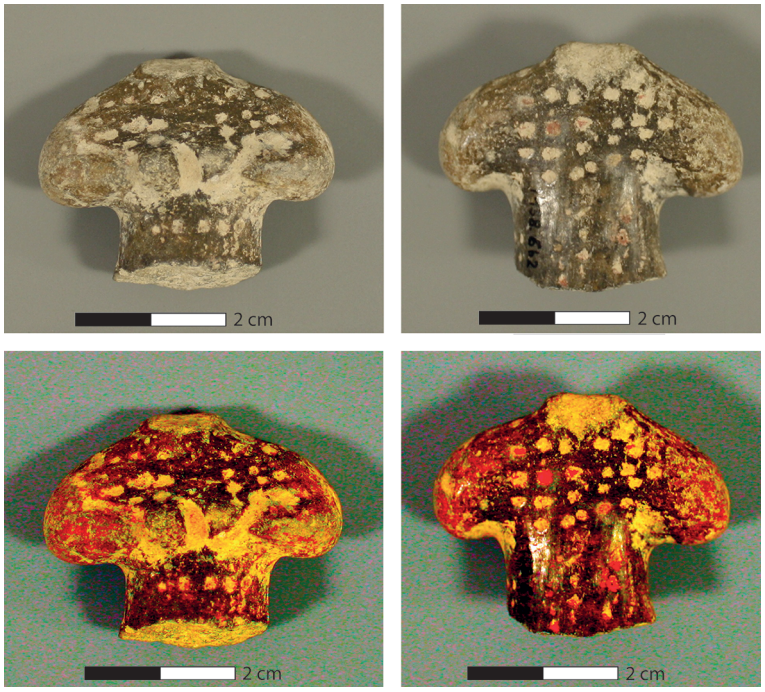

Fig. 6. Top: Front and back views of the dark brown burnished figurine 1938.662 with dot-impressed decoration filled with white and red paste, possibly representing clothing, Late Neolithic Knossos. Bottom: Same figurine viewed with DStretch in colourspace LAB to enhance the red pigment (Photographs by the author, reproduced with permission of the Ashmolean Museum).

No analysis of the pigments has been carried out to date. However, a figurine from Knossos (Accession Number 1905. 1136a.1, Stratigraphical Museum at Knossos) was found together with a large fragment of the base of a bowl that, once broken, was inverted and had traces of yellow ochre (*Tomkins 2017.98*). The figurine and sherd probably date from Middle Neolithic Knossos like the other objects, principally pottery, contained in the box from the same excavation levels. The staining and scattering of the ochre powder on the sherd left a mark that perfectly matched the figurines' size and shape, and there is still a thin stain of yellow ochre on the front of the figurine. XRF analysis on the figurine's yellow ochre stain and the bowl showed a similar

composition, and thus they were probably coloured with the same pigment (*Giumlia-Mair 2017.99–101*). The archaeological evidence associating ochre pigment on the bowl with figurine 1905.1136a.1 may imply its use to colour the figurine. Ochre was probably the main pigment used for figurines of Neolithic Knossos. However, we should not exclude other pigments for the red colour, such as cinnabar, which is attested to for the painting of Cycladic figurines (*Hendrix 1998.8–9*), even though no local sources of this mineral are known in Crete or the Cyclades. Conversely, iron oxides were readily available on the island, and in the case of figurine 1905.1136a.1 yellow ochre was heated to achieve a bright red colour (*Giumlia-Mair 2017.99–101*).

Maria Mina (*2008.126*) considered paint to have a clear pattern: it occurs on breasts and genitalia, which are body parts related to fertility. However, my analysis of the evidence suggests that this pattern is not as clear as previously thought, as no figurines feature colour applied to the genitalia, and only occasionally do red or white colours appear on the breasts or the surrounding area, such as on figurine 1927.3260 (Fig. 2), or applied to incisions in the buttocks area, but decoration and colour were also applied to other areas of those figurines.

The significance of the patterns of paint present on figurines from Neolithic Knossos probably signified the idea of body embellishment either on actual people or those represented by the clay figurines. There is a great deal of variety in the decorative patterns on Neolithic figurines from Knossos. The spacing of the elements, whether incised lines or impressed dots, varies, and the general density of the chosen decoration pattern differs widely, even among examples from the same site. This means that figurines were produced in small quantities and handcrafted individually. In this sense, figurine decoration may be a corporeal extension of the individualized human body, since they are decorated in a unique fashion.

In particular, the figurines suggest the relationship of painting with clothing or perhaps body painting, considering that the areas with the remains of pigment are spread over the figurines' bodies. Incisions and impressions were probably widely used to represent elements of attire and ornaments, since they are frequently painted. Consideration of ethnographic parallels of practices related to body modification and ornamentation may also shed light on how some of these clay figurines were used. Bodily decoration and ornate garments are often worn in rites of passage to mark puberty, adulthood, marriage, childbirth and death (*Hoffman 2002.537*). Women are frequently the primary bearers of such marks due to their critical role in these life transitions (*Hoffman 2002.537–538*), possibly explaining why most decorated figurines in Knossos are female (except for two asexual figurines AMH.2716 and 1905.1136a.1, see *Ramirez-Valiente 2022*). Notably, in figurines with an identifiable sex the most decoration is on female bodies. The figurines analysed in this study may be classified as females and

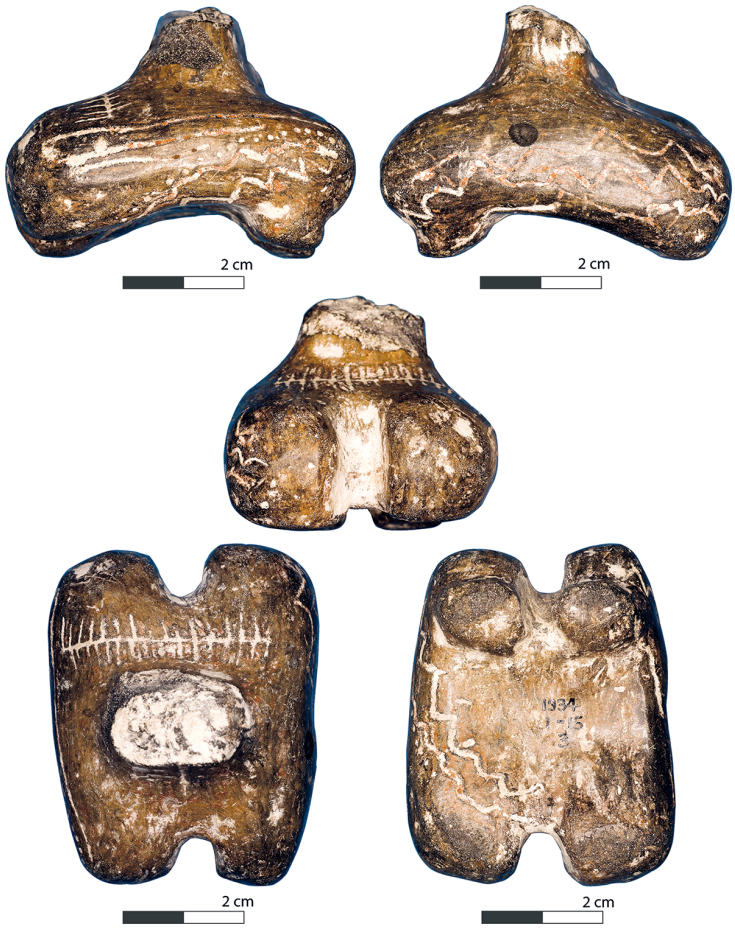

Fig. 7. Right, left, back, top and bottom sides of the brown burnished figurine 1934.0115.3, Late Neolithic Knossos (after https://www.britishmuseum.org/collection/object/G_1934-0115-3, © The Trustees of the British Museum; 10/09/2020, reproduced with permission of the British Museum).

probably females (for a gender analysis of figurines from Greece, see *Ramirez-Valiente 2023*). Arnold Rubin (*1988.16, 19*) emphasizes the focus on female bodily changes, particularly in the case of girls of marrying age, who are given marks on their faces, breasts or bellies in recognition of their position in society and future biological role. The symbolism associated with ochre might add significance to female decorations. For instance, Alfredo González-Ruibal (*2014.127*) suggests that use of ochre among the Gumuz and Dat'sin (https://www.tandfonline.com/doi/abs/10.1080/17531055.2019.1628364) peoples in Africa is related to women who employ this pigment on the occasion of their wedding, with one of his informants stating that *"in old times if a girl wanted to get married, she had to look red"*. However, given the use of red in rites of passage, perhaps this colour was used in girls' puberty rituals to signify blood, since red naturally tends to be a rather universal symbol for blood. Bodily decorations on figurines from Neolithic Knossos focus on female figurines, perhaps representing body painting or most probably ornate gowns used in special ceremonies, such as those marking puberty, coming of age or a wedding. In this sense, it may be significant that only a certain number of female figurines show either painted or incised decoration. The decoration may have represented transient notions of gender, age, status, group affiliation, and family prestige, but also acted as a learning tool to pass on ideas and ideals of beauty and propriety.

Fig. 8. Left, back, top and bottom sides of figurine 1934,0115.3, viewed with DStretch in colourspace LAB to enhance the red pigment.

Conclusions

The goal with this article was to present the utility of DStretch for the analysis of colour and painting on Neolithic figurines from Knossos. However, the results also suggest its applicability for figurines of any other period. The aim was also to increase the body of evidence available by suggesting further surface analysis of figurines with digital aids, as it is, in some cases, difficult or impossible to recognize such painting with the unaided eye. Further benefits of this method include its affordability (DStretch is available with a small contribution fee to its creator, Jon Harman) and the simple and uncomplicated process of learning how to use it. Furthermore, this is a non-invasive method that allows the obtaining of data by using photographs, and thus does not affect the figurine or the preservation of pigments.

The results of applying DStretch to the figurines analysed in this work are promising, particularly for the identification of the faint red pigments on Neolithic figurines from Knossos, which were undetected by previous scholars. The examination of the figurines from Knossos in the Ashmolean Museum collection shows that many were finished with strong colours after firing in patterns that are not easily visible to observers today. Colourspace LAB, in particular, is effective in enhancing red pigments. However, we must be careful when applying this technique. First, we must acknowledge that the visualization results show false colours, and thus they do not reproduce the real colour but an intensely bright version. Secondly, applying this tool to low-resolution photographs may cause false colour traces to be found. For that reason, the personal handling and inspection of any pigment that remains on the original figurine is necessary.

Finally, the use of colour in the Neolithic suggests the symbolic importance of red, white and red-on-white, which are the most widely attested colours. In particular, the use of red and red-on-white on the figurines from Neolithic Knossos analysed in the present study likely implies the representation of richly ornated attires associated with female and probably female figurines, perhaps hinting at their use in special ceremonies such as coming-of-age rituals or weddings.

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A closer look at wound cord: technical analysis of Neolithic pottery decoration from Latvia

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ABSTRACT - *Wound cord (whipped cord, cord stamp) decoration on pottery from the late 4th to early 3rd millennium BC in Latvia has been subject to detailed stereomicroscope study, incorporating reflectance transformation imaging, which proved an invaluable tool for documenting impressions. While this kind of ceramic ornamentation constitutes a European-scale phenomenon, considerable local variation in the methods of making pottery stamps emerges, most significantly in the kinds of support used for winding the cord, which indicates the importance of vertical transmission for this component of pottery technology. Further, the similarity of the cordage to that used for fishing nets implies a close link between pottery-making and fisheries.*

KEY WORDS – *pottery; wound cord stamp; Latvia; fishing nets; reflectance transformation imaging*

Pogled od blizu na navito vrvico: analiza tehnike krašenja neolitske lončenine iz Latvije

IZVLEČEK – *Okras navite vrvice (prepletene vrvice, odtisnjene vrvice) na lončenini iz poznega 4. do zgodnjega 3. tisočletja pr. n. št. v Latviji je bil predmet podrobne stereo mikroskopske študije, ki vključuje slikanje s transformirano odbito svetlobo, kar se je izkazalo za neprecenljivo orodje pri dokumentiranju. Čeprav takšno okraševanje lončenine predstavlja evropski fenomen, so bile prepoznane precejšnje lokalne razlike v načinih odtiskovanja, predvsem v nosilcih, ki so se uporabljali za navijanje vrvice. To kaže na pomen vertikalnega prenosa kot elementa keramične tehnologije. Podobnost vrvice s tisto, ki se je uporabljala za pletenje ribiških mrež, kaže na tesno povezavo med lončarstvom in ribištvom.*

KLJUČNE BESEDE – *lončenina; odtis navite vrvice; Latvija; ribiške mreže; slikanje s transformirano odbito svetlobo*

Introduction

During the later part of the Neolithic, in the 4th and 3rd millennium BC, a special kind of pottery stamp came to be employed across vast areas of Europe: a cord wound onto a support, giving an elongated imprint consisting of a row of short hollows corresponding to the individual windings of the cord. Referred to as *wound cord* [1] (also familiar as *whipped cord* or *cord stamp*)[2], it is a phenomenon that deserves special attention because it spans such a wide spectrum of ceramic traditions. And not for this reason alone:

1 German *Wickelschnur*; French *barbelé*; Italian *a filo spinato*.

2 The author considers cord stamp a misleadingly general term, since stamps for pottery decoration can also be made using cord in other ways than by winding, for instance by knotting or plaiting.

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crucially, we are dealing with a class of ceramic ornamentation that links directly to the fibre arts, providing a special window of evidence on textiles of this period.

Furthermore, viewing by naked eye and ordinary photography are simply inadequate for distinguishing and recording the technical intricacies and identifying variation in cordage characteristics and stamp construction. Accordingly, in order to exploit their full information potential, in the present study stereomicroscope examination of the impressions has been complemented with reflectance transformation imagery (RTI), an outstanding and very accessible but hitherto under-used tool for comparing, documenting and illustrating the features of ceramic surfaces.

Two main tasks were set in this study. The first, drawing on previous research, was to provide an analytical frame and methodology for the microscopic study of wound cord decoration on pottery, employing RTI for documentation. The second task was to investigate the varieties of wound cord decoration identifiable on late 4th and early 3rd millennium BC (late Middle Neolithic) pottery from present-day Latvia, seeking to characterize the cord and construction of the stamp. The concluding section of the article considers these results within the wider context of cordage use and wound cord decoration in European prehistory.

The phenomenon of wound cord decoration and its research potential

The decoration considered here was made with stamps consisting of a cord wound on some kind of rigid support or, in other cases, a cord wound around itself. Close observation generally permits the imprints obtained with this kind of stamp to be distinguished from the superficially similar ornamentation made using comb-like tools or denticulated stamps fashioned from hard materials.[3]

A comprehensive account of the spatiotemporal distribution of wound cord decoration on prehistoric pottery across Europe is quite beyond the scope of this article. But a rough assessment can be given. Thus, in a wide region of north-eastern and eastern Europe – present-day Finland, Karelia, central Russia and Belarus – this kind of ornament is recorded on the pottery of hunter-fisher cultures already in the 5th millennium BC (*Piezonka 2015.178,192,195, 205,216*). The appearance of wound cord decoration is similarly dated in the south-east of Europe: it is found on the pottery of the Sredny Stog Culture in south-eastern Ukraine from *c.* 4600 BC; thereafter it occurs in the Cucuteni-Trypillia area and, more sporadically, in the central and southern Balkans (*Kotova 2010; Bulatović 2014; Uhl 2015*), preceding the 'classic' cord ornamentation that would spread so widely across Europe as the most prominent feature of Corded Ware. Einar Østmo (*2010*) attempts to trace the diffusion of wound cord decoration in Scandinavia during the late 4th and 3rd millennium BC, from the Funnel Beaker Culture, where it is dominant in the decoration of the Virum style, to the 3rd millennium pottery of Norway (even proposing the concept of a 'Cord Stamp Culture') and thence into the Swedish–Norwegian Battle-Axe Culture. Wound cord also occurs in the Netherlands, in the West Group of the Funnel Beaker Culture (*Bakker 1979*) and subsequently on Late Neolithic and Early Bronze Age pottery (*Lanting 1973*). This kind of ornamentation is also a prominent feature of Neolithic and Early Bronze Age pottery in Britain, apparently going out of use by 1200 BC (*Gibson 2002.59,Ch. 4,5*). It is seen on Bell Beaker ceramics from various regions of France (*Salanova 2000.Fig. 28.4,47.8,64.4*) and is widely represented in the Early Bronze Age of south-eastern France (*Vital* et al. *2012.91–109*).

To give a wider context, it should be mentioned that wound cord decoration is also encountered on pottery from other parts of the world, notably the Jomon ceramics of Japan, spanning the 7th to 2nd millennium BC, and the Woodland pottery of North America, dating from a much later period, namely the 1st and early 2nd millennium AD (*Hurley 1979*).

In the research history on European prehistoric pottery, wound cord decoration has generally been put into service as one of the countless pottery traits that contribute to building chrono-typologies for the the various regions where it occurs. However, the use of this specific class of stamp for decorating a diversity of ceramic wares across a vast area during a millennial time interval is a phenomenon in itself, one that has hitherto received practically no consideration. Exceptional as a regional study focussing

3 Somewhat similar impressions can also be obtained using the distal end of a bird tarsometatarsal bone (*Liddell 1929. Figs. 6a,7a*).

on this particular kind of decor is Østmo's (*2010*) attempted delineation of the 'trajectory' of wound cord decoration across the Neolithic cultures of Scandinavia. Noting the relative technical complexity of the stamp, inasmuch as it seems to have consisted of two elements, whereas all other pottery ornamentation instruments used during the Scandinavian Neolithic were apparently single-piece, and positing that it is unlikely to have been invented more than once, he suggests that wound cord ornaments in the South Scandinavian TRB may have been inspired by impulses originating far away, perhaps in south-eastern Europe, and seeks to account in social terms for their transmission between different Scandinavian cultural milieux.

Østmo's treatment demonstrates the interpretive potential of tracing specific decoration methods across archaeological cultures. At the same time, interpretations in the cultural/social realm must be built upon a firm technical comprehension along with a sufficiently clear and consistent terminology, so as to permit the distinction of significant variation and avoid confusion between different kinds of stamping tools that yield superficially similar imprints. This has been a real problem in the history of research. In the Netherlands, for example, Jan N. Lanting (*1973*) and subsequently Jan A. Bakker (*1979*) have wrestled to resolve confusion and inconsistency in the identification and nomenclature of wound cord and classes of decoration resembling it. An instructive example comes from the investigation of roulette stamps in Africa (*Gosselain* et al. *2010*), where the need for an adequately descriptive, systematic and clear classification has proved a strong motivation for research collaboration, with the agreed aim of reconstructing the actual tools used as the essential path to obtaining a clear picture of variation in decorative practices.

Unlike their colleagues studying rouletting in Africa, who also have recourse to ethnographic data, researchers seeking to characterize the tools used to create the wound cord decoration on Neolithic to Bronze Age pottery in Europe have had to rely on replication experiments, and such work has been pursued several countries: in Russia by Sergei Aristarkhovich Semenov (*1955*) and more recently by Igor G. Glushkov and Tamara N. Glushkova (*1992*) and Ekaterina N. Dubovtseva (*2016*), in Norway by Østmo (*2008; 2010*), in south-eastern France by Joël Vital *et al.* (*2012.91–97*) and in Slovenia by Matija Črešnar (*2010*) and Elena Leghissa (*2015; 2021*), while in Latvia Baiba Dumpe (*2003*) has examined the use of a similar instrument not for stamping but for texturing the pottery surface by rouletting.

Under the designation 'cord-wrapped sticks', wound cord decoration is included in the classification of cordage techniques employed by William Hurley (*1979*) in studying the North American material, a system that draws heavily on the replication work by the Japanese researcher Sugao Yamanouchi. This includes elaborations of the technique, whereby the cord was wound in a complex pattern around a split stick or several sticks and the stamp applied as a rouletting tool to produce a complex design. The ethnographic and experimental research into the roulette decoration that features so prominently on past and present African pottery also deserves attention, since this also includes various classes of tools consisting of a cord wound on a core, which were not only rolled across the pottery surface but also used to make single impressions (*Livingstone Smith* et al. *2010; MacDonald, Manning 2010*). Dubovtseva's (*2016*) experimental work replicating Western Siberian pottery decoration in the 7th to 4th millennium BC likewise reveals the use of a variety of techniques for making imprints with wound cord stamps. Also relevant methodologically are studies of 'classic' cord decoration and various other kinds of cord impressions in pottery (*Hurley 1979; Hulthén 1991.21–22; Korkeakoski-Väisänen 1993; Grömer, Kern 2010; Skrzyniecka 2020*).

As emphasized in the introduction, wound cord also deserves attention because of the window of insight it offers into textiles, since it constitutes one of the major kinds of pottery decoration in prehistoric Europe that brings together ceramic and fibre technologies. Whereas actual cordage survives archaeologically only under special conditions, the imprints preserved in the fired clay can potentially offer a spatiotemporally broad insight into ancient cordage and the ways it was employed in making stamps for pottery.

Archaeological and ethnographic pottery from around the world displays a wide variety of impressed decoration created using cordage and other textile materials. This intersection of ceramic and fibre arts is interesting in itself, but is all the more important in archaeology because impressions in a material as durable as ceramics can furnish lasting evidence about the highly perishable products of fibre techno-

logies. The comprehensive studies of ancient cordage conducted in North America and Japan solely on the evidence of impressions in pottery (*Hurley 1979*) testify to the wide potential of this kind of data. Technical studies on various kinds of cord decoration of pottery in Europe have begun to exploit this resource, indicating the character and possible origin of the fibre as well as various characteristics relating to cord production, namely the twist direction, tightness of twist and cord diameter (*e.g., Semenov 1955; Malmer 1962; Korkeakoski-Väisänen 1993; Dumpe 2003; Østmo 2008; Larsson 2009; Grömer, Kern 2010; Kośko* et al. *2010a; 2010b; Dubovtseva 2016; Skrzyniecka 2020; Šatavičė 2020*). Specifically with regard to wound cord, it must be said, however, that much of its potential as a proxy source on Neolithic and Bronze Age cordage remains to be tapped.

The study material

Previous general research on Neolithic[4] pottery in Latvia (*Zagorskis 1967; Loze 1988*) indicates that wound cord first appears in the impressed decoration during the Middle Neolithic, a period approximately corresponding to the 4th millennium BC. A new treatment of the ceramic assemblage from the Riņņukalns site, by Lake Burtnieks in north-central Latvia, showed that wound cord was a commonly used stamp form during the midden phase of this site, dated to the end of the 4th millennium (*Spataro* et al. *2021*). Broadening the investigation, the present study also examines other pottery assemblages from central and eastern Latvia that can be typologically dated to the late Middle Neolithic. Pottery displaying impressions macroscopically resembling wound cord was subject to preliminary inspection under a stereomicroscope, selecting sherds that display one or more largely or completely preserved stamp impressions with clearly visible twists of cordage on the imprints of the windings, thus permitting unequivocal separation from other, superficially similar kinds of stamp, such as shallowly impressed comb. The aim was to obtain a set of samples reflecting the range of variation of wound cord stamps in the region during this period.

Pottery assemblages from four settlements were found to include a number of sherds with sufficiently clear and complete wound cord impressions. These are the above-mentioned Riņņukalns site, Dviete and Munči in south-eastern Latvia and Nainiekste near Lake Lubāns in the east of the country (Tab. 1, see below; Fig. 1). These collections supplied a set of 37 sample sherds for detailed analysis. All of the finds are held at the National History Museum of Latvia, except for the pottery from the 2017–2018 Riņņukalns excavation, which is being held temporarily at the Institute of Latvian History, University of Latvia, pending analysis and transfer to the museum's collection.

The sherds with wound cord ornamentation included in the study (Fig. 2) are tempered with shell, in many cases also showing voids from plant inclusions, with striated or smooth surfaces. Seven are sherds from direct rims with a flat lip, while the rest are body sherds. All of the study material can be assigned to the late Middle Neolithic, *i.e.,* the end of the 4th millennium BC or the very beginning of the 3rd.

Methodology

Technical analysis of cord stamp impressions in pottery can shed light on the production of cordage in general, and on the particular way cord was utilized in making this kind of stamp (generally in combination

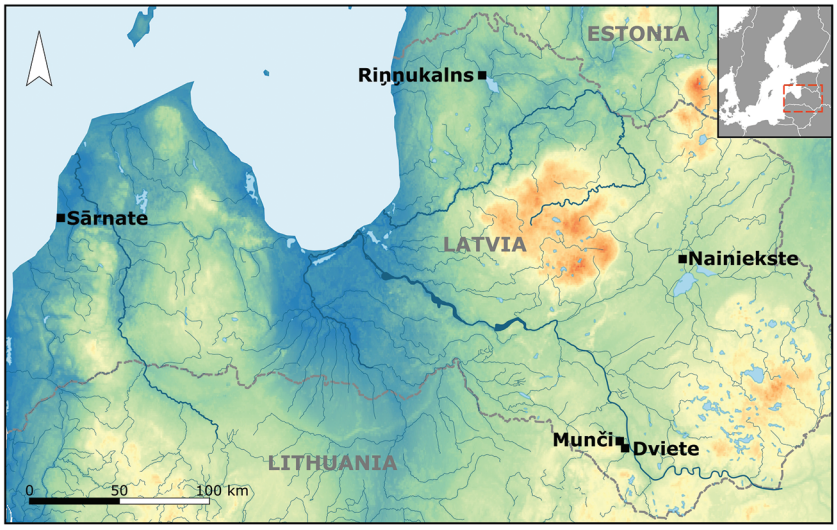

Fig. 1. Map of Latvia showing the sites discussed in the article (map by V. Bērziņš).

4 Here, the term Neolithic designates the ceramic final stage of the Stone Age, rather than indicating the subsistence basis (on this terminological issue, see *Bērziņš 2008.37*).

with a hard material providing the support), in addition to which specific features may be distinguished that reflect the way the stamp was impressed or otherwise applied to the vessel surface, *i.e.* the application technique. All of these aspects were considered in devising the research methodology.

The selected sample sherds were compared against each other macroscopically to verify that each is from a different vessel; in doubtful cases, the features of the impressed ornamentation were compared microscopically. A Bresser *Science ETD-301* trinocular stereomicroscope with a Bresser *MikroCamII* (12 megapixel) camera was used for studying the impressions, primarily at very low magnification (7x). The features of the impressions were characterized by direct observation through the microscope, using a small hand-held flashlight to provide slanting light from different angles.

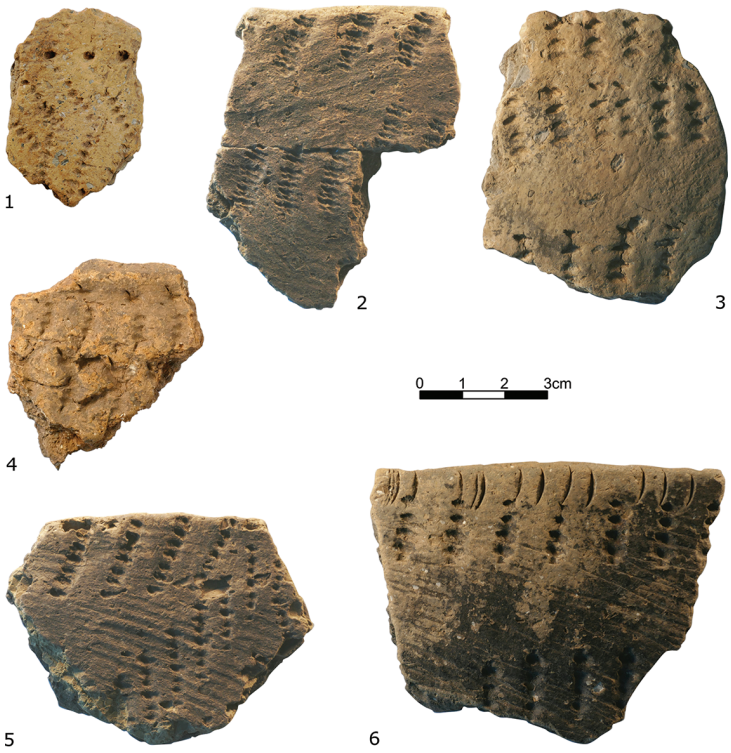

Fig 2. A selection of the investigated sherds with wound cord decoration.* 1 *Riņņukalns, RK-002 (2017 excavation, no. 857);* 2 *Nainiekste, NN-001 (VI 75:501);* 3 *Munči, MU-006 (A10053:35);* 4 *Riņņukalns, RK-012 (A11301:73);* 5 *Dviete, DV-002 (A9586: 63);* 6 *Munči, MU-012 (A10053:39) (photos by V. Bērziņš).

Nowadays, a wide variety of imaging techniques have enhanced our capacity for technical studies of relief patterns on various materials, including ceramic decoration, and, what is no less important, for accurately documenting the observed features and communicating this information effectively within the research community. The present study explores the potential of RTI as an aid for identifying and recording the technical characteristics of impressed pottery decoration. RTI is a computational photography technique that captures the surface shape and colour of the artefact and enables interactive re-lighting of the subject from any light direction. With its capacity for exposing and effectively displaying a variety of pottery surface textures, in ceramic studies RTI has hitherto served to clarify the techniques used in forming vessels (*de Souza, Trognitz 2021; Gunnarssone* et al. *2021*) and applying relief decoration (*Artal-Isbrand* et al. *2011*), as well as permitting the decipherment of inscriptions on makers' stamps (*Lech* et al. *2021*). The present study extends the application of RTI to the analysis of impressed decoration, in this case specifically wound cord impressions.

The sets of photographs needed for compiling the RTI images were obtained using the highlight image-capture technique (*Cultural Heritage Imaging 2010*), with a Panasonic *Lumix DMC-FZ1000* (20 megapixel) digital camera and a small flashlight. The reflecting sphere for recording light directions was a 2mm diameter ball bearing pasted onto 2mm squared paper to provide the scale. A set of 37 to 62 (generally *c.* 40) photographs with different lighting directions was used to create each RTI image. The data were processed with the free program *RTIBuilder* (v. 2.0.2, HSH fitter) for viewing in *RTIViewer* (v. 1.1.0).

The attributes of the wound cord impressions, as recorded microscopically, can be divided into three groups: (1) attributes characterizing the cordage; (2) attributes relating to the construction of the stamp; and (3) attributes relating to the application technique. The different sets of attributes are each considered in turn in the following subsections. Some of the attributes defined below have been adopted from previous studies on wound cord and other kinds of cord impressions in ceramics (as indicated by the references), while the rest were developed in the initial examination of the decoration in the frame of this study.

All linear measurements were made on the RTI images (or on macrophotographs in cases where RTI images were not prepared).

Attributes characterizing the cordage

The study was limited to stamp impressions that show unequivocally identifiable imprints of twisted thread, thus excluding unclear impressions and potential examples of the use of unspun fibre, a strip of leather or other kinds of winding material. The following attributes serve to characterize the cordage used for the stamps.

● Fibre characteristics. In cases where individual fibres are visible, they may be descriptively characterized in terms of coarseness and stiffness (*Semenov 1955; Østmo 2008; Grömer, Kern 2010; Dubovtseva 2016*).

● Spin direction. Likewise recorded in those cases where individual fibres are visible (*e.g.,* Fig. 4) is the spin direction of the yarns making up the cord (S or Z). The spin direction can generally be assumed to be the opposite from the twist direction (see below), but has been separately recorded where observable. The true spin direction is documented, remembering that the spin direction as seen in the impressions is a reversed image.

● Twist direction of the cord (S or Z). Again, the impression will show a reverse image of the twist direction, but the true twist direction has been documented.

● Twist angle (Fig. 3). This describes the intensity of twist, as defined by Emery (*1966.11*), where a loose yarn has a twist angle of 10 degrees, a medium yarn is defined by values between 10 and 15 degrees, and a tight yarn has a 25- to 40-degree twist angle (*Grömer, Kern 2010*). The twist angle was measured using a screen protractor overlaid on an RTI image of the imprint (or an unprocessed macrophoto of the imprint in those cases where an RTI image was not created). Where possible, the angle was measured from multiple windings. Since there is an element of subjectivity in the recording of twist angle, making high precision unrealistic, for the purpose of further analysis the measurements were rounded to the nearest 10 degrees.

● Width of cord impression (to 0.1mm) (Fig. 3): this feature defines the measurable width of the impression of the cord, as seen on the sherd. The width of the impression was measured for up to five windings on an impression, recording the minimum and maximum width.

● Cord diameter (to 0.1mm) (Fig. 3). The width of a cord impression will correspond to the true diameter of the cord if the depth of the impression is at least 50% of the cord diameter (*Grömer, Kern 2010*). This will definitely be the case for those wound cord imprints that also display marks from the support between the cord windings, since this shows that the cord has been completely impressed into the clay. Accordingly, in cases where marks of the support can be seen between the cord windings the maximum width of the cord impressions is taken to equal the true diameter of the cord. In the absence of a mark from the support, the verticality of the sides of the imprint was used to assess whether it is impressed to at least 50% of its diameter and can be regarded as indicating the cord diameter.

Attributes relating to stamp construction (cord + support)

● Overall length of stamp impression (Fig. 3). This is the distance between the outer margins of the terminal windings of the stamp (to 0.1mm).

● Maximum width of the overall stamp impression (Fig. 3), equal to the length of the longest winding impression (to 0.1mm).

● Is the overall axis of the stamp straight or curved, and is there variation between stamps in the degree of curvature? This can help to characterize the material of the support. Thus, if the curvature of the overall stamp axis varies, then this will indicate the use of some kind of flexible support.

● Number of windings.

● Distance between windings (to 0.1mm). The true spacing of the windings of the stamp can be measured only in cases where an imprint from the support appears between the windings. Multiple measurements were taken where possible.

● Orientation of windings in relation to the long axis of stamp (degrees). This is the positive (anti-clockwise) angle between the long axis of the stamp imprint (taken as the initial side of the angle) and the long axis of the imprint of the winding, as measured

from the RTI image using a screen protractor. Whenever possible, the orientation was recorded for multiple windings of a stamp imprint. As in the case of twist angle, there is an element of subjectivity, and accordingly for further analysis the measurements were rounded to the nearest 10 degrees.

● Number of twists visible across the winding impressions. This can help indicate the width of the support.

● Do the terminal windings of the stamp show any distinctive characteristics, compared with the middle windings? This may give an indication of the method of winding.

● Form of the impressions of individual windings across the width of the stamp, such as rounded, which may indicate a cylindrical support, flattened, which may indicate a support with a flat face, or angular (V-shaped), which may indicate a support with a sharp edge (see *Leghissa 2015; 2021*).

● Description of marks left by the support, between the windings and/or at the ends of the stamp, with attention to features that can help indicate the form and material of the support (*Østmo 2008.114–116; Vital* et al. *2012.94–97; Leghissa 2015; 2021; Dubovtseva 2016*).

Attributes relating to application technique

● Orientation of the stamp impressions in relation to the vessel body (vertical/oblique/horizontal, *etc*.), where this can be identified.

● Maximum depth of impression (to 0.5mm). The depth of the deepest winding impression. Only an approximate measurement, since this attribute is very difficult to determine objectively.

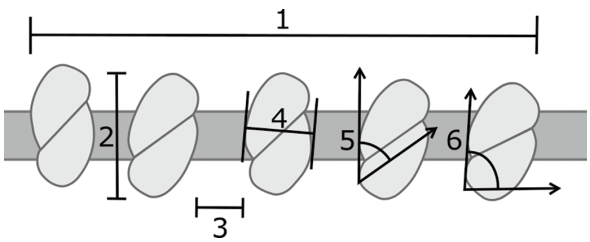

Fig. 3. Diagram of measurements on wound cord impressions (illustration by V. Bērziņš).* 1 *overall stamp impression length;* 2 *stamp impression width (= length of longest winding impression);* 3 *distance between windings;* 4 *cord diameter;* 5 *cordage twist angle;* 6 *winding orientation.

● Description of any noticeable variation in the depth between the ends of the stamp impressions ('pitch' in terms of ship motion) or between the sides of impressions ('roll' in terms of ship motion) (see also *Vital* et al. *2012.99*).

● Is the wound cord stamp also used in other ways, for instance to texture the surface or provide other kinds of decoration (*e.g.,* scraping by dragging across the surface, rouletting, making impressions with the end of the stamp)?

Results and interpretation

The most important attributes for the set of sample sherds, characterizing the cordage and stamp construction, are given in Table 2 (see below). The full dataset can be freely accessed on the Zenodo repository (https://doi.org/10.5281/zenodo.8129223), together with the corresponding set of RTI images and an instruction for viewing them. The actual RTI images offer a greatly enhanced visual representation of the impressions, compared with the 'snapshots' of them presented in Figures 4 and 7 of this article.

Cordage production

In the material under study, imprints of individual fibres could be discerned only in a small number of cases (Fig. 4). The fibres appear rather coarse and stiff – characteristics that, in accordance with observations from experimental studies by Semenov (*1955*), Østmo (*2008.116*) and Karina Grömer and Daniela Kern (*2010*), point to the use of fairly coarse plant fibre. Given the widespread use of bast in the region, in both twisted and untwisted form, as indicated by finds from the Šventoji and Sārnate wetland sites of this same period (*Rimantienė 2005; Bērziņš 2008. Ch. 6*), it appears likely that this material, obtainable in the greatest quantities from the lime tree (*Tilia cordata*), would also have been used for the cordage of the stamps, although this cannot be verified. Fragments of net mesh from Šventoji, consisting of cordage with a comparable diameter to that attested here, have been identified as lime bast (*Rimantienė 2005.65,Fig. 32,174–176*).

The twist direction was clear for almost all of the samples, and all except one cord (RK-012) are S-twisted (Tab. 2). In the few instances where the individual fibres are visible (Fig. 4), they are Z-spun – which is only to be expected, since spinning in one direction

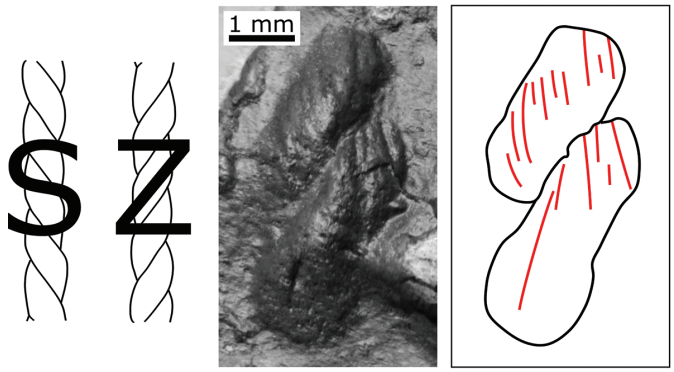

Fig 4. Left: Scheme of the S- and Z-directions of cordage spin/twist. Centre: Microscopic RTI image (with specular enhancement) of the imprint of a single cord winding of a stamp impression, with two twists of the cord visible (sample MU-009). Right: Interpretive line drawing from the image, showing the texture and direction of the fibres, marked in red. The cord is Z-spun and S-twisted, appearing s-spun and Z-twisted in the imprints (image by V. Bērziņš).

and twisting in the opposite is the usual and most effective practice in cordage production.

Cordage twist direction has received particular attention in studies on Corded Ware and related ceramics impressed with cord. Åsa M. Larsson (*2009.244*) notes the exclusive occurrence of S-twisting in the cord used for decorating pottery of the Battle Axe Culture in Sweden. In their study of impressions in Corded Ware from Austria, Grömer and Kern (*2010*) likewise found S-twisting only, and more than 80% of the organic cords found at Swiss lacustrine settlements from the Corded Ware Culture are also S-twisted. This has been considered as reflecting the ergonomic advantage of this twist direction for a right-handed person (*Rast-Eicher* et al. *1997* cited in *Grömer, Kern 2010*). Cord impressions in Corded Ware from south-eastern Lithuania were also found to be predominantly S-twisted, although some Z-twisted examples also occur (*Šatavičė 2020*).

Imprints in Neolithic pottery from western Siberia studied by Dubovtseva (*2016*) likewise indicate S-twisting. The same is true for the great majority of lime bast cordage samples from the 6th and 5th millennia wetland site of La Draga, Spain (*Herrero-Otal* et al. *2023*).

It is hard to gauge, in the present state of knowledge, the factors behind the observed prevalence of S-twisting in various parts of Europe in this period. As discussed by Christopher Carr and Robert F. Maslowski (*1995*), cordage spin and twist direction may potentially relate to the natural predisposition of fibres to twist in one or other direction, to the specific method of cordage production and minor variations in this method as well as to belief systems concerning rotation directions. The picture may also be complicated by right-/left-handedness and idiosyncratic variation. Jill C. Minar (*2001*) and, following her, Herrero-Otal *et al.* (*2023*), see cultural preference (rather than fibre characteristics, production method or handedness) as the determining factor in spin/twist direction. Observing the total absence of Z-twisting among the samples of cordage decorating the Battle Axe Culture pottery of Sweden, Larsson concludes that the making of cords within this culture was "*a tightly controlled practice where no exceptions were allowed*"; this strong cultural preference is contrasted with the Funnel Beaker community, in which "*some cord makers twisted the fibres clockwise, while others twisted them counter-clockwise*" (*Larsson 2009.244*).

Specifically with regard to lime bast, it may be noted that the fibre strands naturally tend to spiral in the Z direction as they dry out. If indeed lime bast was widely employed for the cord of these stamps (which seems likely for this period in the East Baltic region, though it cannot be verified), this pre-rotated condition of the raw material could have promoted a general tendency towards the practice of Z-spinning and S-twisting.

The measured twist angles fall in the range 20 to 60 degrees, most commonly 40 degrees, *i.e.* tightly twisted according to Emery's classification (Fig. 5, top). There do appear to be some differences between sites. Thus, some of the cordage used at Nainiekste shows relatively loose twisting, with three recorded instances of 20-degree twist angles, whereas there is no indication of such loose twisting at the other sites. On the other hand, some of the cord represented in the Riņņukalns material is extremely tightly twisted, with two cases of 60-degree twist angles.

For comparison, the results of Grömer and Kern's (*2010*) analysis of cords impressed in Corded Ware may again be cited: they mostly recorded twist angles of 40 to 50 degrees (exceptionally 20 or 30 degrees), which accords quite well with the results of the pres-

ent study. Šatavičė's (*2020*) examination of Lithuanian Corded Ware recorded twist angles varying from 20 to 50 degrees.

The author's own experience with simple methods of cord production indicates that the finger- and thigh-rolling methods widely attested in ethnographic accounts give a much looser twist (Fig. 6.2, top). Tightly twisted cordage of the kind observed in this study and the others cited above can be made from lime bast strands using the finger-twisting method (Fig. 6.2, bottom). In this method, while holding the two strands together between the index finger and thumb of the left hand, the strand furthest from the person's body is taken up with the right hand, spun in the Z-direction and then laid across the other strand, thus twisting them together in the S-direction, after which the process is repeated with the other strand, producing in this way a length of Z-spun and S-twisted cord. The spin and twist directions can be reversed to obtain S-spun and Z-twisted cord (this will likewise be the case if precisely the same process is carried out by a left-handed individual). Tight twisting is not necessarily indicative of this particular cord-making method, however, since the use of simple tools permits the manufacture of cordage in various other ways (see, *e.g., Herrero-Otal* et al. *2023; Hurcombe 2008.Pl. 1*).

The cord diameter, which could be ascertained for 31 stamps (Fig. 5, bottom), varies in the range of 1.1 to 2.4mm (mean: 1.80mm), the thickest cords being recorded for stamps from Munči.

As noted above, actual cordage from this period is preserved in the collection of finds from the Sārnate site, a wetland settlement near the coast of western Latvia. Among many other organic finds, this collection, held at the National History Museum of Latvia, includes a peat block with a fragment of fishing net mesh (Fig. 6.1,3), recovered from dwelling A_{DR} in 1954 in the course of the excavation directed by Lūcija Vankina (*1970.94; Bērziņš 2008.238–239* [5]). Like the cordage used for the pottery stamps, the cord of the net mesh has been Z-spun and S-twisted from two strands, and the diameter, too, is comparable: approximately 1 to 1.5mm. The raw material has not been positively identified, but the general appearance indicates vegetable fibre, most probably tree bast (and bast, in the form of simple, untwisted strands, has been widely used on this site for tying net floats and sinkers; see *Bērziņš 2008.Ch. 6*).

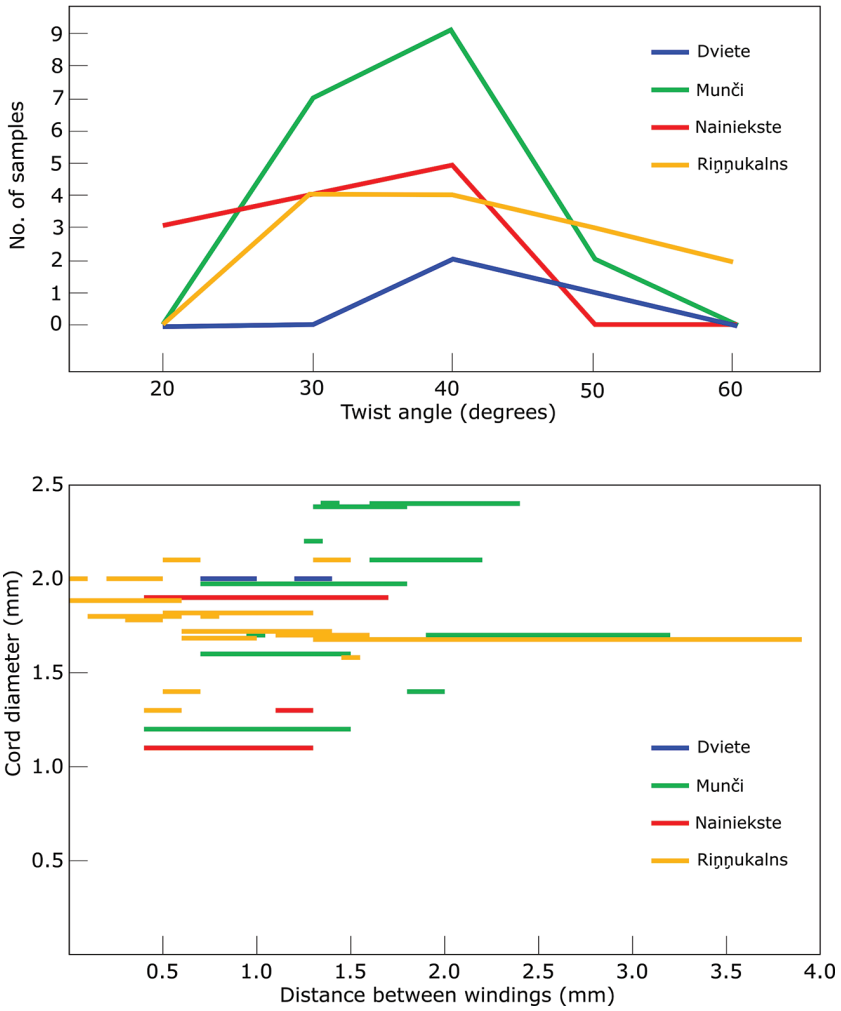

Fig. 5. Top: Graph of cordage twist angle. Bottom: Graph of cord diameter versus distance separating cord windings for the 31 stamps where these parameters could be measured. Distance between windings given as an interval, from narrowest to widest measurable distance between the windings of one stamp (illustration by V. Bērziņš).

This find shows that cord of comparable diameter and the same spin and twist direction (and quite possibly from the

5 The incorrect twist direction is given in the cited work.

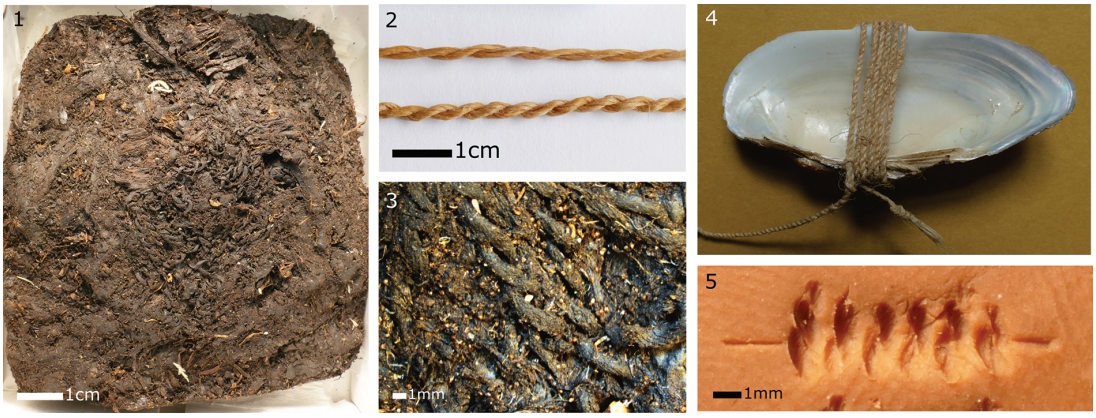

Fig. 6. **1,3** ***Net mesh fragment from Sārnate, Dwelling*** A_{DR} ***(National History Museum of Latvia, A 11418:120m);*** **2** ***experimental cordage, Z-spun and S-twisted from two strands of bast: finger-rolled, showing very loose twist (top), and finger-twisted, showing moderately tight twist (bottom);*** **4** ***experimental wound cord stamp with mussel shell as support;*** **5** ***impression made with the tool (photos by V. Bērziņš).***

same raw material) was being used for pottery-decorating stamps in this region during the 4th millennium BC as was used for making fishing nets. The wider implications are briefly discussed in the closing section of the article.

Stamp construction

The stamp impressions vary in length from 6mm to at least 35mm, the longest being represented by incomplete impressions, and they have between three and at least 13 windings. The shortest stamps are from Riņņukalns, but this site also has a much larger proportion of long stamps for which there are no complete impressions. Moreover, many of the decorative patterns in the Riņņukalns material involve the placement of wound cord impressions end to end, making it hard to identify where one stamp impression ends and the next begins.

The winding imprints display between one and three twists of the cord. The recorded width of the spaces between windings (which could be measured for 31 stamps) ranges overall from zero to 3.9mm (Fig. 5, bottom). The widest space between windings occurs in an imprint from Riņņukalns; more generally, however, it is the stamps from Munči that have relatively widely spaced windings, compared to the other sites. These same Munči stamps also tend to utilize thicker cordage and consequently are more 'robust' in overall appearance.

The imprints of the cord windings are most commonly oriented approximately at right angles to the long axis of the stamp, with the exception of the Munči site, where the winding imprints are more commonly just a little slanting – at an angle of *c.* 100 degrees (*i.e.* 'leaning to the left'). Such a pattern might be seen as consistent with the practice of holding the support with the left hand and winding the cord around it away from the body (first over and then back under the support), which would seem, from personal experience, to be the most comfortable and efficient technique for a right-handed person.

Twenty-one of the samples show at least some imprints from the support, permitting the distinction of different kinds of support. The length of the longest winding imprint is also relevant here, as the length of cord impressed into the clay from each winding evidently relates to the width and form of the support.

The round-edged support

The imprint of the support (Fig. 7.1,4,6) takes the form of a straight, narrow trough (varying in width from 1.4 to 2.9mm but most commonly *c.* 2mm wide) visible in the spaces between the windings, extending a little beyond the outer windings and terminating abruptly, generally cut of approximately at right angles to the long axis of the support. The maximum length of the winding imprint on these stamps varies from 4.0 to 5.5mm. Since, as described above, the windings are generally oriented approximately perpendicular to the axis of the support, even when widely spaced, the cord cannot have been wound onto a stick or some other kind of cylindrical rod, as if the windings are widely spaced with this kind of support they will be obliquely oriented – a distinguishing characteristic highlighted in Leghissa's (*2015; 2021*) experiments with replication of wound cord decoration. Instead, the support must have

been a relatively wide flat plate, one margin of which has been impressed into the clay. The form of the support is most clearly seen from sample MU-011: in this case, the impressions exhibit pronounced 'roll', where one side of the stamp has been more deeply impressed than the other, thus also imprinting part of one of the flat faces of the support. The morphology of the impressions from this group of stamps does not provide a clear indication of the object used for the support, but the similarity between the support imprints of several stamps rather suggests that we might be dealing here with a specific anatomical form (*e.g.,* a specific bone from a particular animal species) that was traditionally employed for this purpose. In the case of MU-011, some longitudinal striae are faintly observable on the imprint of the support.

An imprint from this kind of support is observable in the case of stamps MU-001, MU-002, MU-004, MU-008, MU-011 and MU-012 from Munči and DV-002 from the nearby site of Dviete. In the case of MU-002, MU-004, MU-009, MU-011 and MU-012 the stamp impression is relatively short: three to five windings, with a total length of 10 to 14mm. MU-007 is similar, only in this case the ends of the imprint of the support are rounded (Fig. 7.1). MU-001 and DV-002 are longer than the rest: DV-002 has seven windings and a total length of 19mm, while MU-001, represented only by partial impressions, has at least nine windings, the total length exceeding 20mm. These longer stamp impressions display fairly pronounced 'pitch' – one end of the stamp has been impressed more deeply into the clay than the other.

The sharp-edged support

In these cases (Fig. 7.3,5,8) the imprint of the support occurs in the form of a longitudinal groove, appearing in the spaces between windings and sometimes seen to terminate a little beyond the outer windings. The impressions of the windings themselves are somewhat angular (V-shaped). These features indicate that the support must have been some kind of sharp-edged object. Compared with the stamp impressions showing a round-edged support, the winding imprints are shorter: the maximum length varies from 2.7 to 4.9mm.

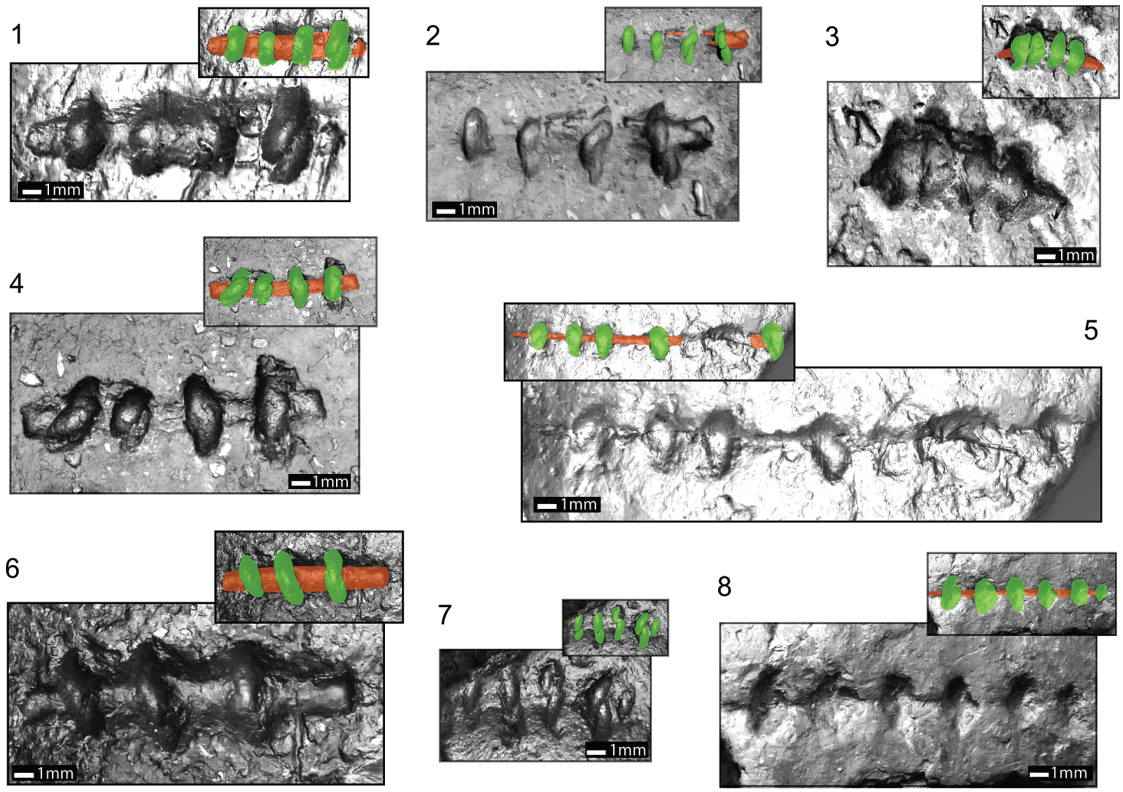

Fig. 7. RTI images of impressions of selected wound cord stamps illustrating the imprints from various kinds of supports, with interpretation of the different elements of the impression: green for the windings and orange for the support.* 1,4,6 *round-edged support (Munči: MU-007, MU-004, MU-008);* 2 *support in the form of a plaited (?) object (Munči: MU-013);* 3 *sharp-edged support, short stamp (Riņņukalns: RK-016);* 5,8 *sharp-edged support, long stamp (Riņņukalns: RK-006, RK-015);* 7 *impression terminating in short imprint of cord (?) (Nainiekste, NN-005) (photos by V. Bērziņš).

Wound cord decoration with imprints from this form of support has been found only on pottery from the Riņņukalns site. RK-001, RK-012, RK-013, RK-014, and RK-016 have been impressed with short stamps of this kind, 6 to 10mm long and with three to four windings. The last two have a markedly curved groove. RK-002 is 10mm long with eight windings, while RK-006, RK-008, RK-009 and RK-015 show fragmentary impressions from longer stamps. RK-006 and RK-015 differ in that their windings are more widely spaced.

Experiments to replicate wound cord impressions with imprints of the support in the form of a groove of V-shaped cross-section have been undertaken by Vital *et al.* (*2012.94–96*), seeking to characterize the stamps used on Early Bronze Age pottery in south-eastern France, and by Leghissa (*2015; 2021*), focussing on Late Bronze Age ceramics from Slovenia. They consider that short flint blades provided the sharp-edged supports used for this purpose, while Leghissa reports successful replication using sharp-edged flat plates of wood and bone.

Freshwater mussels constituted a significant food source at Riņņukalns in this period (as attested by the midden deposit at this site), and the shells were very widely used as pottery temper in the region (*Spataro* et al*. 2021*), so the outer margin of a mussel shell may seem a logical choice as the support for a wound cord stamp producing a longitudinal groove. An experimental tool fashioned from the shell of a large freshwater mussel (*Unio* sp.), filed down to leave a 12mm long section of the margin and wound with cord (Fig. 6.4), did indeed produce an imprint closely resembling the examples in the pottery assemblage from Riņņukalns (Fig. 6.5).

The stamp impression terminating in a shorter imprint of cord (?)

This form of stamp has been distinguished only on three sample sherds in the Nainiekste material (Fig. 7.7). The impressions are relatively long: 14mm with seven windings (NN-001), 16mm with eight windings (NN-002) and at least 17mm with at least eight windings (NN-005). The impressions of the windings are of comparable length to those of the stamps with a round-edged support (max. length: 3.8mm; 3.8mm; 5.4mm), whereas the only evidence of a support is a shallow, wide, rounded depression seen in the spaces between the windings on the latter two samples. At least one end of each stamp impression terminates in what appears to be a shorter impression of the cord, resembling a narrow winding of which only a single twist is visible. In the case of NN-005, this terminal feature of the stamp also has some faintly visible texture – apparently fibres of mixed orientation. This feature might be interpreted as relating to a particular kind of cord whipping technique, but definitive interpretation is currently not possible.

Sample MU-013 (Fig. 7.2), from Munči, displays a fairly clear imprint of a support differing markedly from the others. Appearing at one end of the stamp as well as between the windings, it is difficult to interpret but may consist of some kind of plaited object, possibly knotted at the end.

Application technique

The wound cord impressions on the vessel exteriors have been placed vertically or obliquely, and form horizontal and oblique rows of impressions that can often be seen to constitute parts of more complex designs (Fig. 2). In four cases, rows of wound cord are also found on the inside near the rim, and in six cases on the flat lip. The impressions are shallow: generally 1 to 2mm, exceptionally reaching a depth of 3mm. In some cases the stamp has been more deeply impressed at one end ('pitch') or more deeply on one side than the other ('roll'), but these characteristics are not widely represented in the set of samples.

A stamp consisting of cord wound onto a cylindrical support can be used not only for impressing but also as a roulette stamp, rolled across the pottery surface to create distinctive patterns. This technique is widely attested in the Jomon pottery of Japan and in North America (*Hurley 1979*). Of course, wound cord stamps with a support in the form of a flat object, as identified in this study, have no potential for use in this manner. Significantly, wound cord stamps with a cylindrical support did come into use in eastern Latvia at the close of the Neolithic, and were indeed widely employed for rouletting, as revealed in the study by Dumpe (*2003*). The change in the form of support thus very significantly influences its potential modes of application and the spectrum of pottery decorating techniques.

It may be noted that the investigated samples from Latvia do not indicate the use of the kinds of special decorating techniques using wound cord stamps ('stepping', 'pricking-incising') that Dubovtseva (*2016*) has identified in the Neolithic material of Western Siberia.

The only other use of a wound cord stamp attested in the set of material investigated here is the possible utilization of the four-winding stamp of sample MU-007 for scraping the interior of the vessel, so as to create a regular striated pattern. Sets of four striae on the inside of the vessel have the same combined width (12mm) as the width of the wound section of the stamp. The correspondence is not, however, clear enough to confirm that this was the tool used. Two other sample sherds also show pronounced striation of the surface, but in these cases comparison of the wound cord impressions with the striations indicates that the wound cord stamp was *not* used for creating the striated finish. Whether various kinds of wound cord stamps can also double as effective tools for producing a striated finish on pottery is a question that would seem to merit experimental work in future studies.

Discussion and conclusions

Before considering the specific results of this study and their implications, it is worth noting that RTI did indeed prove a most valuable aid. This imaging technique, complementing examination of the pottery decoration under the stereomicroscope, provided a rapid, straightforward and inexpensive way to document the impressions, with a sufficient level of detail. The manipulation of lighting direction to reveal different details plays a very important role in the examination of relief decoration on pottery, and RTI provides an effective means of replicating this in a virtual environment. Maximally exploiting this possibility, the collection of RTI models was extensively utilized for taking measurements and, most importantly, for comparison among samples.

Given its potential and accessibility, RTI merits wider application as a tool for analysing decoration and perhaps deserves to become a standard component in the toolkit for analysing and documenting pottery surface features. It should be noted, however, that RTI does not offer a true 3D picture. Accordingly, certain kinds of important observations, for example, regarding the cross-sectional shape of various elements of the impressions, need to be made under the stereomicroscope, since the RTI models will not provide this information.

The comprehensive study of the set of 37 samples of wound cord decoration from four sites has given a new understanding of how this concept of decorating pottery was implemented in practice in this particular territory in the late 4th and early 3rd millennium BC. It appears that plant fibre (bast?) was widely used, almost always twisted in the S-direction from two Z-spun strands into a cord of *c.* 1 to 2.5mm diameter, using some method (such as finger-twisting) by which the strands could be tightly twisted. The stamps were fashioned so as to produce an impression from 6mm to at least 35mm in length, with three to at least 13 windings of cord. Rather than being wound on a stick or other cylindrical object, in this region and period the cord was generally wound on a support consisting of a flat plate with a rounded edge (at Munči and Dviete) or with a sharp edge (in the case of Riņņukalns), while some other kind of support, not clearly identified, was used at Nainiekste.

Thus, while maintaining the essential concept of a stamp consisting of cord wound on a rigid support, there is marked variation even across this relatively small area, in terms of cord diameter, stamp impression length, number of windings and, most importantly perhaps, the kind of support employed. The differences between the sites in the form of the support indicate that we are seeing local-level technical solutions for implementing a general idea shared across a vast region. It may be noted that the detailed study by Vital *et al.* (*2012.107–109*) on Early Bronze Age pottery in south-eastern France likewise demonstrates considerable technical variation within that region in terms of the execution of this kind of impressed ornamentation, involving the use of different kinds of support. Both of these cases imply a strong element of vertical (generation-to-generation) transmission of the technical knowledge of pottery stamp production, as opposed to widespread sharing of methods between groups, which could be expected to give greater regional uniformity.

This can be related to the social context of pottery production and use, which determines the visibility of particular technical traits. Essentially, the patterns impressed on a vessel can be observed by anyone handling it or viewing it close up, and on the basis of such observations a stamp may be made that produces similar decoration. On the other hand, knowledge of the actual form of stamp that has been used for decorating a vessel and the method of making it was a part of the pottery-making tradition that stayed 'behind the scenes' and was not automatically accessible to those outside the tradition.

Thus, lack of knowledge about the stamping tools used to achieve particular kinds of imprints is not only the archaeologist's problem. It is a situation that would have confronted contemporaries when faced with decorated vessels made in a ceramic tradition they did not belong to. Illustrative of such situations are Olivier Gosselain's *et al.* (*2010*) accounts of contemporary African potters' reactions to decorative treatments unfamiliar to them, where they were inclined to reinterpret the unknown technical practice in terms of the materials and techniques that they were accustomed to applying in their own pottery traditions.

It is the sharing of stamp-making methods (rather than the creation of superficially similar impressions) that indicates close cultural ties, while the use of different methods points to the existence of boundaries between traditions. Hence, if the distinction and classification of different kinds of wound cord stamps could be performed systematically on a wider spatiotemporal scale, the data thus obtained might be applied in tracing cultural traditions and characterizing sociocultural relationships between groups. The limited conclusion from the analysis of the Latvian material, in light of this argumentation, is that specific communities tended to retain their own technical practices of stamp-making for wound cord decoration, which were practiced in contexts not readily accessible to outsiders and were not widely shared across the region.

Setting local variation aside, we may now return to the question of the cultural significance of this Europe-wide phenomenon, represented in various regions during a total period of at least three millennia, of ornamenting pottery with impressions of cord wound on a support. It is a concept of pottery decoration spanning very different ceramic traditions, and moreover shared between pottery-makers belonging to farming communities in Central Europe and their contemporaries in northern and eastern parts of Europe living mainly or exclusively from wild resources. The fact that they could all relate to this concept in spite of the significant differences in lifeways can most probably be explained in terms of the importance of cordage for all of these societies. There is no doubt that cord served a wide variety of needs in agricultural and fishing/hunting communities alike.

It may be noted in this connection that the creation of a pottery stamp by winding an object with cord, or whipping, is closely related to the binding of tools tightly to their handles with multiple windings of cord. Among the scatter of Stone Age finds of implements secured in their hafts by means of whipping, there are a couple of such pieces from the Eastern Baltic region, namely an eel leister and a wooden axe/adze sleeve from Šventoji (*Rimantienė 2005.Figs. 125.10,186.5–6*). Thus, in preparing this kind of instrument for stamping their pottery, people would have been applying technical skills they commonly employed in hafting various tools and weapons, and this may have been a factor promoting the rapid and wide spread of the practice.

While the everyday need for cordage is essentially universal, there is a domain of prehistoric subsistence technology that required cord in particularly large amounts. This is, of course, the use of nets in fishing. Communities that engaged in net fishing had a need to process fibres into cordage on a large scale, meaning that the activity would have held a major place in these people's lives, demanding a considerable investment of material, labour and time. This also applies to the communities inhabiting the coastal areas and lakeshores of the Eastern Baltic region during the period in question: the importance of fisheries for subsistence is indicated by stable isotope studies of human skeletons (*Meadows* et al*. 2018; Simčenka* et al*. 2022*), and indeed nets were an important part of the fishing toolkit (*Rimantienė 2005; Bērziņš 2008*).

As noted above, the cord employed for the pottery stamps was of the same kind as that utilized for fishing nets, so that the use of such stamps on pottery created a close technological and presumably also perceptual/semantic link between fishing and the production and use of pottery. More probably, in fact, the decoration of pottery with stamps of cord simply reinforced a pre-existing link between these two spheres of life, since lipid analysis of residues on pottery indicates that cooking fish was one of the main functions of pottery vessels of the 6th to 4th millennium BC in the region (*Spataro* et al. *2021*). Cordage production for fishing nets and the practices of catching fish, pottery-making and pottery use for boiling fish all constituted elements in a technological web of everyday tasks. Consequently, at least in this region, wound cord decoration on pottery can be readily understood as a reflection of these connections.

The proposed link to net fishing does not, in itself, indicate why wound cord decoration came into use in

this particular period and spread across such a vast region, including farming communities. After all, fishing nets were already known in Northern Europe a long time before ceramics came into use (*Berihuete-Azorín* et al. *2023*), but wound cord does not feature in the decorative repertoire of the earliest pottery. Accordingly, the widespread adoption of wound cord decoration, especially in the 4th millennium, might be taken as an indication that cordage and articles made from cord had obtained a heightened significance in this particular period. Presumably, the subsequent rise of 'classic' cord decoration, as seen on Corded Ware – likewise across a wide swathe of Europe – relates to the same phenomenon. Taken together, these pottery ornamenting techniques imply a particular cultural focus on cordage during the later part of the Neolithic and the Early Bronze Age, spilling over, as it were, into the medium of ceramics.

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Tab. 1. Data on study sites and pottery assemblages (see map Fig. 1).

Site, code for pottery samples	Excavation	References	General characteristics of pottery assemblage	Dating
Dviete (DV)	Eduards Šturms, 1938 (surface collection of redeposited artefacts)	*Šturms 1938; Zagorskis 1967*	Mixed assemblage dominated by shell- and organic-tempered pottery with direct rim and inward-sloping flat lip. Impressed decoration includes pits, bars, narrow comb, textile impressions and cord. Admixture of rock-tempered Comb Ware.	Studied sherds typologically dated to late Middle Neolithic.
Munči (MU)	Eduards Šturms, 1938	*Zagorskis 1967*	Mainly shell- and organic-tempered pottery with inward-sloping flat lip, with impressed decoration consisting of pits, bars, ovals, narrow comb, textile impressions and grooves. Also includes some rock-tempered Comb Ware.	Studied sherds typologically dated to late Middle Neolithic.
Nainiekste (NN)	Ilze Loze, 1964	*Loze 1988*	Organic- and shell-tempered, round-based pots with direct rim and flat lip. Impressed decoration includes pits, bars, comb, wound cord, circles, arcuate impressions. Also includes some rock-tempered Comb Ware.	^{14}C date: area A, peat sample at depth 40–50 cm, lithological layer 4: 3262–2347 calBC (LE-648, 4170±130; 95.4% prob.; OxCal v4.4.4 Bronk Ramsey (*2021*); atmospheric data from Reimer *et al.* (*2020*)) (*Loze 1988. 99*). Studied sherds typologically dated to late Middle Neolithic.
Riņņukalns (RK)	Carl Georg Sievers, 1874–1875, 1877; several other excavations in late 19th, early 20th cent.; Ilga Zagorska, 2011; Valdis Bērziņš, 2017–2018	*Bērziņš* et al. *2014; Brinker* et al. *2020; Spataro* et al. *2021*	Studied samples derive from midden deposit: shell-tempered, pointed-based pots with direct rims, most commonly with inward-sloping flat lip. Impressed decoration includes pits, wound cord, bars, grooves, porpoise tooth, narrow comb. Also incised lines.	Several ^{14}C dates for midden deposit: late 4th millennium BC (late Middle Neolithic)

Tab. 2. Most important attributes of the sample set of sherds with wound cord impressions (for full table of observations and RTI images see dataset on Zenodo repository: https://doi.org/10.5281/zenodo.8129223).

Ceramic technology sample no.	Accession no. / Riņņukalns 2017/2018 excavation find no.	Yarn spin direction (s/z) (true, not reversed direction)	Cord twist direction (S/Z) (true, not reversed direction)	Twist angle	Cord diameter	Overall length of stamp impression (mm)	Overall width of stamp impression (mm)	No. of windings	Distance between windings where support visible between windings, giving true spacing of windings	Orientation of windings in relation to long axis of stamp	Identified form of support
Dviete											
DV-001	A 9586:82	z	S	40–50	2	11.6	4.2	5	0.7–1.0	90	?
DV-002	A9586:63		S	40	2	19	4.2	7	1.2–1.4	80–90	round-edged
Munči											
MU-001	A10053:38		S	30	1.2	>20	5	at least 9	0.4–1.5	90	round-edged
MU-002	A10053:35		S	30–40	1.7	14	5	5	1.1	70–80	round-edged
MU-003	A10053:35	z	S	30–40		>19	4.5	at least 6		90–100	?
MU-004	A10053:35	z	S	40	2	12.6	4	4	0.7–1.8	90–100	round-edged
MU-005	A10053:35	z	S	40–50	2.4	18	4.6	5	1.6–2.4	90–100	?
MU-006	A10053:35		S	40	2.4	14	5.3	4	1.3–1.8	100	?
MU-007	A10053:35	z	S	30	2.4	12.9	4.9	4	1.4	100	round-edged
MU-008	A10053:35		S	40	1.7	10.5	5.2	3	1.9–3.2	90–100	round-edged
MU-009	A10053:35	z	S	30		18.4	3.2	6		90–100	?
MU-010	A10053:35		S	30	1.6	>29.0	5.4	13	0.7–1.5	100	?
MU-011	A10053:35	z	S	40–50	2.1	13.1	4.5	4	1.6–2.2	90–100	round-edged
MU-012	A10053:39		S	40	2.2	12.9	5.5	4	1.3	90	round-edged
MU-013	A10053:35	z	S	30–40	1.4	10.6	4.2	4	1.8–2.0	90–110	?
Nainiekste											
NN-001	VI 75:501	z	S	20–40		13.8	5.4	7		90	[stamp impression terminating in shorter cord imprint]

Tab. 2 continued

Ceramic technology sample no.	Accession no. / Riņņukalns 2017/2018 excavation find no.	Yarn spin direction (s/z) (true, not reversed direction)	Cord twist direction (S/Z) (true, not reversed direction)	Twist angle	Cord diameter	Overall length of stamp impression (mm)	Overall width of stamp impression (mm)	No. of windings	Distance between windings where support visible between windings, giving true spacing of windings	Orientation of windings in relation to long axis of stamp	Identified form of support
NN-002	VI 75:502		S	30	1.1	16	3.8	8	0.4–1.3	90	[stamp impression terminating in shorter cord imprint]
NN-003	VI 75:503	z	S	40		>18	6	at least 5		90–100	?
NN-004	VI 75:506	z	S	20–40		15.5	5	at least 6		90	?
NN-005	VI 75:506	z	S	20–40	1.3	>17.5	3.8	at least 8	1.1–1.3	90–100	[stamp impression terminating in shorter cord imprint]
NN-006	VI 75:506	z	S	30–40	1.9	14	6.3	at least 5	0.8–1.7	80–90	?
Riņņukalns											
RK-001	(2017/2018) 282		S	indet.	1.6	7.4	3.3	3	1.5	indet.	sharp-edged
RK-002	(2017/2018) 857	z	S	30–40	1.3	10.5	2.7	8	0.4–0.6	90	sharp-edged
RK-003	(2017/2018) 2264-2	z	S	30	2.1	>12	2.8	at least 6	0.5–0.7	60	?
RK-004	(2017/2018) 2264-3	z	S	40		>19	2.7	at least 12		indet.	?
RK-005	(2017/2018) 903		S?	indet.	1.8	7.0	3.9	3	0.7–0.8	indet.	?
RK-006	(2017/2018) 1008-1	z	S	indet.	1.7	>35	3.6	?10	1.3–3.9	indet.	sharp-edged
RK-007	(2017/2018) 1008-2		S	50	1.7	>21	3.2	9	0.6–1.0	indet.	?

Tab. 2 continued

Ceramic technology sample no.	Accession no. / Riņņukalns 2017/2018 excavation find no.	Yarn spin direction (s/z) (true, not reversed direction)	Cord twist direction (S/Z) (true, not reversed direction)	Twist angle	Cord diameter	Overall length of stamp impression (mm)	Overall width of stamp impression (mm)	No. of windings	Distance between windings where support visible between windings, giving true spacing of windings	Orientation of windings in relation to long axis of stamp	Identified form of support
RK-008	A11301:26		S	30–40	2	>13.0	3.7	6	0.2–0.5	100	sharp-edged
RK-009	A11301:26		S	indet.	1.8	(incomplete)	3.6	indet. (partial impressions only)	0.1–0.6	indet.	sharp-edged
RK-010	A11301:26	z	S	40–50	1.8	(incomplete)	4.1	indet.	0.5–1.3	80–100	?
RK-011	A11301:26			indet.	1.9	8.0	3.8	3	0.0–0.6	indet.	?
RK-012	A11301:73		Z	indet.	1.7	10.0	3.6	4	0.6–1.4	indet.	sharp-edged
RK-013	A11301:73		?	indet.	1.4	6.0	3.8	3	0.5–0.7	indet.	sharp-edged
RK-014	A11301:73		S	60	1.7	6.4	3.7	3	1.1–1.6	90–110	sharp-edged
RK-015	A11301:73		S	60	2.1	(incomplete)	3.2	indet.	1.3–1.5	90;120	sharp-edged
RK-016	A11301:91		S	50	1.8	8.7	4.9	4	0.3–0.5	indet.	sharp-edged

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Troy III-V: new radiocarbon dates confirm a gap in Blegen's sequence

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ABSTRACT - *To investigate the dating of Troy III-V, and in particular to test whether in Blegen's Troy sequence a gap exists between Troy III and Troy IV, 26 bone samples covering Troy III to VIa from the University of Cincinnati excavations were submitted for ^{14}C-AMS analysis. Excluding outliers, they yield dates that are consistent with a chronological scheme which includes a 110±20 year gap after Troy III, with Troy IV beginning 2060±10 cal BC. The hypothesis of a Proto-IV period which might bridge the gap, featuring deposits known only from the more recent excavations, can therefore be entertained.*

KEY WORDS – *Troy; Aegean chronology; Anatolian chronology; Early Bronze Age; radiocarbon dating; correspondence analysis*

Troja III-V: novi radiokarbonski datumi potrjujejo vrzel v Blegenovi sekvenci

IZVLEČEK – *Da bi lahko raziskali datacijo Troje III-V in preverili, ali v Blegenovi sekvenci obstaja vrzel med stopnjama Troja III in IV, smo v ^{14}C-AMS analizo poslali 26 vzorcev kosti z izkopavanj Univerze v Cincinnatiju, ki pokrivajo stopnje Troja III-VIa. Ob neupoštevanju odstopajočih vrednosti so ti datumi skladni s kronološko shemo, v kateri je po stopnji Troja III 110±20-letna vrzel. Stopnja Troja IV se začne 2060±10 cal pr. n. št. Hipotezo o stopnji proto-IV, ki bi morda lahko premostila vrzel in vključuje le depozite z novejših izkopavanj, lahko torej sprejmemo.*

KLJUČNE BESEDE – *Troja; egejska kronologija; anatolska kronologija; zgodnja bronasta doba; radiokarbonsko datiranje; korespondenčna analiza*

The background

Stratigraphic analysis of Troy III-V

This paper, which does not necessarily represent the official view of the Tübingen Troy Project, is concerned with the stratigraphy and chronology of periods III to V at Troy. These have a complicated history which it may be helpful to clarify first.

Heinrich Schliemann put forward his original numbering of these periods in 1874 (*Schliemann 1874. v–lvii; 1875.10*) but revised it in 1880 as a result of his second set of excavations (1878–79). Thereafter he left it basically unchanged. His 1882 season did cause him to subdivide Troy II into two phases and to transfer to it the *epithet* 'burnt' which previously he had applied to City III, but he did not transfer any of the architecture (*Schliemann 1884.52–53, 181–182; Easton 2014.58–60*). The numbering and division of strata remained otherwise unaltered. The same division of the strata, with the same numbering,

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was taken over by Wilhelm Dörpfeld (*Easton 2000; 2014.56–63*).

Schliemann's main object in his excavations was to expose the buildings of Troy II across as much of the centre of the mound as he could. In pursuit of this he cleared away most of the overlying strata with little record of the architecture, although he kept quite a full record of the pottery. Consequently when in 1932–1938 Carl Blegen and a team from the University of Cincinnati came to investigate the periods immediately following Troy II he could only do so in isolated areas. Two of the most important of these, in squares E6 and F4-5, were unexcavated 'pinnacles' of deposits, up to 8m tall, which Schliemann had left standing amid the ruins of Troy II. A third area, in F7-8, lay over the southern edge of the Troy II citadel. In these, and to a lesser extent elsewhere, Blegen was able to trace a sequence of occupation, with many building-phases, throughout Troy III, IV and V. He assumed it to be continuous. His numbering of the strata, however, differed from Schliemann's. This was because he misunderstood the change made by Schliemann after the 1882 season and thought that "*the whole of the 'Burnt City' was re-assigned by Schliemann to Troy II*" (*Blegen* et al. *1950.207*). In other words Blegen thought that in 1882 Schliemann had transferred to Troy II everything that he had previously called Troy III – architecture, surrounding deposits and all associated finds – not just the epithet 'burnt'. As a result Blegen's Troy II is equivalent to Heinrich Schliemann's Troy II *and* Troy III, his Troy III is equivalent to Schliemann's Troy IV, and his Troy IV and V together are equivalent to Schliemann's Troy V (*Easton 1976.148–149; 1990.436, Fig. 7; 2000; Jablonka 2000.103*). This is important chronologically: we cannot use Schliemann's City IV material to date Blegen's Troy IV. Blegen's numbering has become standard and is followed in this article.

From 1987 to 2012 new excavations were conducted by the University of Tübingen under, first, Manfred Korfmann and then Ernst Pernicka. Korfmann faced the same problem as Blegen and, to expose the III-V sequence, could dig only in a limited number of isolated areas. These have no direct, stratigraphic link with the III-V deposits of Blegen and can only be related to them by a combination of stratigraphic, ceramic and other comparisons. Two of the areas dug by Korfmann have been published in detail: a 'pinnacle' in square E4-5 (*Frirdich 1997; Mansfeld 2001*), and a small area in A5-6, to the northwest of the Troy II citadel (*Blum 2012*). The architecture and stratigraphy of a third area on the south edge of the Troy II citadel, D7-8 has also been published, but with very limited information about the pottery (*Sazcı 2005; 2007.116–132*). A modification of Blegen's II/III divide is contemplated for the final publication (*Easton 2014.63*).

In a 2018 article the present authors examined the published architecture and pottery of the three Korfmann areas (*Easton, Weninger 2018.36–42*). The trench in D7-8 deepened the south end of Schliemann's north-south trench. The topmost, and latest, 'Troy IV' phase found in it (no.7) must have lain almost immediately below the deepest wall found by there Schliemann in 1872, but that wall is probably the continuation of a wall dated to Troy IVb which Blegen found in square HJ 6-7. It therefore looked to us as though all but one of Manfred Osman Korfmann's and Göksel Sazcı's 'Troy IV' phases in D7-8 were earlier than Blegen's Troy IV. We also looked at the relative percentages of the main ceramic fine wares in the three areas. These too pointed to Korfmann's 'IV' deposits, and in A5-6 also his 'V.1-2' deposits, being earlier than Blegen's Troy IV. Furthermore we found that the ceramic shapes attested in these phases showed a mixture of chronologically significant types: five are known from Blegen's Troy III but do not continue into his Troy IV; four, perhaps six, are absent from his Troy III but are present from the beginning of his Troy IV. The combination suggested that these Korfmann phases might be a transitional period lying between Blegen's III and IV. In this transitional period the classic 'Troy IV' types appear only part way through, out of synch with the architectural periodisation. Peter Demjan and Peter Pavúk (*2020.434–436*) have found just such a pattern in Troy VI. It seems to be characteristic of the site. A difference between Korfmann's 'IV' deposits and Begen's Troy IV shows up again in the faunal spectra (*Uerpmann 2003.258, Fig. 2*). The Korfmann strata (in D7-8 and A5-6) have a much lower proportion of cattle and a much higher proportion of ovicaprids.

Thus, while a lack of published pottery from D7-8 meant that our information was incomplete, conventional archaeological analysis suggested to us that occupation might not be continuous between the Troy III and IV of Blegen, and that up to six building phases from the three Korfmann areas might need to be inserted between them.

Statistical analysis of Blegen's and Schliemann's pottery

Statistical analysis of Blegen's pottery pointed in the same direction. Bernhard Weninger has for many years been exploring the use of statistics as a means of dating deposits relative to one another and as a supplement to radiocarbon dating. He has carried out an analysis of the entire corpus of Blegen's Bronze Age pottery to try to quantify how it develops over the two millennia *c.* 3000–1000 BC. For this he has used Correspondence Analysis (CA). CA takes groups of items, in this case of pottery, and arranges these groups in order of similarity. Weninger's CA seriation takes the pottery assemblages from every one of the individual deposits described in the four volumes of Blegen's final excavation report, and arranges all of them in a single spectrum which shows where each falls in the ceramic evolution of the site (*Weninger 2002; 2009*). Their order in this spectrum corresponds fairly well with the known stratigraphic and chronological order, showing that a deposit can usually be placed within the sequence with an accuracy of ±1 building-phase. In 1992 we tested the method on two closely related trenches containing deposits of Early and Middle Troy VI, and found that the CA related them to one another almost exactly as the stratigraphy did (*Easton, Weninger 1993*).

The CA seriation of Blegen's pottery exhibits two gaps. One is between Troy I and Troy II. Weninger estimated that it was equivalent to a gap of 'at least three, perhaps even five, architectural phases' (*Weninger 2002.1043–1044*). Unknown to him at the time was the fact that Easton had postulated just such a gap (*Easton 1976.148, Fig. 1*) and that the intervening building-phases had actually been found in the excavations of 1998 (*Korfmann 1999.8–9*). This demonstrated that a statistical gap in the CA could represent a real, stratigraphic and chronological gap.

The second gap, only identified later, is between Troy III and Troy IV – again in Blegen's pottery sequence (*Weninger, Easton 2014.169–175, especially Fig. 8*).Weninger gave it an estimated length of 100–200 years. Clearly this corresponds well with the stratigraphic observation that allowance might have to be made for up to six additional building-phases between the two periods. So this statistical gap, too, looked as if it might indicate a real stratigraphic and chronological gap in the Blegen sequence (Fig. 1). The possibility that there might be gap at this point was raised a number of times during the new excavations (*Korfmann 1996.23–24; Mansfeld 2001. 162–3; Sazcı 2005.63–64; 2007.123–124*) but has not been taken up in more recent publications (*Blum 2012.405, Fig. 143; Pernicka 2014.14*).

A different, but complementary, picture was suggested by Schliemann's pottery. Donald Easton had completed a detailed re-working of Schliemann's excavations of 1870–73 based on his unpublished notebooks (*Easton 2002*). He had been able to reconstruct where Schliemann was digging on any given date and (with some reservations) what he found there. He was able to suggest find-spots for over 3000 objects. This produced a somewhat revised pottery sequence. In 2013 we inserted this into the Blegen seriation to see how it compared. A number of pottery shapes showed a longer life in Schliemann than in Blegen, but otherwise there was broad agreement between the two – with the difference that in the Schliemann material a small number of excavation units appeared to bridge the gap between Blegen's Troy III and IV (*Easton, Weninger 2018.42–46, Fig. 3*). While some uncertainty obviously attaches to this, it nevertheless suggested further possible evidence of a transitional period.

Radiocarbon dating

From periods III-V the Blegen excavations have produced only one radiocarbon date, from a late phase of Troy IV: 3575±100 BP (T-168: *Warren, Hankey 1989.177, 181*). The large standard deviation means that it is of little use. By contrast the Tübingen excavations have produced 63 published radiocarbon dates from the same periods (*Easton, Weninger 2018.67–68, listed under 'Old Phasing'*). Practically all were measured on long-lived charcoal, and many have proved to be either from old wood or from material which must have been re-deposited in antiquity. But some have proved usable (*Easton, Weninger 2018.54–59, Figs. 4,7*).

Based partly on the ^{14}C data and partly on external evidence, consensus has emerged around dates of *c.* 2170 cal BC for the end of Troy III, and *c.* 1750 cal BC for the end of Troy V/beginning of Troy VI (*Blum 2012.407; Pavúk 2014.403; 2020.69, Fig. 26; Pernicka 2014.14; Easton, Weninger 2014.Fig. 16; 2018.57*). Since Blegen originally dated the Troy V/VI transition to *c.* 1900 BC (*Blegen* et al. *1951.229*), these new dates show a length of time between Troy III and Troy VI that is at least 130 years longer than Blegen at that time supposed. This means that, on the

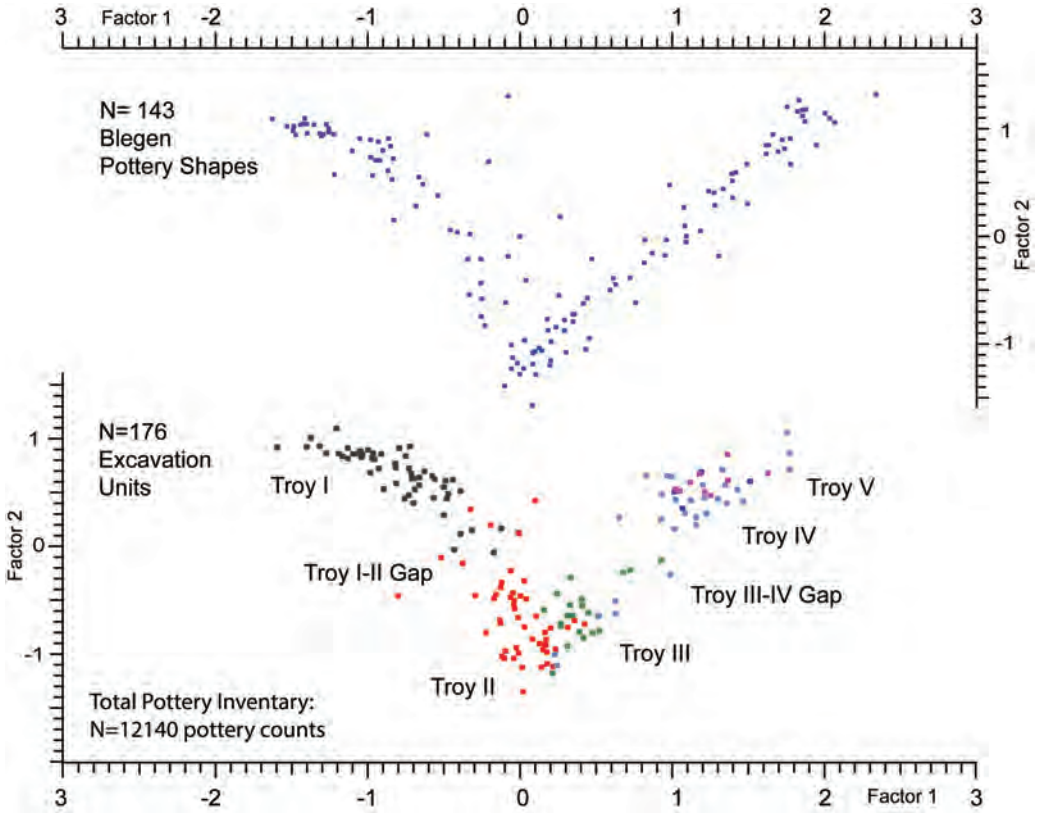


Fig. 1. Correspondence Analysis of pottery from Blegen's Troy I-V. In the lower graph each dot represents the pottery assemblage from a single deposit (as isolated in* Blegen *et al.* 1950; 1951*). The spread shows their relative positions in the ceramic evolution of the site judged according to their degree of similarity. The Troy periods are differentiated by colours: Troy I, black; Troy II, red; Troy III, green; Troy IV, blue; Troy V, mauve. A gap is apparent between the units of Troy I and Troy II, as well as between those of Troy III and Troy IV. The upper graph shows where in the stratigraphic sequence the statistical weight of each Blegen pottery shape lies.

conventional model in which the Blegen sequence III-IV-V is seen as continuous, the periods IV and V need to be stretched out. But if there is an additional period of perhaps six building-phases to be fitted in after Troy III this becomes unnecessary.

Our 2018 analysis indicated that the few reliable ^{14}C dates from the Korfmann excavations were consistent with there being a transitional period running from *c.* 2170 cal BC to *c.* 1990 cal BC (*Easton, Weninger 2018.57–60*). This, together with all the other indications, led us to propose the existence of a 'Proto-IV' period. In this scheme Troy IV and V then fell into the period *c.* 1990 to *c.* 1750 BC.

A re-dating of Troy IV to later than *c.* 1990 cal BC flies in the face of its widely accepted synchronism with the Early Helladic III period. We have argued, however, that the well known Trojan vase of Straw-Tempered Ware found in late Lerna IV can equally well be correlated with the Proto-IV period, and that other supposed EH III synchronisms involving Pefkakia, Manika and elsewhere collapse if we take Schliemann's pottery into account and widen our sights to include parallels in southwest Anatolia (*Easton, Weninger 2018.51–2*).

The Proto-IV period, if it exists, will be synchronous with the 4.2ka cal BC climate event. It may be that, after the end of Troy III, the climatic deterioration caused occupation on the site to dwindle, leaving some areas temporarily uninhabited. These would include the areas where Blegen dug. But (we have suggested) occupation could have continued in other areas, some of which the Tübingen excavations happened to find (*Easton, Weninger 2018.65*).

Table 1 shows how our stratigraphic proposal relates to the periodisations of Schliemann and Blegen. Figures 2 and 3 show the strata in squares A5-6 and E4-5 which we have suggested may belong to Proto-IV. We know of no published profile of D7-8.

Summary

The position, then, is this. The pottery and, to some extent, the architecture of the deposits attributed in three areas of the Korfmann excavations to Troy IV suggest that these deposits may actually belong to a transitional period, 'Proto-IV,' that fits in between the Troy III and Troy IV of Blegen. This appears to be supported by the (admittedly rather thin) ^{14}C evidence from the same (Korfmann) excavations. CA seriation of Blegen's pottery exhibits a gap between Troy III and Troy IV into which this Proto-IV period could perhaps fit.

SCHLIEMANN 1874	SCHLIEMANN 1880	DÖRPFELD 1902	BLEGEN	EASTON & WENINGER	cal BC
GAP	VI	VI	VI	VI	*c.* 1750
IV	V	V	V	V	
			IV	IV	
III	IV	IV	GAP	Proto-IV?	*c.* 2170
			III	III	
II	III	III	II	II	
Ib	II	II			
Ia	I	I	GAP	Transitional I-II	
			I	I	

Tab. 1. The proposed periodisation of Troy I-V in relation to previous schemes.

What we have been lacking until now is a good suite of ^{14}C dates from Blegen's excavations. This might decide the question whether or not a gap really exists. To rectify this we have turned to the plentiful animal bones from the Cincinnati excavations.

The faunal remains and their documentation

During the Blegen excavations of 1932–1938 samples of animal bones and shells were collected systematically 'from all strata in all areas of digging' and placed in large baskets or, when there were fewer, in wooden trays or small cloth bags. Each container was accompanied by a wooden label which showed "*area, section, level, sequence number, date, notebook reference etc*" (*Blegen* et al. *1950.17, 21*). For the seasons of 1937 and 1938 Nils-Gustaf Gejvall joined the team and in each year made a selection of specimens for further stud.[1] After each season he published a short preliminary report (*Gejvall 1937–1938; 1938–1939*). Afterthe 1937 season he also produced a typewritten list of the 5273 specimens he had selected (*Gejvall 1937*). He sent one copy to Cincinnati and retained another in Stockholm. From the 1938 season he produced no full list of the remaining 1452 specimens until 1947 (*Gejvall 1947*). That second typewritten list, of which a copy was again sent to Cincinnati, was less detailed than the first because at the time the relevant pieces were still in Istanbul (*Blegen 1947*) and the list was compiled solely from previous documentation. In the interim Gejvall had, however, completed a limited study of the 1937 collection which investigated dogs, horses and cattle (*Gejvall 1946*). The typescript was circulated privately. He evidently intended to continue work on the Troy collection (*Gejvall 1951*) but it seems that the duties of his position at the State Historical Museum prevented him from doing so. Nothing more was published or circulated.

The collection, which includes Gejvall's selections from both 1937 and 1938, was stored initially in the Museum of Natural History in Stockholm (*Gejvall 1938–1939.2*), and subsequently in the Museum of Mediterranean and Near Eastern Antiquities. In 2019 it was moved to the Osteoarchaeological Research Laboratory of Stockholm University where it has been re-organized and catalogued with the help of Gejvall's original documentation which is also preserved.

Gejvall was quite selective in his choice of specimens. For the more common domestic species he general-

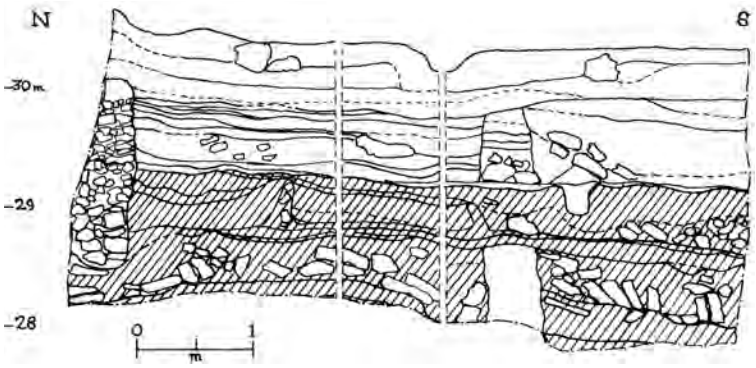


***Fig. 2. East profile of the trench A5-6. Shading shows the strata which may belong to the Proto-IV period. Adapted from* Blum 2014. Part II: Taf. 57.**

1 For more information about Gejvall see Laszlo Bartosiewicz (*2020.13–15*).

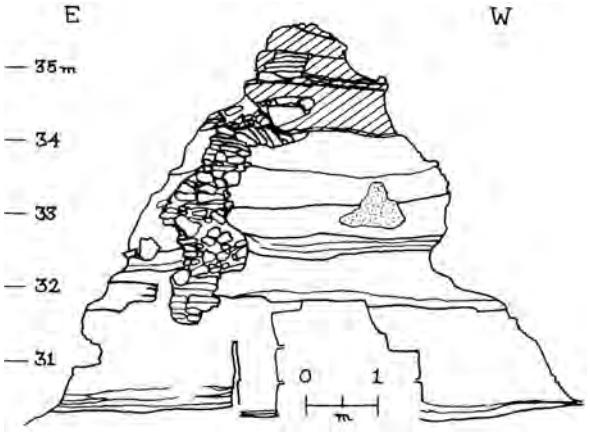
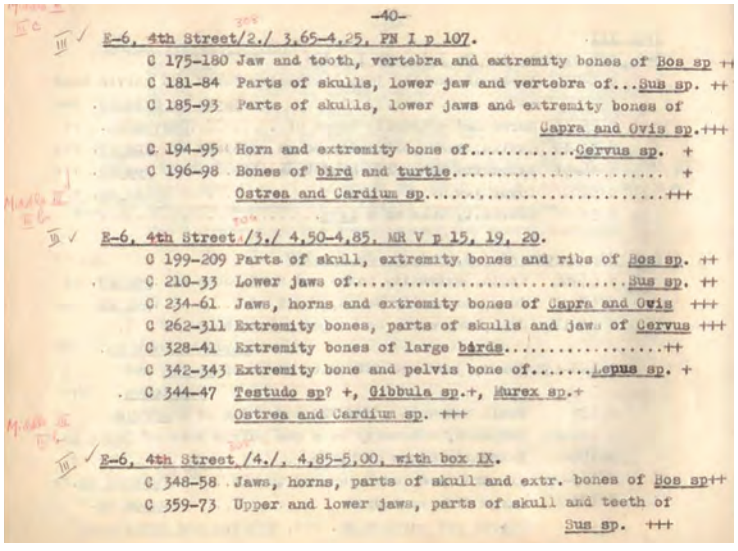


***Fig. 3. South profile of the pinnacle E4-5. Shading shows the strata which may belong to the Proto-IV period. Adapted from* Firdrich 1997.198, Taf. 0.**

ly retained only the jaws, horns, antlers and metapodials. From the less common species he kept more elements. Most bones he labelled individually in ink, using an alphabetic prefix to show the Troy period (I-IX) to which it belonged – A to J in 1937, M to Y in 1938 – followed by a serial number. Some bones he left unlabelled but stored in groups together with their original wooden labels.

To make a broad, preliminary selection of samples for ^{14}C-AMS analysis we used the Cincinnati copy of Gejvall's 1937 list, an example of which is shown in Figure 4. The list is arranged by period (Troy I-IX), subdivided by archaeological context. The description of each context normally notes the square, the area, sometimes a subdivision of the area, the depths from the local datum, and sometimes a reference to an excavation notebook or pottery notebook. Probably these descriptions were taken originally from the excavators' wooden labels. The numbered bones from each context are grouped together by species with a brief note of the anatomical elements represented. The Cincinnati list, preserved in the Troy Archive of the Department of Classics, has the great advantage that it has been annotated by Marion Rawson (in red) and Carl Blegen (in pencil). Their annotations show the period, phase and sometimes area to which they finally assigned each context. The resulting allocations correspond to those published in the final Troy report, and have the same nomenclature – such as 'Room 300' and 'Street 309.' This mostly makes it very easy to place individual specimens within the archaeological sequence as Blegen finally understood it. We have been able to supplement the published information by referring to the unpublished excavation notebooks, also in the Cincinnati Troy Archive and now available online (see Appendix).


-40-

E-6, 4th Street/2./ 3,65-4,25, FN I p 107.
C 175-180 Jaw and tooth, vertebra and extremity bones of Bos sp ++
C 181-84 Parts of skulls, lower jaw and vertebra of...Sus sp. ++
C 185-93 Parts of skulls, lower jaws and extremity bones of Capra and Ovis sp.+++
C 194-95 Horn and extremity bone of.....Cervus sp. +
C 196-98 Bones of bird and turtle..... +
Ostrea and Cardium sp.....+++

E-6, 4th Street/3./ 4,50-4,85, MR V p 15, 19, 20.
C 199-209 Parts of skull, extremity bones and ribs of Bos sp. ++
C 210-33 Lower jaws of.....Sus sp. ++
C 234-61 Jaws, horns and extremity bones of Capra and Ovis +++
C 262-311 Extremity bones, parts of skulls and jaws of Cervus +++
C 328-41 Extremity bones of large birds.....++
C 342-343 Extremity bone and pelvis bone of.....Lepus sp. +
C 344-47 Testudo sp? +, Gibbula sp.+, Murex sp.+
Ostrea and Cardium sp. +++

E-6, 4th Street /4./, 4,85-5,00, with box IX.
C 348-58 Jaws, horns, parts of skull and extr. bones of Bos sp++
C 359-73 Upper and lower jaws, parts of skull and teeth of Sus sp. +++

Fig. 4. A page from Gejvall's 1937 list of bones. The bones are presently stored at the Osteoarchaeological Research Laboratory of Stockholm University. (Department of Classics, the University of Cincinnati).

The selection of samples

For the new analysis 26 bone samples were selected first by context and then by physical suitability. Our object was to obtain samples from all phases of Troy III, IV and V, but the 1937 list included no specimens from Troy IVe or Vd so these phases had to be omitted. We did, however, include one sample from Troy VIa. For periods IIIa to Va we chose specimens from the well stratified sequence in square E6; for periods Vb to VIa we used specimens from squares G8 and F8-9 (Fig. 5). The selected samples were taken for analysis to the Tandem Laboratory, Uppsala University. Details of the samples and their contexts are given in Table 2, in which the new Uppsala ^{14}C-ages (Lab Code: Ua) are shown together with the available Tübingen samples (Lab Codes: (mainly) Heidelberg Hd; also Groningen (N=3) GrA). Additional details are given in the Catalogue of Samples (below).

Table 2 provides for each ^{14}C-age all information that is relevant to the following chronological analyses, in which the samples are referred to either by their Lab-Code (*e.g.,* Ua-69599) in combination with the ^{14}C-age (Ua-69599: 3393±29

BP), or by the unique sample ID number as given in the first column. The use of ID-numbers (ID-1 to ID-40) for sample identification is to assist in finding the dates both in Table 2 and in the age-model graphs (Figs. 7 and 8). The ^{14}C-ages we have identified as outliers are shown in a separate table, with the main reason for exclusion given in its own column (Tab. 3). A further discussion of the stratigraphic properties of these outliers is given below in the section Old Bone. The nomenclature of the two tables is otherwise similar.

Next to the Lab Code and conventional ^{14}C-age, the tables include information as to the dated material. In most cases this is short-lived animal bone, but in some instances human bone (here: from burials), seed/fruit or twigs. There is also a small number (N=6) of ^{14}C-ages on charcoal samples that were previously shown to be derived from short-lived and phase-contemporaneous (*i.e.* not re-deposited) wood-charcoal (*Easton, Weninger 2018.54–59*). To avoid transfer of analytical 'memory-errors' from these previous studies to the present one we have carefully repeated all the new analyses, by running all models both with and without these specific ^{14}C-ages. Since effectively identical results were achieved in practically all cases, there is no need to discuss all of the many different models that we have tested.

Following the Material column, both tables (Tabs. 2 and 3) provide further information for each sample as to the excavation square (Area) and *Behälter* (Beh) number as well as the assigned phase/period. For sake of completeness, the single-sample specific calibrated ^{14}C-ages are provided in the CalAge column, with abbreviated (short-hand) cal-scale dating errors noted as shortest 68%-intervals that can be calculated for the often complex-shaped (multimodal) calibrated age distributions. In ^{14}C-age calibration we applied the calibration curve Intcal20 (*Reimer* et al. *2020*) in combination with CalPal-software (Version 2022.4).

Preliminary evaluation and modelling

Of the 26 new Uppsala samples, 11 yielded ^{14}C-dates that, on any accepted chronology, are too early for the contexts in which they were found (Tab. 3). These seem to replicate in bone the well-documented 'old wood' problem at Troy (*Manning 1995.28; 1997; Kromer* et al. *2003; Weninger, Easton 2014.166–168; Easton, Weninger 2018.54–55*) and suggest that there was frequent re-deposition of soil from older layers (see further Old Bone, below). One, from IIIc, is much too young. At this stage, therefore, we eliminated the 12 samples concerned from further consideration.

Initial, exploratory age-modelling using single-age calibration, both with and without the set of previously accepted 23 Hd- and 3 GrA-measurements (Tab. 2), showed only a poor fit with the outline chronology proposed by the Tübingen team (with the Troy III-IV transition at *c.* 2200/2150 cal BC). The new Troy IV dates exhibited considerable overlap with those from the deposits assigned to Troy IV in the Tübingen excavations, but it was nevertheless apparent that they represented a slightly later period. Comparison of the two sets of dates by means of a dispersion diagram demonstrates the point (Fig. 6), and the result remains almost the same even if the two samples from squares A5-6, which are less certainly of the same period, are excluded. But there was an equally poor fit with the modelled scheme which we had proposed in 2018 (with a gap after Troy III, and with Troy IV beginning *c.* 1990

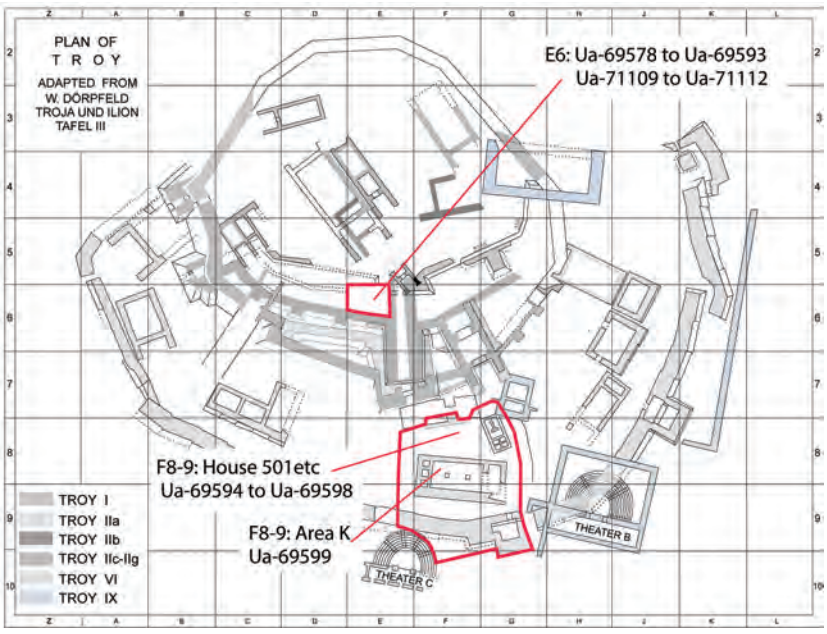


***Fig. 5. Plan of Bronze Age Troy showing the areas from which the samples derive. Only a selection of architectural features is shown. Adapted from* Blegen *et al.* 1950.Fig. 147.**

cal BC). There appeared to be a good fit, however, with a modified version of our 2018 scheme in which the gap (or Proto-IV period) was shortened and the beginning of Troy IV was placed *c.* 2050 cal BC.

For further, more precise modelling we used the Intcal20 calibration curve and CalPal software (version 2020.4) which has recently been expanded (*Doumet-Serhal* et al. *2022*) to allow the graphic presentation of our Gaussian Wiggle Matching (GaussWM) results in context together with Intcal20 raw data (Fig. 7).

The method of Gaussian Monte Carlo Wiggle Matching (GaussWM)

Gaussian Monte Carlo Wiggle Matching (GaussWM) is described in a number of recent publications: Weninger (*1986*); more recently, Barbara Horejs *et al.* (*2012*), Weninger *et al.* (*2018*); Stefanos Gimatzidis and Bernhard Weninger (*2020*); Claude Doumet-Serhal *et. al.* (*2022*). To remind the reader briefly how the process works: a set of ^{14}C dates is entered into the computer programme along with their known or

ID	Lab Nr	^{14}C-Age [BP ± 1σ]	Material	Period and phase	Area / beh	CalAge [calBC ± 68%]	Reference
1	Ua-69599	3393 ± 29	bone	VIa	F976, T4.6	1680 ± 50	This work
2	GrA-nd 2	3532 ± 29	human bone	VIa	A7.1474	1850 ± 60	*Pavuk 2014*
3	GrA-nd 1	3473 ± 32	human bone	VIa	A7.1335	1800 ± 60	*Pavuk 2014*
4	GrA-24678	3520 ± 50	human bone	LV / EVI	A7.1026-1	1840 ± 70	*Pavuk 2014; 2020*
5	Hd-16682	3491 ± 16	wood	V?	D20.471	1810 ± 40	*Easton, Weninger 2018*
6	Ua-69593	3494± 29	bone	Va	E9, T6.5	1810 ± 50	This work
7	Hd-22226	3516 ± 37	charcoal	V	x7.357	1830 ± 60	*Easton, Weninger 2018*
8	Hd-16508	3520 ± 36	wood	V?	D20.473	1840 ± 60	*Easton, Weninger 2018*
9	Hd-23653	3529 ± 23	charcoal	V?	A7.1399	1840 ± 60	*Easton, Weninger 2018*
10	Hd-22538	3559 ± 30	charcoal	V	x7.368	1890 ± 60	*Easton, Weninger 2018*
11	Ua-69598	3598± 28	bone	Va	E253, T4.5	1960 ± 50	This work
12	Hd-18913	3575 ± 34	seed/fruit	LIV / V	K8.727	1930 ± 50	*Pavuk 2020*
13	Hd-14440	3594 ± 32	seed/fruit	LIV / V	K8.367	1950 ± 50	*Pavuk 2020*
14	Hd-29191	3624 ± 25	human bone	IV?	HI 25/26.153	1980 ± 40	*Easton, Weninger 2018*
15	Hd-28866	3557 ± 24	human bone	IV?	HI 25/26.153	1900 ± 40	*Easton, Weninger 2018*
16	Hd-29190	3599 ± 24	human bone	IV?	HI 25/26.153	1960 ± 40	*Easton, Weninger 2018*
17	Ua-69586	3730 ± 30	bone	IVd	D71, T29.41	2120 ± 60	This work
18	Ua-71110	3635± 33	bone	IVc	D138, T18.12	2010 ± 60	This work
19	Ua-71109	3701 ± 33	bone	IVa	D125, T1.4	2090 ± 50	This work
20	Ua-71112	3772 ± 33	bone	IVa	D382, T18.27	2200 ± 60	This work
21	Ua-69592	3798 ± 30	bone	IVa	D340, T8.9	2230 ± 60	This work
22	Ua-69589	3716 ± 30	bone	IVa	D124, T1.4	2110 ± 60	This work
23	Hd-16831	3767 ± 53	twig	Proto-IVf	D8.832	2180 ± 90	*Easton, Weninger 2018*
24	Hd-23695	3663 ± 20	charcoal	Proto-IVd-g	A5/6.777	2050 ± 60	*Easton, Weninger 2018*
25	Hd-17859	3783± 30	seed/fruit	Proto-IVd	D8.1206	2210 ± 60	*Easton, Weninger 2018*
26	Hd-23779	3769 ± 37	charcoal	Proto-IVc	A5/6.921	2190 ± 70	*Easton, Weninger 2018*
27	Hd-17706	3713 ± 44	plant remains	Proto-IVc	D8.1768	2110 ± 70	*Easton, Weninger 2018*
28	Hd-19853	3718 ± 22	twig	IIId	G6.217	2110 ± 60	*Easton, Weninger 2018*
29	Hd-15266	3797 ± 31	twig	IIId	E4/5.112	2220 ± 60	*Weninger, Easton 2014*
30	Hd-15268	3830 ± 38	twig	IIId	E4/5.112	2290 ± 80	*Weninger, Easton 2014*
31	Hd-15267	3751 ± 25	charcoal	IIId	E4/5.178	2140 ± 60	*Weninger, Easton 2014*
32	Ua-69581	3857 ± 31	bone	IIIc	C181, T3.5	2330 ± 80	This work
33	Ua-69582	3847 ± 32	bone	IIIb	C584, T18.11	2320 ± 80	This work
34	Hd-15407	3847 ± 41	twig	IIIb	E4/5.162	2320 ± 90	*Weninger, Easton 2014*
35	Ua-69583	3855 ± 31	bone	IIIb	C666, T3.5	2330 ± 80	This work
36	Ua-69584	3830 ± 29	bone	IIIa	C786, T6.3	2280 ± 70	This work
37	Ua-69585	3764 ± 29	bone	IIIa	C847, T18.26	2190 ± 60	This work
38	Hd-20174	3795 ± 19	seed/fruiit	IIg?	G6.1056	2220 ± 50	*Easton, Weninger 2018*
39	Hd-20039	3834 ± 55	twig	IIg?	G6.558	2300 ± 100	*Easton, Weninger 2018*
40	Hd-20414	3860 ± 40	seed/fruit	IIg?	G6.1054	2330 ± 80	*Easton, Weninger 2018*

Tab. 2. ^{14}C-ages used in chronological analysis and age-modelling.

assumed stratigraphic sequence. During computer run-time this fixed sequence of dates is expanded step by step along the calendric timescale. At each step the programme calculates the best fit of the data to the calibration curve, displays the model in real time on the screen, and records the statistical variables. At the end of the run the programme carries out a numeric optimisation of all the variables recorded, and decides on the model that shows the best overall fit between the data-set and the calibration curve.

In mathematical terms the approach is to minimize the statistical distance (on both scales: ^{14}C-scale and calendric) between the sequenced archaeological data and the calibration curve. This optimisation is formally based on a χ^2 test, but there are additional criteria which are adapted to the (not yet widely recognised) fact that the process of ^{14}C-age calibration can fundamentally be best described as a Fourier Transform *(Weninger, Edinborough 2020; Doumet-Serhal* et al. *2022)*. This explains, from the theoretical perspective of quantum theory, practically all observed statistical properties of conventional and calibrated ^{14}C-ages, in particular the often observable (and clearly artificial) clustering, age-shifting, and amplitude-distortion of the dates, that are so typically correlated on both ^{14}C-scale and calendric scales.

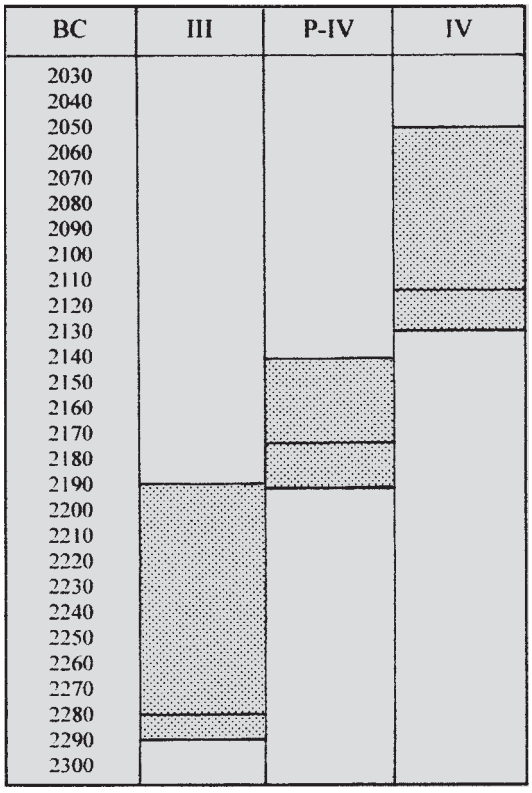


Fig. 6. Dispersion diagram comparing ^{14}C dates from Troy III, the possible Proto-IV period and Troy IV. Only the inner quartiles, as defined by Barbara Ottaway (1973), are shown. (Historically the dispersion calibration method of Ottaway (1973) was the very first procedure that supported graphic display of calibrated sets. We know today that it does not provide the calibrated dates with correct weights.)

The CalPal programme has another characteristic which it is important to understand. Typically it is the case that within a single archaeological phase the true chronological (calendric) order of the samples is unknown. So in CalPal a random number generator is used to vary the positions of the samples *within* the phases to which they have been assigned. The main purpose of this 'Monte-Carlo' re-positioning of samples is to establish quantitatively within each model what are the output errors for each sample position.

Once the entire run (which typically takes a few hours) is completed the optimised chronology is stored to file. The resulting chronology can then be adjusted if numerical refinement or visual improvement is needed. This is achieved in a separate CalPal dialogue (as shown in *Weninger* et al. *2018.ebda, Fig. 3*). This separate dialogue supports, in particular, the largely automated ^{14}C-offset analysis for all laboratories participating in the archaeological study, as well as in calibration curve construction. The new offset-methodology is described in Doumet-Serhal *et al. (2022).*

Beyond such technical details, perhaps the most urgent need in current Aegean and Near Eastern scientific dating procedures is for a more generalised comparison of the different available statistical packages. There was an initial software-comparison paper by T. C. Aitchison *et al. (1989),* but very few software/calibration comparisons have been formally published since then. So far as (elementary) single ^{14}C-age calibration is concerned, a comparatively large variety of systematically applied comparisons of the CalPal-algorithms with other calibration software can be found in the CalPal-repository at CERN (doi.10.5281/zenodo.7422618). The 'inter-software' comparison file also contains a detailed historical documentation of the changes in dating that result from the calibration curve updates in the years 2005–2020.

Direct (and more complex) comparisons of the modelling results achieved by application of GaussWM

Lab Nr	^{14}C-Age [BP ± 1σ]	Material	Period and phase	Area/container	CalAge [cal BC ± 68%]	Reason for exclusion
Ua-69596	3765 ± 29	bone	Vc	E107, T6.5	2190 ± 60	too old, residual
Ua-69597	3782 ± 29	bone	Vc	E134, T20.5	2210 ± 60	too old, residual
Ua-69594	3746 ± 29	bone	Vb	E45, T11.12	2140 ± 60	too old, residual
Ua-69595	3849 ± 29	bone	Vb	E62, T20.5	2320 ± 80	too old, residual
Ua-69587	3817 ± 33	bone	IVc	D108, T20.4	2260 ± 60	too old, residual
Ua-69588	3827 ± 29	bone	IVc	D111, T1.4	2280 ± 60	too old, residual
Ua-69590	3848 ± 30	bone	IVb	D147, T1.4	2320 ± 80	too old, residual
Ua-71111	3820 ± 32	bone	IVb	D146, T1.4	2270 ± 60	too old, residual
Ua-69591	3971 ± 30	bone	IVb	D148, T4.4	2500 ± 50	too old, residual
Ua-69578	3944 ± 42	bone	IIId	C11, T20.3	2440 ± 80	too old, residual
Ua-69579	4048 ± 34	bone	IIId	C35, T3.5	2570 ± 60	too old, residual
Ua-69580	3620 ± 34	bone	IIIc	C135, T18.26	1980 ± 50	too young

Tab. 3. List of outliers excluded from age-modelling.

(CalPal) and of Bayesian Sequencing (OxCal) for the same archaeological data (and effectively the same models) can be found in the recently published papers by Gimatzidis and Weninger (*2020*) (for the Early Iron Age Age at Sindos/Greece), by Marion Benz *et al*. (*2012*) (for the Early Neolithic at Körtik Tepe/Turkey), and by Doumet-Serhal *et al.* (*2022*) (for Late Bronze and Early Iron levels at the sites of Tel Tayinat/Turkey, Meggido/Israel, and Tel Rehov/Israel). These are, to our knowledge, the only published comparisons of modelling results that have been achieved using the same data and archaeological models, but with two entirely different software packages.

Taking all these results together, to us it appears that for contemporary ^{14}C-studies it is *possible* to achieve statistically identical chronological results, independently of the applied software or statistical approach (Bayesian *or* Fourier Transform) method, but only on the error-level of some few decades on the calendric time-scale. Presumably this will also apply to the present results.

The database

In our ^{14}C database (Tab. 2) we included (a) the 14 new Ua-samples from Blegen's animal bones considered to be reliable; also (b) from the published Tübingen ^{14}C dates all short-lived samples (from grain, plant remains, twigs *etc.*), which are securely placed stratigraphically and have standard deviations of less than ±51 BP, and which are not obviously too old or too young for their contexts; (c) also from the published Tübingen material, seven samples all probably from Troy IV or Troy V but which cannot be assigned to a definite period with certainty (nos. 5, 8, 12–16 in our database; see Table 2). These were included partly to help the modelling programme in areas where there were few other dates, and partly to see what periods the programme would place them in. The programme was run both with and without these seven samples with no significant difference to the result.

The results

Our results are shown in Figures 7 and 8. Modelling details are given in the respective figure captions. Troy III begins 2267±10 cal BC. This is later than the date proposed in the Tübingen scheme (*c.* 2340 cal BC). It has the advantage, in age-modelling, that more time is available for the numerous preceding building-phases of Troy II (probably 11 or 12: *Easton 2002.307–308, Figs. 196–198; Ünlüsöy 2010*). The period ends 2170±10 cal BC, as already proposed (*Easton, Weninger 2018.Figs. 7, 8*), and this date is entirely compatible with Tübingen's (*Blum 2012.Fig. 143; Pernicka 2014.14*).

It is interesting to note how the immediately following ^{14}C-ages, from periods Proto-IV and Blegen IV, follow the calibration curve, and in particular its two strong wiggles at *c.* 2150 cal BC and 2050 cal BC (Fig. 7). The dates from the hypothetical Proto-IV period and also the many (N=6) new Ua-dates from Blegen IV all fit well into the general sequence at this point. Decisive are the new ^{14}C-ages on samples 17–22 (from Blegen's IV), in combination with the previous Hd-measurements in samples 23–28 (from Proto-IV). Both data groups are clearly differentiated from the preceding Troy III dates, derive from different excavations (Korfmann and Blegen) and were independently measured by two laboratories (Hd and Ua). The combined data bring the end of

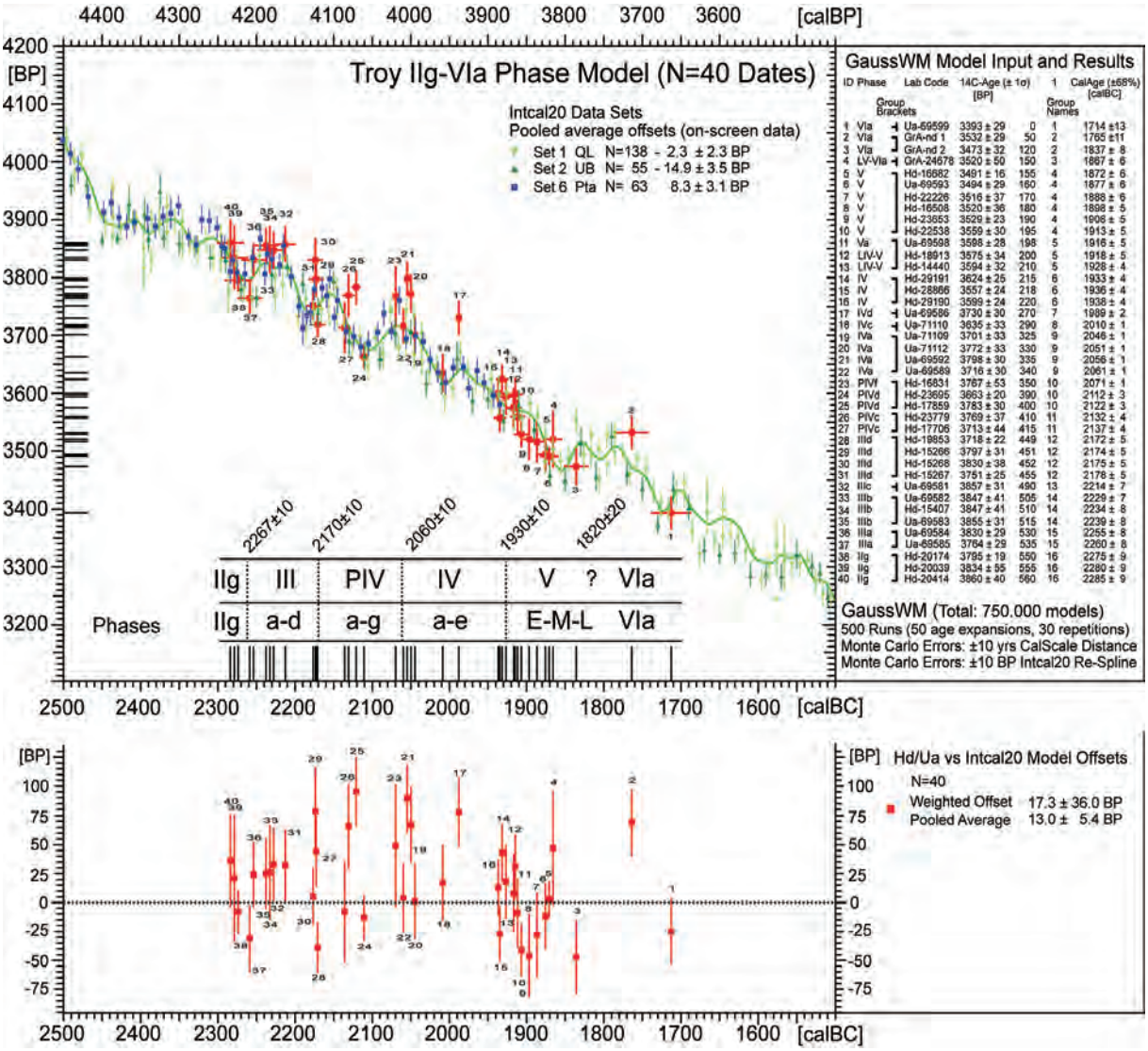


Fig. 7. Archaeological age model for Troy (periods/phases IIg-VIa), based on N=40 ^{14}C-dates (Data: Table 2, with outliers removed).

Data list (upper right): GaussWM model input and results. The ^{14}C-ages are arranged in stratigraphic order, with samples assigned to architectural phases and application of phase-internal randomisation (by grouping) of samples that are stratigraphically indistinguishable (cf. group brackets). The applied equal phase-length GaussWM modelling is based on 500 runs (run-time 12 hrs) with modelling errors of ±10 yrs applied to Monte Carlo sample re-positioning, and Monte Carlo errors of ±10 BP applied to the raw-data used in Intcal20 re-splining. Otherwise of interest in terms of the (quite exceptional) modelling stability indicated by this, all listed (calculated) GaussWM model errors with values smaller than ±10 yrs (68%) are deemed unrealistic.

Central graph: Due to the applied group-wise sample-order randomisation, the specific ('optimal') sample-sequence shown in the central graph represents only one of many (altogether: 750 000) tested sample-sequences. Statistical fitting of the data to the IntCal20 calcurve is based on a non-central chi-squared metric with non-centrality parameter λ=10.

Lower graph: Calculated model-offsets between the data and IntCal20, as shown with sample-specific ID-numbering, indicate that the statistical spread of the modelled ^{14}C-ages is predominantly due to random processes. This applies both in terms of (calendric-scale) sampling 'noise' as well as for noted ^{14}C-errors. The spread of modelled ^{14}C-ages around the calibration curve for strong 'down'-wiggles (at c. 2260/2170/2110 cal BC) and strong 'up'-wiggles (at c. 2220/2150/2070 cal BC) can be seen at higher graphic resolution in Fig. 8.

the Proto-IV period to 2060±10 cal BC. Overall the result suggests a duration of 110±20 years for this period, if it exists (see The Proto-IV Hypothesis below for further comment). Blegen's Troy IVa falls at 2060±10 cal BC if samples 19 and 22 may be taken as determinative. Samples with ID 20 and 21 perhaps represent old bone re-deposited. No. 18 places Troy IVc at 2010±10 cal BC, after which two further phases (d, e) must be allowed for, bringing the end of Troy IV to 1930±10 cal BC or later. The one previous sample from Blegen's Troy IV, T-168, has a central value of 3575 BP, *c.* 1950 cal BC, which fits well with this result. Two grain samples from square K8, Nos 12 and 13, fit well into the resulting Late IV, as previously suggested (*Easton, Weninger 2018.56–57*, and *online supplement 8–9*), although by both context and date they might almost as well be assigned to Troy V (*Pavúk 2014.390–392*).

The age-modelling results for Troy V and VIa are less clear. For the optimisation process samples with ID nos 5–10 have all been treated as belonging to the same phase, with unknown phase-internal order. Ultimately all but No. 6 are of uncertain phase, and Nos. 5, 8, 9 are not even certainly from Troy V. But the model has placed No. 6, which is certainly from Troy Va, latest in this group at 1877±10 cal BC.[2] When considering the seemingly precise position of all samples as shown in Figures 7 and 8, it should be borne in mind that the ordering of samples within a single phase is entirely random. The same group could arguably belong in the region 1877–1830 cal BC, with the internal order reversed. The only other sample certainly from Troy Va is No. 11, placed at 1916±5 cal BC, but this could again be old bone re-deposited. For the initial date of Troy V, therefore, we can only say that it lies in the region 1916–1877 cal BC.

The uncertainties are even greater when we turn to Troy VIa. This is partly due to the very small number of short-lived samples (only three),[3] and partly to the plateau in this area of the calibration curve. Sample No. 1 is from a very late stage within phase VIa and may even come from debris levelled off after its destruction. It yields a modelled date of 1714±13 cal BC which is consistent with Pavúk's proposal for the end of his Ceramic phase 1, *c.* 1720 cal BC (*Pavúk 2020.69*). For the beginning of VIa the model suggests a date of 1820±20 cal BC. But the model position assigned to sample 3 may be affected by the lack of samples from Troy Vb and c, in which case there are potentially more exact dates for VIa. A date of 1780/1750 cal BC, as proposed by Pavúk (*Pavúk 2014.394–396, 404*), is perhaps as likely as our modelled date, if not more so, but depends to a large extent on external synchronisms. We have allowed for this in the scale of phases at the bottom of Figure 7. Thus our model for Troy VIa is far from final.

Overall the model exhibits a good fit both with the Intcal20 curve and with much of the raw data on which it is based (see Figure 7 upper), and appears to provide inter-laboratory offsets with similar range (see Figure 7 lower). It confirms the existence of a gap between Blegen's Troy III and IV, but of slightly shorter duration (110±20 years) than was originally proposed (150±20 years).

The Proto-IV hypothesis

In our previous article we did not assert that a Proto-IV period definitely exists. We proposed it as a hypothesis, provisional in that it is in part based on incomplete data from preliminary reports and is subject to alteration or invalidation by further work (*Easton, Weninger 2018.37, 66* and *online supplement: 1*). The final Tübingen report covering this period of the site's history is not yet published, and it is to be expected that, in this complex site, mature consideration and additional data may reveal new correlations between excavated areas and possibly some new phasing of deposits.

The Proto-IV hypothesis is not directly confirmed by the new samples since none come from the deposits which might be assigned to it. But when they are set alongside the dates from the Tübingen samples a suggestive picture emerges. Given some of the late dates for Blegen's Troy IVa (samples 19, 22) and IVc (sample 18), it would be difficult to regard these deposits as contemporary with those assigned to Proto-IV. The dispersion diagram (Fig. 6) supports this view. Thus, based on the data we presently have, the Proto-IV hypothesis looks plausible although the period would be slightly shorter than we originally suggested.

2 Note that, as the Monte Carlo modelling error has a potentially over-precise value of ±6 years, we have rounded all such values up to minimum error of ±10 years.

3 No. 4, from a burial associated with a jug of probable MMIIb or IIIa date, may belong equally well in Late V or Early VI; *Pavúk 2007.305–306; 2014.371–374; 2020.63–66; Easton, Weninger 2018.57.*

Old bone

As noted above, practically all the ^{14}C-ages that we have identified as outliers (Tab. 3) must be considered too old for the contexts in which they were found. This to some extent replicates the situation with charcoal samples, although in the latter case there are other factors to be allowed for, such as the use of inner rings and the re-use of old timber. In short, the site shows evidence of frequent re-deposition of old material. Animal-bones, being from short-lived organisms, provide the more certain indication of this, but the available data from Troy show that bones and charcoal are similarly affected (both in number and stratigraphic depth).

In Troy III-V Blegen recorded many cases where successive floors were separated by deposits of earth mixed with sherds, shells, bones and other materials.

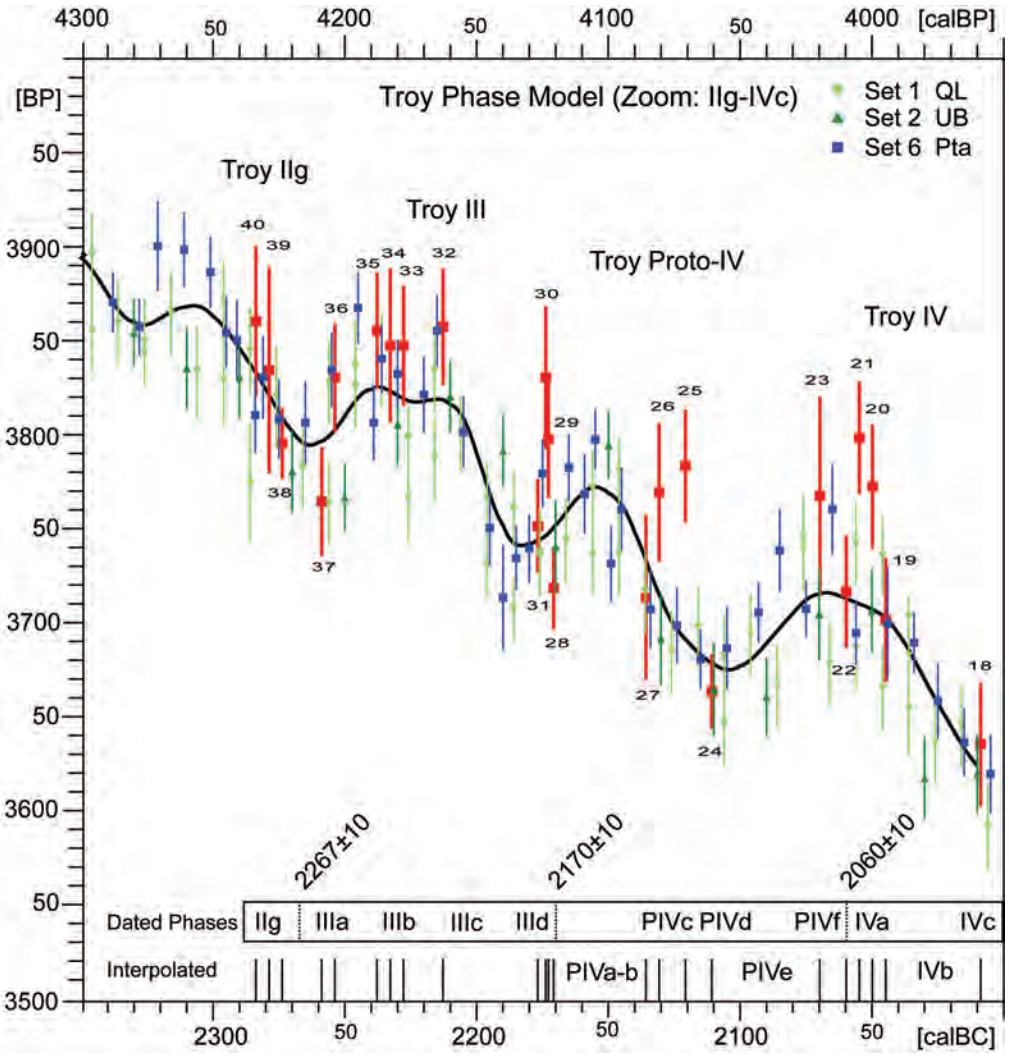


Fig. 8. Graph identical to Figure 7, but now at higher graphic resolution to facilitate visual quality comparisons for archaeological modelling and Intcal20 calibration curve construction. The graph shows the modelled dates for periods/phases Troy II(g), Troy III (abcd), Troy Proto-IV(abcdef), and Troy IV (abc), with (directly ^{14}C) dated and (only) interpolated architectural phases as indicated in the chronology scheme. The model-derived calendric ages for the transitions Troy II to III (at 2267±10 cal BC), Troy III to Proto-IV (at 2170±10 cal BC), and Troy Proto-IV to IV (at 2060±10 cal BC) are indicated by age-interpolated dashed lines and given values (with assigned 68%-errors). We observe generally good agreement between all dates in in the archaeological sequence and the Intcal20 calibration curve, as well as generally good agreement between the laboratory raw-data (SET 1: Queens's Lab (QL); SET 2: University Belfast (UB); and SET 3: Pretoria (Pta), used in Intcal20-construction (Reimer et al. 2020). The observed high conformity between the many different data sets (i.e. the archaeological ^{14}C-ages, the sample phase assignments, the Intcal20-calibration curve, the inter-laboratory data sets) provides some striking new evidence and verification for the existence of a gap between Blegen's Troy III and IV and hence also for the possible existence of Proto-IV.

He explained these deposits as rubbish accumulated during the course of habitation (*e.g., Blegen* et al. *1951.5,37,57,60,65–68,90,158,214,216,255,273, 276,284, Figs. 4, 202*). But the presence in them of evidently re-deposited animal bones suggests that, in some instances at least, they are perhaps to be explained as bedding deliberately laid down before the installation of a new floor or indeed of a new building. It appears that earth was taken from abandoned areas of the site without removing the sherds, shells, bones or charcoal left by earlier occupants, and would then be spread over an old floor in a layer several centimetres thick. The available ^{14}C dates show a pattern in this activity. In Troy III the inhabitants mostly used deposits from Late Troy I and Early Troy II. In Proto-IV (if it exists) and IV they drew on deposits of Late Troy II and Early Troy III. In Troy V it was deposits from Troy III and (Proto-)IV that they mostly used.

When carrying out such an operation the ancient Trojans would presumably have removed inconveniently large objects such as whole pots or antlers. But, if this explanation of the many re-deposited samples in the Troy ^{14}C database is correct or partially correct, then it must set a question-mark against statistical studies – whether of pottery, faunal or botanical remains – which include smaller items from such deposits. Whether there was frequent re-deposition upwards, or even frequent intrusion downwards, the Blegen deposits nevertheless clearly exhibit a clear statistical gap between periods III and IV. And when it comes to dating, the importance of the normal archaeological rule must be underlined: that only the latest dateable item can be relied upon.

Conclusions

The ^{14}C-testing of 26 samples of animal bone from Blegen's Troy excavations appears to confirm the existence of a gap between his Troy III and Troy IV periods. The gap has an approximate length of 110 years. This is slightly shorter than the 150 years previously suggested but, with two-sided dating errors in the order of ±10 years (minimum), the difference has no crucial statistical relevance. The hypothesis that the III/IV gap, observable in the Blegen-CA, was bridged by a Proto-IV period (unknown to Blegen but attested in the new excavations) is not directly confirmed but is, we propose, quite consistent with the newly acquired ^{14}C-ages.

The new ^{14}C-ages supply additional evidence for the extensive re-deposition of materials in antiquity. The inhabitants seem frequently to have used earth from abandoned parts of the site when laying the bedding for new floors and new structures. This must induce caution when including items from such deposits in statistical or other studies.

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THE TROY ARCHIVE in the Department of Classics, the University of Cincinnati, is now largely available online at https://drc.libraries.uc.edu/handle/2374.UC/757552

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Appendix

Catalogue of Samples

The samples are listed below by Troy phase and by laboratory number. Against each we note also the serial number given in Gejvall's 1937 list (*e.g.*, C786) and his description of the context from which the specimen came. As mentioned above, his descriptions include measurements of depth (*e.g.*, 5.40–5.85m). These were taken from local datum points. The E6 datum lay at 38.10m A.T. (*Rawson Notebook 12, 1937. 53*; the point lay 7.3m above the Propylon IIC threshold at 30.79m A.T.), the F8-9 datum at 37.52m A.T. (*Caskey Notebook 6, 1936.112*). In the comments which follow we have supplemented the information available from Blegen's published report by referring to the relevant excavation notebooks: for E6 those of Friedrich Goethert (*1932*), Walter Heurtley (*1932*) and Marion Rawson (*1933* onwards); for F8-9 those of Margo Taft (*1935; 1936*) and John Caskey (*1935* onwards). For E6 the Pottery Notebook I (PN I) of Marion Rawson is also sometimes helpful. The locations from which samples came are shown in Figs. 9–13 (sections and plans).

Phase IIIa

Ua-69584. Gejvall 1937: C786. *Bos*, mandibula. 64.3g.
'E6, Room 400 / 5a / East Half. 5.40–5.85.' Excavators' annotations: Phase IIIa, Room 300.

The excavation of this deposit is described on numerous pages in *Rawson Notebook 5, 1934.75–125* and *Notebook 6, 1934.25–35.* Sketch plan at *M. Rawson Notebook 5, 1934.90. M. Rawson Pottery Notebook I. 139* notes a half sepet (wicker basket) of bones. The "*east half*" is the area southeast of the mudbrick bin (*Blegen* et al. *1951.Fig.264*). The depths (32.70–32.25m A.T.) place the deposit below the floor of phase IIIb, descending to what Rawson identified as the original IIIa floor of the building (*Notebook 6, 1934.90; Blegen* et al. *1951.66* locates it at

32.19m A.T.). Here, below thick, sloping layers of shells and ashes alternating with thin layers of earth and carbonised matter, she found "*a different kind of earth*", brown and burned looking (*Rawson Notebook 5, 1934.75*). These deposits are described in a general way by Blegen (*Blegen* et al. *1951.66, Fig. 4*).

Ua-69585. Gejvall 1937: C847. Cervus, maxilla. 12.1g.
'E6, Room 400 / 5b / West End, 5.40–5.85, 5.50–5.75. PN II p. 138.' (PN II is an error for PN I and refers to Marion Rawson's pottery notebook.) Excavators' annotations: Phase IIIa, Room 300.

The "*west end*" is the area northwest of, and including, the mudbrick bin (*Blegen* et al. *1951.Fig. 264*). Otherwise all the comments on Ua-69584 (above) apply also to this sample.

Phase IIIb
Ua-69583. Gejvall 1937: C666. Sus, cranium. 2.6g.
'E6, Room 400 / 3 / 4.45–5.10. PN 130–32.' Excavators' annotations: Phase IIIb, Room 300.

The excavation is described at *Rawson Notebook 5, 1934.33–62*; see plan at *Blegen* et al. *1951.Fig. 265*. The pottery notebook (No. 1) records one set of

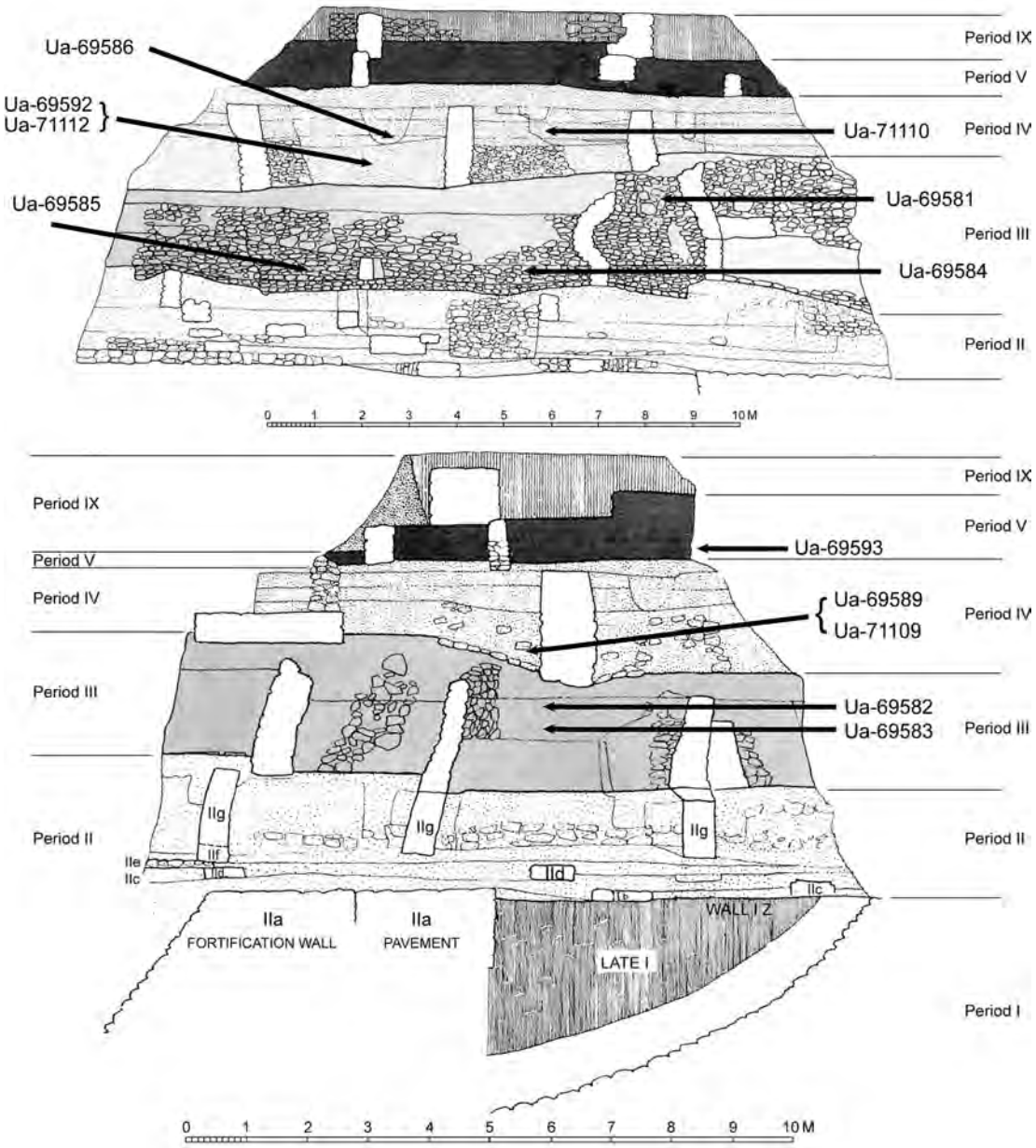

***Fig. 9. Diagrammatic sections in square E6 as seen from southwest (above) and from southeast (below). Adapted from* Blegen *et al.* 1951.Figs. 261 and 262.**

bones. The depth of 5.10m (=33.00m A.T.) takes this deposit down to the level of the IIIb floor at *c.* 32.94m A.T. noted by Blegen (*Blegen* et al*. 1951.67)*.

Ua-69582. Gejvall 1937: C584. Cervus, mandibula. 40.3g.
'E6, Room 400 / 2 / 4.35 – 4.45. PN p.128.' Excavators' annotations: Phase IIIb, Room 300.

The excavation is described at *M. Rawson Notebook 5, 1934.16–36*; see plan at *Blegen* et al. *1951.Fig. 265*. The pottery notebook (No.1) records the collection of two bags of bones, clams, oysters, limpets, mussels and finger shells. Within the deep deposits in House 300 Blegen mentions floors at 32.94m A.T. (attributed to IIIb) and at 33.79m A.T. (IIIc) (*Blegen* et al. *1951.67*), implying an interval of 85cm between them. That interval was filled with "*ashy debris and vast quantities of shells in thick strata alternating with layers of earth and clay*" (*Rawson Notebook 5, 1934.17, 32–34*). The depths ascribed to the group of bones from which this sample comes (33.65–33.75m A.T.) place our specimen in the topmost 14cm of the accumulation, and mean that this sample was deposited later in the phase than Ua-69583.

Phase IIIc
Ua-69580. Gejvall 1937: C135. *Cervus*, mandibula. 10.6g.

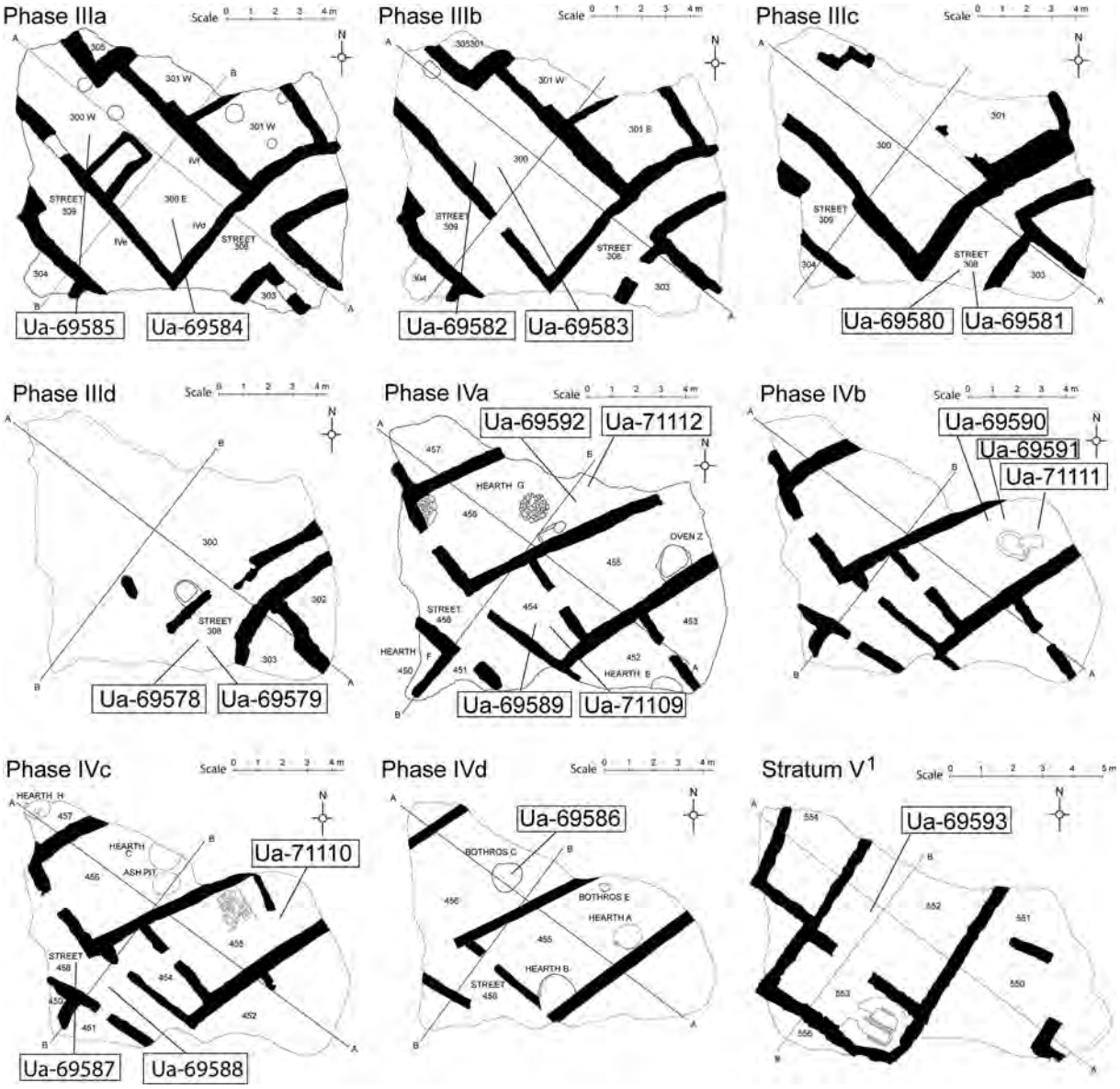

***Fig. 10. Plans of square E6 in phases IIIa to V1, showing approximate find-spots of all samples from this area. Adapted from* Blegen *et al.* 1951.Figs. 264–267,269,271–273,280.**

Ua-69581. Gejvall 1937: C181. *Sus*, cranium. 58.6g. 'E6, 4th Street / 2 / 3.65–4.00 (4.25 in the case of C181). PN I p.107.' Excavators' annotations: Phase IIIc, Street 308.

"*4th Street*" in the notebook is the same as Street 308 in the final publication (*Rawson Notebook 3, 1933.93; Blegen* et al. *1951.45–46, Figs. 8–11, 266*). The pottery notebook mentions only the depths of 3.65–4.25, not 3.65–4.00, and refers to two boxes of bones (three in *Rawson Notebook 4, 1933.147–148)*. The depth of 3.65m represents the assumed lower limit of Troy IIId (see comments on Ua-69578 and 69579). The depth of 4.20 / 4.25 (33.90 / 33.85m A.T.) seems arbitrarily to have been selected as a division.

Phase IIId

Ua-69578. Gejvall 1937: C11. *Ovis/capra*, maxilla. 13.4g.

Ua-69579. Gejvall 1937: C35. *Sus*, cranium. 77.5g. 'E6, 4th Street / 1 / to 3.65. PN I p.104.' Excavators' annotations: Phase IIId, Street 308.

The excavation is recorded at *Rawson Notebook 3, 1933.64,77,88,94,96,99,102*. On the identity of "*4th Street*" with Street 308 see phase IIIc, above. The existence of the street was first suspected on 27th May 1933 when Rawson was removing the overlying deposit of IVa to a depth of 3.40m below the local datum, *i.e.* to *c.* 34.70m A.T. (*Rawson Notebook 3, 1933.76*). The bones, from a collection of 1.5" baskets, come from the deposit immediately below this, "*under Wall Z1*", the southeast wall of Room 455 (*Rawson, Pottery Notebook 1.104*). Rawson (*Pottery Notebook 1.79*) places the bottom of Wall Z1 at a depth of 3.34 to 3.42 (= 34.76 to 34.68m A.T.). The depth of 3.65m (34.45m A.T.) was reached three days later when Rawson noted "*tremendous numbers of sherds, bones + shells ... Deposit hard and gray looking, everywhere looks green*" (*Rawson Notebook 3, 1933.96, 99*). As the Troy III deposits in this street reached down to *c.* 32.39m A.T. and had a total depth of 2.25m or more (*Blegen* et al. *1951.45*), these samples evidently came from the topmost Troy III strata. Blegen, however, noted that the area produced many sherds that apparently belonged to Troy I, "*suggesting that earth taken from an earlier deposit had been dumped in the street*" (*Blegen* et al. *1951.46*). The early dates of our samples are consistent with that.

Phase IVa

Ua-69589. Gejvall 1937: D124. *Sus*, mandibula. 55.9g.

Ua-71109. Gejvall 1937: D125. *Sus*, mandibula. 21.6g.

'E6, Sect.IIb / 2[?] / 3.27 – 3.65. MR p.64.' Excavators' annotations: Phase IVa, Room 454.

'MR p.64' is a reference to *Rawson Notebook 3, 1933.64. Rawson Notebook 2, 1933.15* confirms that Section IIb included Room 454 of the final publication (*cf. Blegen* et al. *1951.114–115, Figs. 268–269*). The final report notes that one bag of animal bones was collected from this phase of Room 454, although this is not mentioned in the notebook. On 23rd May 1993 Rawson had 'finished leveling off this area' to depths varying from *c.* 3.45 to 3.66 (34.65–34.44m A.T.), and she records a "*very hard clayey deposit, possibly floor, or under floor. Practically no carbonized matter.*" The depth of 3.27 referred to in Gejvall's description had been reached a week earlier (*Rawson Notebook 3, 1933.40*) and the deposits immediately below it had included carbonised matter and a lot of fallen mudbrick (*Rawson Notebook 3, 1933.45*).

Ua-69592. Gejvall 1937: D340. *Sus*, scapula. 52.2g.

Ua-71112. Gejvall 1937: D382. *Cervus*, maxilla. 14.4g.

E6, Sect III / 3 / 3.00 – 3.50. PN I pp.78–79.' Excavators' annotations: Phase IVa, House 456.

Rawson Notebook 2, 1933.15 confirms that Section III included House 456 (*cf. Blegen* et al. *1951.Figs. 268–269;* see also *pp.157–158, Figs. 117–122*). The pottery notebook mentions shells but not animal bones. The 3.00m depth (35.10m A.T) is that of the floor attributed to phase IVb (*Rawson Notebook 2, 1933.107,109; cf. Blegen* et al. *1951.177*). The underlying floor of IVa was found only at depths of 3.85 to 3.88 (*Rawson Notebook 3, 1933.54*) *i.e.* at 34.25 to 34.22m A.T. (*cf. Blegen* et al. *1951.158,* 34.29 to 34.04m A.T.). But the deposit from which the bones came had its lower limit at *c.* 3.50 (34.60m A.T.), almost 40cm higher. The deposits at this depth, shown in a photograph in the published report (*Blegen* et al. *1951.Fig. 122*) are described as "*alternate layers of clay and rubbish*" (*Rawson Notebook 3, 1933.52*) containing ashes, carbonised matter, bones, shells, sherds and decomposed brick (*Rawson Notebook 3, 1933.22,25,28,30*) whereas the floor deposit at 3.88 was "*quite different*"(*Rawson Notebook 3, 1933.54*).

Phase IVb
Ua-69590. Gejvall 1937: D147. *Sus*, mandibula. 17.9g.
Ua-69591. Gejvall 1937: D148. *Sus*, maxilla. 25.1g.
Ua-71111. Gejvall 1937: D146. *Sus*, mandibula. 13.5g.
'E6, Sect. IIa / 2 / 2.75 to Floor at 2.78–2.90.' Excavators' annotations: Phase IVb, Room 455.

The equation of E6, Section IIa with Room 455 is confirmed by *M. Rawson Notebook 2, 1933,15* (see plan at *Blegen* et al. *1951.Figs. 270–271*). The level of –2.75 is that of the assumed floor of phase IVc of the same building (see comments on Ua-69587 and 69588 below), those of –2.78 and 2.90 indicate the floor attributed to phase IVb (*Rawson Notebook 2, 1933.62,63,83,91*). She refers (p.83) to the floor at 2.78–2.98, and the latter depth agrees better with the 35.14m A.T. of *Blegen* et al. *1951.174* than Gejvall's 2.90. The latter may perhaps be an error. Rawson noted at this depth "*a thick layer of burned stuff ... which extends across the whole room*"; "*everywhere the remains of burning are extensive*" (*Rawson Notebook 2, 1933.62,70; cf. Blegen* et al. *1951.173–176, Figs. 125–127,270–271*). The number of pots (at least ten) from this level indicates the existence of a genuine floor deposit (*Rawson Notebook 2, 1933.48–49,63,68,70*), but the relatively early dates of the samples suggest that at the same depth there was earth that had been brought in from elsewhere to level the area before the next floor, perhaps of IVc, was laid.

Phase IVc
Ua-69587. Gejvall 1937. D108. *Ovis/capra*, maxilla. 16.8g.
Ua-69588. Gejvall 1937: D111. *Sus*, mandibula. 30.7g.
'E6, 5th Street / 1 / 2.35–2.75.' Excavators' annotations: Phase IVc, Street 458.

The identification of "*5th Street*" with Street 458 of the publication is confirmed by *Rawson Notebook 2, 1933.15,35* (see plan at *Blegen* et al. *1951.Fig. 272*). The area was excavated by Heurtley in 1932 and Rawson in 1933, but as it was Rawson who named it "*5th Street*" the samples must come from 1933. Her work was concentrated on the northwestern end of the street (*Rawson Notebook 2, 1933.28,35,51,54,58, 60,64,69,76,82)*. The published report makes clear that the accumulated deposits of fallen stone, disintegrated brick, ashes, carbonised matter, shells, animal bones and sherds were homogeneous (*Blegen* et al. *1951.149,173,186;* see also *Figs. 110,123*), so the division into phases was evidently rather arbitrary. A possible pivot stone based at a depth of 2.70m (35.40m A.T.) may have suggested a relationship with the phase IVc floor of Room 455 (*Rawson Notebook 2, 1933.69*; see comment on Ua-71110 below). Blegen says that the IVc strata in E6 began at 35.40m A.T., with a further 30 to 50cm on top (*Blegen* et al. *1951.186*). The depths of 2.35–2.75m thus denote the deposits below those of phase IVd (*Heurtley Notebook 3, 1932.8*) and above the floor of phase IVc.

Ua-71110. Gejvall 1937: D138. *Cervus*, mandibula. 21.6g.
'E6, Sect. IIa / 1 / 2.55–2.75. Middle.' Excavators' annotations: Phase IVc, Room 455.

Rawson Notebook 2, 1933.15 confirms that Section IIa in E6 is Room 455 of the published report (see plan at *Blegen* et al. *1951.Fig. 272*). A small paved area (or platform?) and a number of pots were taken to be an indication of a floor at *c.* 35.43m A.T. (*Blegen* et al. *1951.187*, see also *Figs. 126,272*). Levels for the stone paving and the pots are at *Rawson Notebook 2, 1933.26,46,48*; the stones appear on the plan on p.23. A slightly higher level (–2.58) for the stones is given at *Heurtley Notebook 3, 1932.8,10*. This corresponds roughly to the –2.75 level. The feature was first noted in 1932 (*Heurtley Notebook 3, 1932.6,8,10–12*), but the sample probably comes from 1933 when the division of the area into 'sections' was introduced by Rawson. The deposit above the 2.75 level appears to have been a destruction deposit consisting of burnt and fallen mudbrick and other charred matter (*Rawson Notebook 2, 1933.17–18,21*). Thus the sample can probably be assigned to the end of phase IVc.

Phase IVd
Ua-69586. Gejvall 1937: D71. *Lepus*, mandibula. 2.9g.
'E6, Sect. III / 1 / from bothros.' Excavators' annotations: no phase indicated.

The sample must come from 1933 when Marion Rawson introduced 'sections' into the area. Its location in Section III places it in House 456 and the pit ('*bothros*') must be Bothros C (*Rawson Notebook 2, 1933.15,20; cf. Blegen* et al. *1951.201–204, Fig. 273*). The rim of the pit lay at *c.* 35.70m A.T. (*Blegen* et al. *1951. 201; Heurtley Notebook 2, 1932.66*). It was exposed and partly emptied in 1932, the operation continuing in 1933 (*Heurtley Notebook 2, 1932.66, Rawson Notebook 2, 1933.20–22,26,31,107,112*). Rawson's operation there in 1933 began at 35.21m

A.T. and descended to 35.10m A.T. (*Rawson Notebook 2, 1933.26*). Thus the sample must have come from near the bottom of the pit. The pit had remnants of plaster (*Blegen* et al. *1951.201*) so may originally have been for storage, but the contents – charred matter, pieces of bone, sherds, pieces of burnt mud-brick and small stones – were plainly general debris. Possibly it was filled up in levelling operations at the end of the phase.

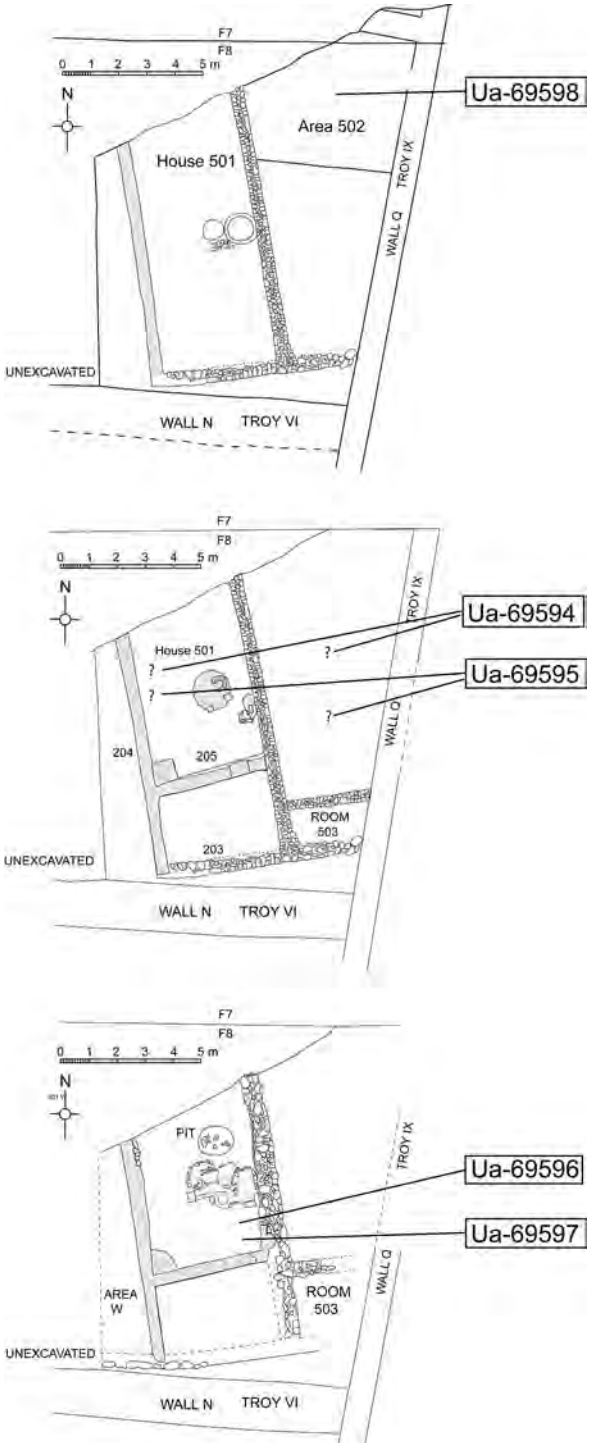

***Fig. 11. Plans of square F8 in phases Va to Vc, showing approximate find-spots of all samples from this area. Adapted from* Blegen *et al.* 1951.Figs. 304, 305,307.**

Phase V.1

Ua-69593. Gejvall 1937: E9. *Bos*, mandibula. 268.3g. 'E6, West /1–4/ 0–1.85 + Central Rooms 1.85–2.00.' Excavators' annotations: Phase V[1].

The "*west room*" is House 554 of the final publication and the "*central room*" is House 552 (*Heurtley Notebook 2, 1932.12,22 (plans); cf. Blegen* et al. *1951.Figs 280,281*). Heurtley excavated the central room (552), and identified the floor of the V2 phase at 1.70m. The levels 1.85–2.00 thus belonged to an earlier phase. But no clear floor level for the V[1] phase is recorded, and the 2m level seems to be a generalisation from the base level of the walls (*Heurtley Notebook 2, 1932.22*). If those walls were laid in foundation trenches, a sample from 1.85–2.00m could then have come either from the earliest deposits of Troy V or from late Troy IV. The depths translate to 36.25–36.10m A.T. Blegen located the V1 floor of House 552 at approximately 36.34m A.T. (*Blegen* et al. *1951.262,264;* also *262–268* and *Figs. 210–216,280–283* for the phase generally). This too could permit an attribution of the sample to Late IV, although the excavators clearly considered it to derive from V1. In the west room, dug mainly by Goethert, the depths of 0–1.85 might in theory have included everything from Troy V to Roman; but the marginal note assigning this and other bones of the same group to V1 was written by Marion Rawson who took over the area in 1933, so should probably be trusted. The '1–4' in Gejvall's description of the context may refer to cuts made by Goethert.

Phase Va

Ua-69598. Gejvall 1937: E253. *Sus*, maxilla. 20.4g. F8, 'Area 110, 2–70–2.80.' Excavators' annotations: Phase Va.

For this phase see *Blegen* et al. (*1951.255–256, Figs. 188,190,304*). Area 110 lay in the northeast corner of the trench and corresponds to the Area 502 shown in the publication (*Caskey Notebook 6, 1936.52 (general plan); cf. Blegen* et al. *1951.Fig. 304*). The depths of 2.70–2.80 translate to altitudes of 34.72–34.82m, so the sample does not come from the very deepest Va deposits in this area which descended to 34.52m (*Blegen* et al. *1951.255*). The publication describes the Va deposits here as "*earth and habitation depos-*

its with bones and carbonized matter"which were "*laid down horizontally, obviously as a result of gradual accumulation.*"

Phase Vb

Ua-69594. Gejvall 1937: E45. *Bos*, maxilla. 9.1g

Ua-69595. Gejvall 1937: E62. *Ovis/capra*, maxilla. 30.5g.

'F8-9, 1935, Area B+D.' Excavators' annotations: Phase Vb, 'House 204 (3.40–3.90 floor deposit?)'

For this phase see *Blegen* et al. *1951.258–259; Figs. 191,192,194,305*. "*House 204*" is identifiable as the House 501 described in the final publication (*Taft Notebooks 1, 1935.50 (plan) and 3, 1936.7–32; cf. Blegen* et al. *1951.Fig. 307*). Area B lay in the west half of the trench, partly outside the west wall of House 501, and Area D lay entirely outside the east wall of the same house (*Taft Notebook 1, 1935.50*). It is not clear why the excavators' marginal note places the samples within "*House 204/501*" or gives the depths of 3.40–3.90. The depths (34.12–33.62m A.T.) are those recorded for the floor of the north room (*Taft Notebook 1, 1935.55*). If correct they would place the samples in, or contemporary with, a 30cm-thick deposit described as "*a deep layer of habitation*" which "*may have comprised several different floor levels but if such is the case they were so close together that it was impossible to divide them*" (*Taft Notebook 1, 1935.109*).

Phase Vc

Ua-69596. Gejvall 1937: E107. *Bos,* mandibula. 136.2g.

Ua-69597. Gejvall 1937: E134. *Ovis/capra*, maxilla. 23.9g.

'F8-9, 1935, Area C, above 3.20.' Excavators' annotations: Phase Vc, 'House 204, second floor.'

For this phase see *Blegen* et al. *1951.271–273, Figs. 196–204,307*. "*House 204/501*" is House 501 of the final publication (see above on Ua-69594 and Ua-69595). Area C ('section' C in the notebook) lay in the east half of the north room (*Taft Notebook 1, 1935.50, plan*). It is not entirely clear where the upper limit of the deposit lay, except that it cannot have been higher than an overlying floor of the succeeding Vd building at 34.95 (north end) to 34.25 (south end) (*Blegen* et al. *1951.284*). The lower limit of 3.20 (34.32m A.T.) places the deposit immediately over a floor of phase Vc (*Taft Notebook 1, 1935.55, section; Taft Notebook 3, 1936.8*). The floor in fact sloped down to *c.* 34.20m at its south end, a figure which *Blegen* et al. *1951.272* gives as the average. The "*thin layer*" of the floor was "*recognizable ... by remnants of plaster coating, the comparative blackness of the deposit, the large quantities of bones, shells and ashes*" (*Taft Notebook 3, 1936.8*). It sounds as though the floor was not easily traced. There is therefore the possibility that the deposit included some fill either from below the Vc floor or from above it. If this had been taken from earlier deposits elsewhere on the site it could explain the earlier dates of our samples.

Phase VIa/b

Ua-69599. Gejvall 1937: F976. *Sus*, maxilla. 17.1g.

'F8-9, Area 3, 6.40–7.40.' Excavators' annotations: Phase VIa.

"*Area 3*" is the Area K described in the final publication (see plan and section in *Caskey Notebooks 6, 1936.52* and *7, 1937.54* and *Blegen* et al. *1953.Figs. 449,460*). The deposit was excavated as a horizontal spit in 1935 (*Caskey Notebook 4, 1935.107*), and lay at 31.12–30.12m A.T., so at the deepest level of the excavated area. The deposit is described by Blegen (*Blegen* et al. *1953.133, Figs. 122–123,449,460)* and

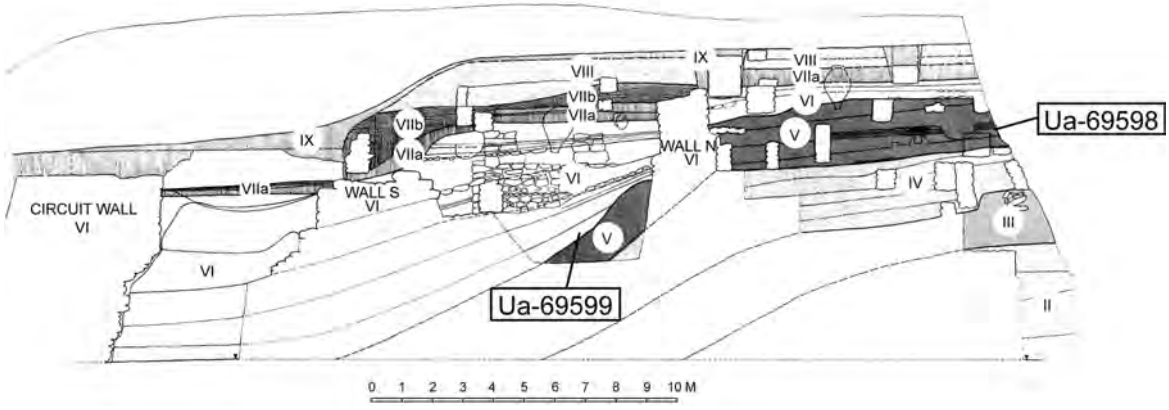

***Fig. 12. Diagrammatic section of squares F 7-8-9, looking west, to show approximate find-spots of samples 1 and 11. Adapted from* Blegen *et al.* 1953.Fig. 453.**

appears to have been a layer of fill sloping down over the face of a fall of stones (or perhaps a glacis?) abutting what he took to be a circuit wall of Troy IV, V and perhaps Early VI. The latest pottery in the fall of stones was of Early VI date (*Blegen* et al. *1951.139, Fig. 309*). The overlying deposit, from which our sample comes, must be at least of the same date but could include material of Blegen's VIb layer, as Pavúk notes (*Pavúk 2014.120–121*). Consequently the context may belong to either Ceramic phase 1 or Ceramic phase 2 in Pavúk's terms and could date as late as 1635/1600 BC (*Pavúk 2020.69*).

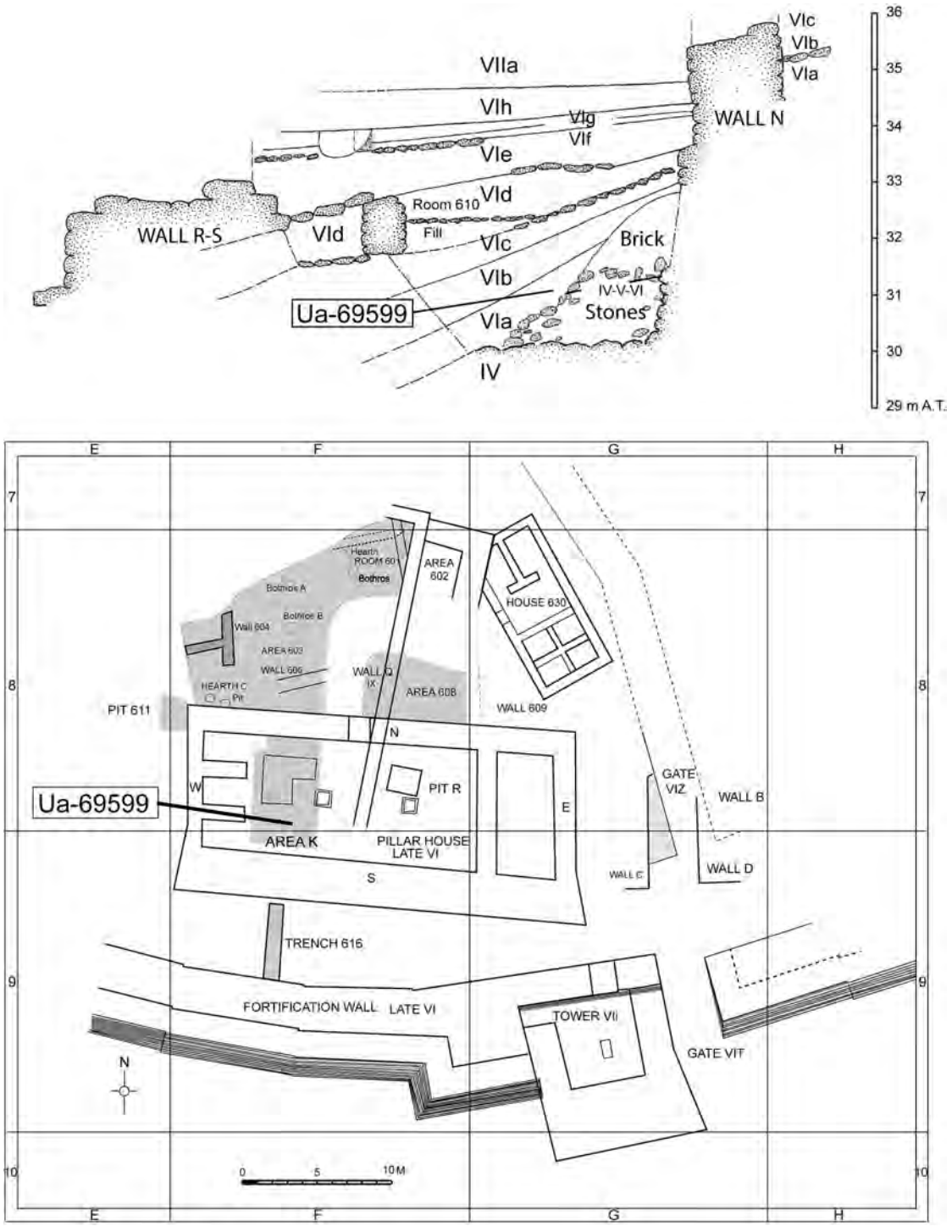

***Fig. 13. Above: Diagrammatic section showing strata of Troy VI in Area K, as seen from east, with approximate stratigraphic position of sample 1 (Ua-69599). Below: plan of squares EFGH 7-8-9-10 in Early Troy VI, showing approximate find-spot of the same sample. Adapted from* Blegen *et al.* 1953.Figs. 460,449.**

The earliest traces of metallurgy in Greater Poland: tuyère from Kotowo, Poland

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ABSTRACT – *During rescue excavations at Site 1 in Kotowo in 1958, a ceramic tube was discovered in a feature of the Funnel Beaker culture. Currently, XRF analysis suggests that it is a ceramic tuyère associated with copper processing. The feature, radiocarbon dated to 3911–3714 BC (68.3% probability), most likely housed a metalworking workshop. The artefact from Kotowo has several analogues in the Polish lands, mainly from sites of the Lengyel-Polgár culture. With a clear and well-documented cultural context, it testifies to the existence of the oldest metallurgical workshop so far known in the Funnel Beaker culture.*

KEY WORDS – *Funnel Beaker culture; Lengyel-Polgár complex; metalworking workshops; copper*

Prvi sledovi metalurgije v Velikopoljski: tuyère z najdišča Kotowo na Poljskem

IZVLEČEK – *Med zaščitnimi izkopavanji na najdišču 1 v Kotowu je bila leta 1958 v kontekstu z gradivom kulture lijakastih čaš odkrit keramični predmet cevaste oblike. XRF analiza je pokazala, da gre za keramično tuyère, povezano z metalurgijo bakra. Kontekst je radiokarbonsko datiran v čas 3911–3714 pr. n. št. (68,3 % verjetnost) in najverjetneje predstavlja delavnico za obdelavo kovin. Za artefakt iz Kotowa poznamo več primerjav z najdišč kulture Lengyel-Polgár. Jasno in dobro dokumentiran kulturni kontekst dokazuje obstoj najstarejše doslej znane metalurške delavnice v kulturi lijakastih čaš.*

KLJUČNE BESEDE – *kultura lijakastih čaš; kompleks Lengyel-Polgár; metalurška delavnica; baker*

Introduction

The advent of metallurgy to the Polish lands in the Oder and Vistula drainage basins dates back to the second half of the 5th millennium BC. Metallurgy was first practised by Lengyel-Polgár circle communities such as the Brześć-Kujawski and Lublin-Volhynia cultures or the Wyciąże-Złotniki group (*Kadrow 2017. 84–86*). In the early 4th millennium BC, interest in copper processing was taken over by the communities of the Funnel Beaker culture (FBC) (*Nowak 2017.155–156*; *see also Kośko, Szmyt 2019.233*). A strong indication of the knowledge of metallurgy is given, it is believed, by the occurrence of metalworking production debris on archaeological sites such as slag, crucibles, various forms of raw material and

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characteristic ceramic objects – blowpipes and their fragments interpreted to be tuyères. A single specimen of a tuyère, excavated on Site 1 in Kotowo, Kościan Commune, Greater Poland, is the subject of this article.

On this site, the staff of the Archaeological Museum in Poznań investigated a Lusatian culture cemetery in 1958. Besides Bronze Age graves, they also unearthed the remains of a Neolithic settlement left by FBC populations. The only Neolithic feature they identified yielded many material remains, including a pipe-like ceramic object, although its discoverer did not associate it with any function (*Lipińska 1963*). Attention was only drawn to a possible connection between this find and copper metallurgy in 1979. It was then that Tadeusz Wiślański included the Kotowo item in a set of remains of FBC copper metallurgy together with crucibles from Ćmielów and Gródek Nadbużny, as well as a burnt tuyère from Janówek (*Wiślański 1979.239*, *Fig. 138*). A re-analysis of Neolithic pottery from Kotowo and ^{14}C dates for the FBC feature (*Żurkiewicz 2020*) also provoked a re-examination of the ceramic tuyère. The main aim of this article is therefore to confirm the function of the Kotowo artefact through comparative research, and so place it in a broader cultural and spatial context.

FBC sources from Kotowo, Site 1

The site in Kotowo is located in central-western Poland on the Mogilnica River, a right-bank tributary of the Obra, in the Poznań Lakeland, central Greater Poland (Polish Lowland).

The FBC feature, designated as number 1, was discovered in the southern part of a narrow excavated strip of land, extending along the edge of a sand pit (Fig. 1.a). An oval feature ceiling, measuring 3.5×3.0m, was exposed at a depth of 0.70–0.95m below the ground level as it was at that time. The feature depth stayed below 0.5m, and inside the feature contour three smaller intensively coloured depressions were found that contained three clusters of archaeological material (Figs. 1.b, 2; Tab. 1).

The feature held a total of 318 FBC pottery shards. Most were found in Cluster 2, which held 144 pottery shards, including three partially preserved funnel beakers accompanied by ten bone fragments, small pieces of daub and a ceramic tuyère. Additionally, burnt pottery shards were recorded in Clusters 2 and 3, while in Cluster 2 char and burnt rocks were found. This led the researcher in charge of the excavations to conclude that Cluster 2 could have been a hearth, while the whole structure suggested a dwelling or an economic feature (*Lipińska 1963.310*).

The source materials from each cluster are shown in Table 1. A technological analysis of pottery from Feature 1 showed that pottery with a wall thickness of 5 to 8mm dominated in Clusters 1 and 2. These were vessels made of clay tempered with small amounts of fine sand and grog. There are a few vessels with walls 9–17mm thick in Clusters 1 and 2, but these are dominant in Cluster 3. The technology of most vessels in all clusters, regardless of wall thickness, is similar (for a detailed specification of technological traits see *Żurkiewicz 2020*). Technological differences are found only in plates.

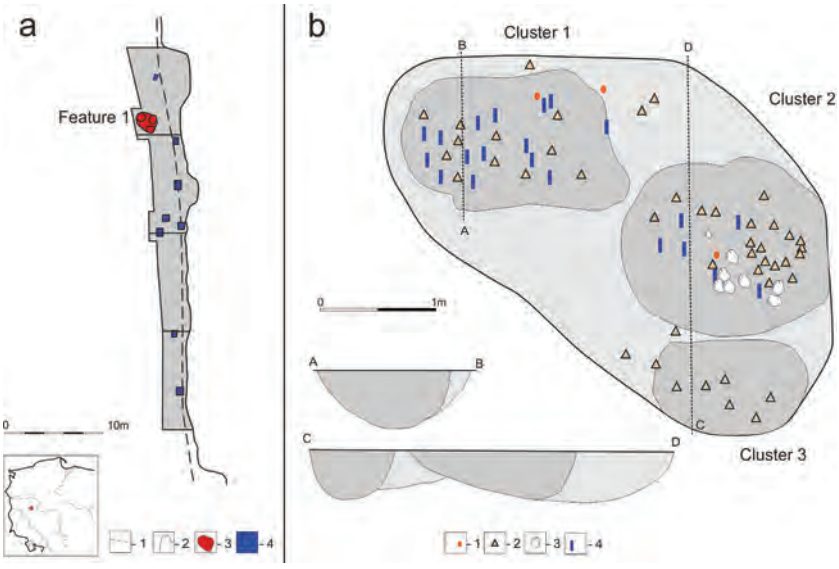

Fig. 1. Kotowo, Site 1, Greater Poland:* a *site location;* b *Feature 1 plan and profile (after* Lipińska 1963*). Legend:* a.1 *farmland border;* a.2 *sand extraction ;* a.3 *FBC Feature;* a.4 *cremation graves;* b.1 *daub;* b.2 *pottery;* b.3 *stones;* b.4 *bones.

Pottery from Feature 1 included six funnel beakers and three plates (Fig. 2) with noticeably raised edges and bowl-shaped. For two of these plates the diameter was estimated at approximately 28–29cm. The technology used for these items is distinctly different from that seen

with the rest of the pottery assemblage. The plates are made of clay tempered with medium and coarse grog. Two plates are ornamented with finger imprints running around their edges. Additionally, on the inner surface of one plate, there runs a circumferential row of impressed pits. In the FBC's Eastern group, such pottery is the most numerous in early phases. Beakers from Feature 1 are ornamented on the outside under the rim with simple single-element circumferential motifs and all were made of clay tempered with fine sand and grog. One, preserved best, may be counted among funnel beakers associated with the oldest FBC development phase in the Eastern group.

The pottery from Feature 1, in terms of its style, has been considered as settlement remains from the early (first) FBC development phase in Greater Poland (*Żurkiewicz 2020.124–126*). This claim is made more plausible by ^{14}C dates obtained for the clusters of finds discovered in Feature 1.

The Poznań Radiocarbon Laboratory dated two animal bone fragments from Cluster 1 and two pottery shards (vessel bellies) from Cluster 1 and Cluster 2, in terms of technology unequivocally connected to the FBC, on which an organic residue was observed. Four determinations were obtained:

- Poz-102283 5080±40 BP – for the organic residue on a pottery shard from Cluster 2;
- Poz-139969 5015±35 BP – for a fragment of an unidentified animal bone from Cluster 1 (0.8%N, 5.4%C, 1.6% coll);
- Poz-101632 5000±40 BP – for a fragment of an unidentified animal bone from Cluster 1 (1.8%N, 6.4%C, $d^{13}C=-20.8‰$, $d^{15}N=6.7‰$);
- Poz-102674 4960±40 BP – for the organic residue on a pottery shard from Cluster 1.

A combination of radiocarbon dates made using the 'R_Combine' function in the OxCal v4.4.4 software (*Bronk Ramsey 2021*), at the probability of 68.3%, rendered the time bracket of 3911–3714 BC for Fea-

Fig. 2. Kotowo, Site 1, Greater Poland. Selected materials from clusters found in Feature 1 (after* Żurkiewicz 2020*).

Materials	Cluster 1	Cluster 2	Cluster 3	Total
FBC pottery – number of shards	103	144	71	318
FBC pottery – weight of assemblage [g]	2847	3596	1893	8336
Number of FBC ornamented shards	17	9	3	29
Vessel forms	3 beakers, 3 plates	3 beakers	beaker fragments – stuck together with those from Cluster 2	9
GAC pottery	6	45	26	77
Bones	46 + fragment of a human skull	10		57
Daub	15	14		29
Rough-cast ware	6	2		8
Burnt pottery fragments		5	12	17
Others	bone chisel	ceramic tuyère	grindstone	

Tab. 1. Kotowo, Site 1, Greater Poland. Finds.

ture 1. When the probability was raised to 95.4%, the bracket was expanded to 3942–3708 BC (Fig. 3).

Ceramic tuyère from an FBC feature in Kotowo, Site 1. Object description

The artefact found in Cluster 2 of Feature 1 was restorated (glued together) from many fragments. Portions missing from its centre were filled with gypsum. Its inlet (wider end) has an edge broken off, while the mouth (narrower end) is chipped, perhaps with little being left of the original surface (Fig. 4a). Dimensions: total length: 8.4cm (judging by the state of preservation of its inlet and mouth, it can be assumed that this figure is close to the original total length); outer inlet diameter: max. 2.5cm, inlet opening diameter: 1.65cm; outer mouth diameter: 2.3×2.0cm, mouth opening diameter: 1.15×1.0cm.

The object is slightly asymmetrical. Its outer surface is smooth, even, hard, of a beige colour and bears traces of using a slick. Inside, along the object, some impressions are noticeable, perhaps left during its formation (*Botwid 2020.238*). The inner surface is dark, almost black, perhaps a result of sooting or smoking. The technology used to make it, judging by a small exposed surface on its outer wall, involved the use of a clay with a small amount of medium-grained grog. The fracture colour is dark, almost black. The artefact has no obvious burn marks on either end.

Ceramic tuyère from an FBC feature in Kotowo, Site 1. Results of XRF analyses

The analyses were performed at the Faculty of Foundry Engineering, Stanisław Staszic AGH University of Science & Technology, Kraków, Poland. The chemical composition of the inner surface of the object at its inlet was examined, using energy-dispersive X-ray fluorescence spectroscopy (ED-XRF). For this purpose, a stationary spectrometer SPECTRO MIDEX, designed for metallic elements analyses, was used, fitted with an X-ray tube with an Mo anode and a semiconduc-

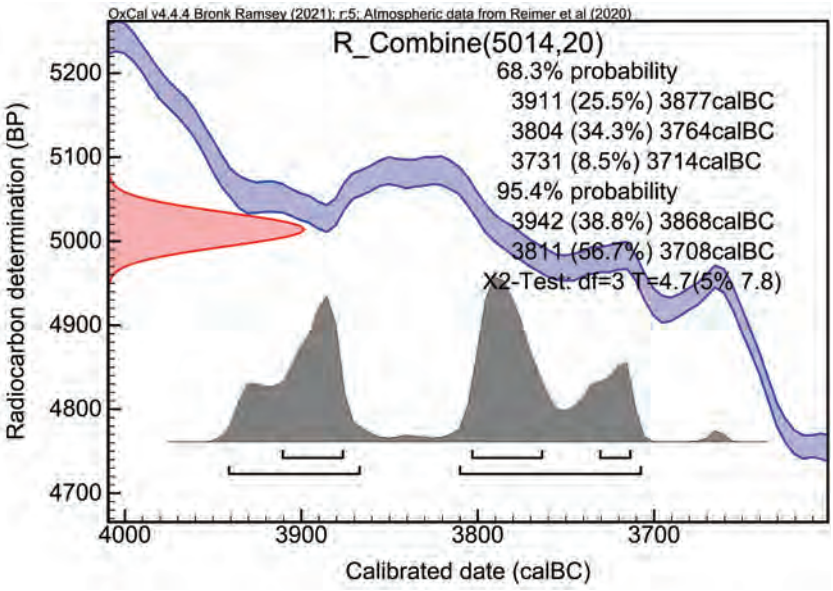

Fig. 3. Kotowo, Site 1, Greater Poland. Joint calibration of ^{14}C determinations in OxCal v4.4.4 (*Bronk Ramsey 2021*).

tor detector Si SDD. A SPECTRO MIDEX spectrometer took measurements in areas 0.02–0.5mm in diameter. The qualitative analyses of the chemical composition searched for characteristic elements such as Fe, Co, Ni, Cu, As, Ag, Au, Sn, Sb, Pb and Bi. The chemical composition of the object interior was determined by making five measurements at the broken-off fragment of the tuyère inlet (Fig. 4b). These indicated a considerable amount of copper, from 1.19% to 5.46%, with the average of the measurements being 2.9%. The second largest share belonged to zinc (from 1.67 %to 2.93%, with an average of 2.39%). However, this element should be linked to the material of which the tuyère was made, *i.e.* clay. There was relatively little tin on the surface (below 1.0%). Detailed percentages of the elements that were identified are shown in Table 2.

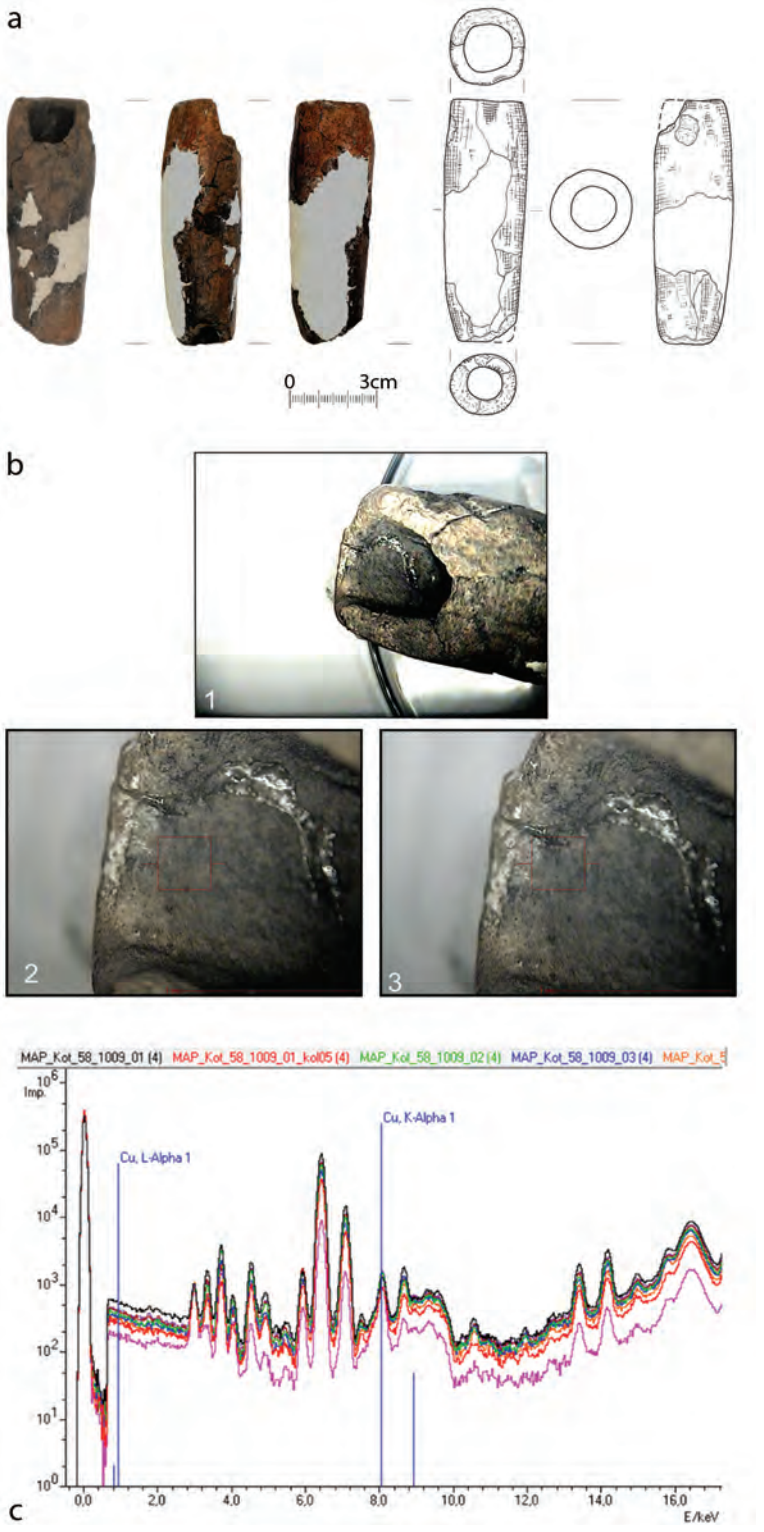

Fig. 4. Kotowo, Site 1, Greater Poland. **a** ***ceramic tuyère an artefact;*** **b.1** ***spectroscopic analysis area – inlet;*** **b.2** ***measurement area: Cu content of 2.9%;*** **b.3** ***measurement area: Cu content of 5.4%;*** **c** ***diagram of X-ray fluorescence spectra.***

The usefulness of the XRF method for the examination of Neolithic ceramics has already been confirmed on many occasions (*e.g., Menne 2020*) and has also been found helpful in detecting traces of metallurgical processes on ceramic artefacts. Its application helped reveal traces of copper (up to 6.2%) on the surface of a crucible fragment linked to the FBC Northern group (*Gebauer* et al. *2021*). A high proportion of silver and tin was also found on the related ore (*Rostoker 1975.314*).

The analysis results of the Kotowo tuyère suggest that it should be directly linked to metalworking. Being a qualitative confirmation of contact with molten metal, the results of analogous analyses made on casting moulds (*Garbacz-Klempka, Dzięgielewski 2021*; *Garbacz-Klempka* et al. *2016*) make the percentages for the Kotowo tuyère appear surprisingly high. In the case of casting moulds from a Bronze Age cemetery in Gogolin-Strzebniów, the copper content ranges from 2% to 18% (*Garbacz-Klempka, Dzięgielewski 2021*). Tuyère, unlike moulds, rarely show traces of direct contact with molten metal (*cf. Dziekoński 1962*; closest analogy from Cyprus, *Tylecote 2002.22*). However even if the tuyère did not come into direct contact with molten metal, a closed hearth system

could cause metal vapours to be drawn inside the tuyère. This hypothesis is perhaps supported by the domination of copper and a small percentage of the other elements in the XRF examinations.

Possible uses of the Kotowo tuyère

The results of physicochemical analyses show that the tuyère was a fireproof ending of an installation supplying air to a copper smelting reactor. The purpose of blowpipes and tuyères was to aid the burning of charcoal with an additional air blast that helped ensure the right temperature. Hence, they are believed to be proof of local metalworking (*Garbacz-Klempka 2018.20; Höppner* et al. *2005.299; Carozza, Mille 2009.143*). The relatively large diameters of the Kotowo tuyère inlet and mouth suggest that the object could not have been used as a blowpipe because its diameters should not have been greater than 10mm. Instead, it must have ended in bellows that effectively supplied oxygen to the reactor charge (*Bourgarit 2007*).[1] Experiments have shown that the use of human breath through a blowpipe, ending in a clay element or bellows with a tuyère, ensures the right temperatures and conditions for liquefying, melting or smelting copper (*Rehder 1994*). Furthermore, it is suggested that the local topography and natural conditions were taken advantage of when places for metalworking workshops were selected. This shows that wind was harnessed to supply air to furnaces (*Bourgarit 2007; Martinón-Torres, Rehren 2014.110*).

In the light of available information, the morphology of Eneolithic metalworking features can be characterized as varied (*Bourgarit 2007*). What draws attention in this context is a particular type of structure, using bowl-like ceramic vessels (*Bourgarit 2007.Tab. 1*). The list of relevant sites given in the cited publication (*Bourgarit 2007.Tab. 1*) is supplemented by a site at Belovode (Serbia) where Europe's oldest traces of copper processing have been documented, attesting to the advanced skills of Eneolithic metallurgists (*Radivojević* et al. *2010*; *Radivojević, Rehren 2021; Radivojević* et al. *2021*). The discoveries made there prompted researchers to carry out an experiment to find out whether such vessels and ceramic tuyères with bellows could be used to process copper, and the results showed that they could.

As known from various European Eneolithic sites, vessels used in metalworking installations (*Cadet* et al. *2021*) find counterparts in the Kotowo plates/bowls. Interestingly, they also have uncertain analogies in other FBC settlement contexts on the Polish Lowland. What attracts attention is their technology because, as the only ones on this site, they were made of clay tempered with medium- and coarse-grained grog. This may indicate that they were designed for other purposes than those of the other vessels. Admittedly, no traces of use for metallurgical purposes have been found on the Kotowo plates/bowls, but the same is true for the Belovode vessel artefacts. Experiments carried out on them have not found any such traces on the vessels that were examined, and neither have the spectrographic analyses of original reactor remains on the Belovode site revealed any substantial residues of slag or copper on the vessel surfaces (*Radivojević, Rehren 2021.128*).

The advent of metallurgy in the Vistula and Oder drainage basins

In the lands of present-day Poland, we now know of nine fragments of potential ceramic tuyères, originating with five Eneolithic sites of which only three may be linked to FBC communities. The others are

Analysis no.	Concentration (wt%)										
	Co	Ni	Cu	Zn	As	Ag	Sn	Sb	Au	Pb	Bi
MAP_Kot_58_1009_01	< 0,020	< 0,015	1,19	2,15	0,05	0,34	0,65	0,18	< 0,020	0,01	< 0,001
MAP_Kot_58_1009_02	< 0,020	< 0,015	2,18	2,03	0,05	0,41	0,50	0,16	< 0,020	0,02	< 0,001
MAP_Kot_58_1009_03	< 0,020	< 0,015	2,71	2,93	0,00	0,48	0,49	0,01	< 0,020	0,20	< 0,001
MAP_Kot_58_1009_04	< 0,020	< 0,015	2,96	2,82	0,06	0,42	0,53	0,12	< 0,020	0,08	< 0,001
MAP_Kot_58_1009_05	< 0,020	< 0,015	5,46	1,67	0,00	0,48	0,94	1,15	< 0,020	0,01	< 0,001
Medium	**< 0,020**	**< 0,015**	**2,90**	**2,32**	**0,03**	**0,43**	**0,62**	**0,32**	**< 0,020**	**0,07**	**< 0,001**

Tab. 2. Kotowo, Site 1, Greater Poland. Results of the chemical composition analysis of the ceramic tuyère, using X-ray fluorescence spectroscopy (ED-XRF) in wt%.

1 For a slightly different opinion on the function of differences in tuyère diameters see Marcos Martinón-Torres and Thilo Rehren *(2014.111)*.

associated with the groups of the Lengyel-Polgár circle. However, the list of Eneolithic finds from the Polish lands, attesting to the knowledge of copper processing skills, is a little longer. In it, one may include fragments of vessels in the categories of crucibles, semi-finished products, raw-material bits or slag. Below, in chronological order, the other finds are described, being the oldest known testimony to the knowledge of copper smelting in the lands of present-day Poland. At this juncture, one should caution that where hypothetically finds could be linked with metal processing but the link has not been substantiated by specialist analyses (*e.g.,* Opatowice, Site 42, Kujawy-Pomerania Province – *Kośko, Szmyt 2007.247*) or a context is uncertain, such finds have not been considered. Furthermore, as part of the project named "*The catalogue of the oldest metal object from Wielkopolska*", analyses have been carried out of potential crucibles and ladles from Neolithic sites in Greater Poland (Śrem, Site 8, Mrowino, Site 3). The results in this instance, however, have been negative.

The oldest finds, attesting to the knowledge of metallurgy that have been discovered in the Polish lands and documented in reliable archaeological contexts, come from Brześć Kujawski culture settlements, **Brześć Kujawski**, Sites 3 and 4, Kujawy-Pomerania Province. On Site 3, in the ceiling of a settlement feature, a discovery was made of a slag lump fused with a crucible fragment (*Grygiel 2008.208, Fig. 184*). Site 4, in turn, yielded miniature ingots, in the form of elongated bands and rods with a rectangular cross-section (*Jażdżewski 1938.53, Fig. 38*). On the same site, in the cultural layer, underneath a grave, a ceramic tuyère was found. It tapered towards one end and had its thicker end broken off similarly to the Kotowo specimen (Fig. 5.e; *Jażdżewski 1938.15, Fig. 35:5*). All these finds are connected to the classic phase of the Brześć Kujawski culture and roughly dated to 4500–4300 BC (*Grygiel 2008.1992*).

Slightly younger Lublin-Volhynia culture finds were unearthed in **Złota – Grodzisko I and II sites**, Świętokrzyskie Province. The finds comprised five remains of ceramic tuyères (Fig. 5.c,d,f,g,h), fragments of 22 crucibles for smelting copper and many raw material lumps and metal ornaments (*Dziekoński 1962*). Unfortunately, the dating of these finds cannot be narrowed down, and thus they can be only generally assigned to the horizon of the Lublin-Volhynia culture, coinciding with the period 4300/4200–3800 BC (*Zakościelna 2006.80–88*). This is the same time bracket to which the Kotowo tuyère is assigned.

Among the materials of the Wyciąże-Złotniki group, dated to 3700–3600 BC (*Włodarczak 2006.33*), discovered at a site in **Złotniki**, Małopolskie Province, crucible fragments were identified that bore copper residues on the inside (*Dzieduszycka-Machnikowa 1964*).

In this context, a crucible found in **Złota** – Nad Wawrem site can be considered as a continuation of interest in metallurgy among FBC communities. It is a small vessel with an opening next to its base from which a pipe-like mouth protrudes. However, a qualitative analysis carried out at the Spectrography Laboratory, State Archaeological Museum, has not found any traces of copper on its surface (*Matraszek 2001.151*). An object similar to this find, from Ćmielów and discussed below, was taken to be the remains

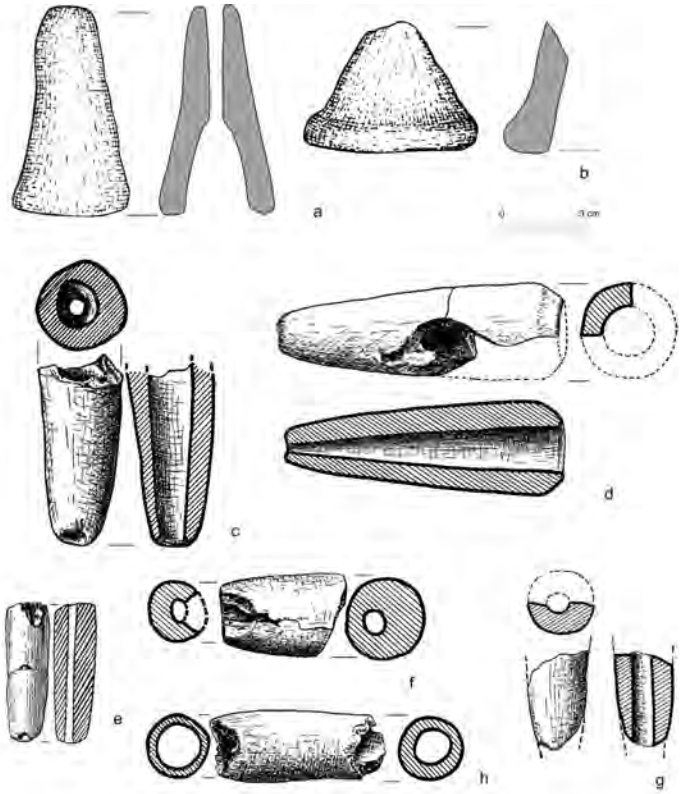

Fig. 5. Artefacts from the Polish lands interpreted to be ceramic tuyères and dated to the Eneolithic: **a, b** ***Janówek;*** **c, d, f** ***Złota, Site Grodzisko I;*** **g** ***Złota, Site Grodzisko II;*** **e** ***Brześć Kujawski, Site 4. After Konrad Jażdżewski (*****1938*****), Tadeusz Dziekoński (*****1962*****), and Włodzimierz Wojciechowski (*****1973*****).***

of a smoking pipe (*Matraszek 2001.151*). Importantly, these finds are associated with FBC communities, while the settlement phase of the site in Złota supposedly corresponds to Phase BR II dated to 3750/3700–3500/3400 BC (*Matraszek 2001.167*; *Kruk* et al. *2018.40*).

From a site at **Gródek Nadbużny,** Lublin Province, a number of varied artefacts were recovered, attesting to advanced and intensive copper processing. Among them are 22 crucible fragments with fused metal or residue, pointing to contact with copper, 25 lumps of strongly burnt daub and five lumps identified as ore or slag (*Gumiński 1989.166–169*). For Feature 18, from which one crucible fragment with fused metal came, the ^{14}C date GrN-16125 4665±40 BP (*Gumiński 1989.173*) was obtained, assigning the feature, at a probability of 68.2%, to the time bracket of 3513–3372 BC. Prior to the FBC settlement, the site was occupied by a Lublin-Volhynia culture community, although it did not practise metallurgy (*Kadrow 2015. 203*).

At an FBC settlement in **Ćmielów**, Świętokrzyskie Province, dating to 3600–3400 BC (*Włodarczak 2006.Fig. 16*), in addition to a 'smoking pipe' similar to that found in Złota, a discovery was made of fragments of over a dozen crucibles that bore visible traces of copper on the inside (*Krzak 1963*).

Finds from the FBC Southern group from **Janówek**, Lower Silesia Province, represent the two youngest specimens of hypothetical ceramic tuyères, found in the Polish lands in an FBC context (*Wojciechowski 1973.40*). Both objects were found in two economic features, holding rich materials stylistically dated to the younger (Luboń) FBC phase. Unfortunately, there are no ^{14}C determinations available for the site, hence its chronology can be only generally described as coinciding with the Luboń phase that is roughly dated to 3400–2700 BC in Wielkopolska (*Wierzbicki 2013.156*). The FBC settlement at Janówek was preceded by settlement remains from the early phase of the Lengyel culture (*Wojciechowski 1973.4*). However, we have little information about these remains.

The advent of metallurgy, and tuyères in Eneolithic communities

Copper minerals and native copper were first used in the Middle East as early as the 8th millennium BC (*O'Brien 2014; Roberts* et al*. 2009; Maddin* et al*. 1999*). It was there that early agrarian communities appreciated the aesthetic value of native copper fragments encountered on the ground. What they also found attractive was the possibility of shaping such pieces by cold forging. In turn, copper thermal processing is first evidenced in 7th millennium BC Anatolia (*Pernicka, Anthony 2010*), although serious reservations have recently been raised about this (*Radivojević* et al. *2017*). By the 6th millennium BC, the skills and expertise of copper processing were advanced enough to melt and shape it in moulds (*O'Brien 2014*).

A more recent series of radiocarbon dates shows metallurgy in the Balkans predates that known from the Aegean. This, however, does not allow one to simply deduce that knowledge of metallurgy from the Middle East was imported to Europe, but rather tends to support the hypothesis that metallurgy was invented independently in the two regions (*Renfrew 1969*; *O'Brien 2014.38*; *Rosenstock* et al. *2016.106; Radivojević* et al. *2010; Radivojević 2015*). Additional support for this hypothesis comes from Serbia and Bulgaria, where traces of copper mining and processing were founded, dated to 5200–4500 BC and tied to the Vinča culture (*Marić* et al. *2021*; *O'Brien 2014.40*; *Rosenstock* et al. *2016.75–76*).

In the early 5th millennium BC, knowledge of copper metallurgy is observable among the communities of the Lengyel and Tisza cultures and other Carpathian Basin groups. The region's oldest metallurgical workshop was identified on the site of Slovenské Pravno, okr. Turčianske Teplice, north-central Slovakia. There, at a settlement of the Ludanice culture, dated to 4100–3800 BC, a roasting furnace was found holding slag and copper lumps (*Czajlik 2014*).

Finds interpreted to be ceramic tuyères are known from Eneolithic sites stretching from the Caucasus to Iberia (*Gailhard* et al. *2021*; *Murillo-Barroso* et al. *2017*). However, it must be noted that on the oldest European site, where all the major elements of the metallurgical *chaîne opératoire* are recorded at Belovode, Petrovac county, Serbia, dated to 5000–4600 BC, the remains of ceramic tuyères have not been found yet. Nonetheless, experiments attempting to reconstruct local metalworking assume that such objects were used (*Radivojević, Rehren 2021.128*).

In central Europe, the oldest known site evidencing copper metalworking skills is located in the Tyrole-

an Alps. On the site Brixlegg, distr. Kufstein, at a settlement of the Münchshöfen culture, dated to *c.* 4500 BC, pieces of slag and two ceramic tuyères were found (*Höppner* et al. *2005*). Research has shown that an experimental attempt was made there to purify copper, originating with local deposits. However, most metal goods of this community are believed to have been made of imported raw material, most likely from the lands of today's Serbia (*Höppner* et al. *2005*).

The list of ceramic tuyères connected to the FBC, apart from finds from the Oder and Vistula drainage basins, can be expanded to include discoveries made in the Czech Republic and Denmark.

In Moravia, the oldest finds evidencing the knowledge of copper metallurgy are tied to the FBC. They come from site Podoli okr. Brno-Venkov (*Kos, Šmíd 2013*). In a certain feature, and together with pottery characteristic of the FBC, a discovery was made of a fragment of ceramic tuyère and pieces of slag (Fig. 6.a). The feature is radiocarbon dated to 3796–3708 BC (probability of 95, 5%; Poz-60110, 4990±35 BP). In the Bohemian Basin, a fragment of ceramic tuyère was found together with the materials of the Baalberg group, marking the early phase of the FBC (3800–3400 BC) at site Cimburg, okr. Kutná Hora (Fig. 6.b; *Zápotocký 2000.72, Taf. 7:21*).

In Denmark, and from the FBC Northern group, cultural-layer finds have been unearthed at the site of Lønt, comm. Haderslev. These are a crucible fragment, which has been subjected to XRF analysis, and a small fragment of ceramic tuyère (*Gebauer* et al. *2021*). They were found together with materials roughly dated to the FBC early phase, *i.e.* 3800–3500 BC (Fig. 6.c).

Discussion and conclusions

The archival discoveries listed above and the new examinations of the Kotowo tuyère justify the inclusion of the Vistula and Oder drainage basins among the lands where early knowledge of advanced copper processing has been identified among FBC communities.

The feature found on Site 1 at Kotowo may be interpreted as the remains of economic activity, which is indicated by its size and form, an elongated oval with a flat bottom, as well as internal organization, the division into three zones in which economic activity was carried out. This is seen in separate concentrations within the feature, having clearly distinct fills in which most of the movable finds were found.

Furthermore, the content of individual concentrations attests to the economic purpose of the feature. They were found to contain animal bone fragments, daub, a bone awl and a grindstone but the most numerous remains were pottery shards, both thin- and thick-walled ones. Some of the shards have been visibly refired. Archival descriptions mention visible layers of char in Cluster 2, *i.e.* where the tuyère was found. Moreover, the fact that some thick-walled ware had rough surfaces indicates its functional, probably, economic purpose.

Among the pottery, small fragments of three plates deserve special attention. Plates are common among the early material of the FBC Eastern group. What makes the Kotowo ones different is their raised edges, making them look somewhat like bowls. What's more, the best preserved plate was probably made using an atypical technology: by impressing its form in a kind of basket, the structure of which is still visible on the outside surface of the plate (Fig. 2.a). Finally, all the plates were made following a potter's recipe that was different from that used for the other vessels from this site. Here, the clay of which the plates were made was tempered with medium and coarse grog.

However, the rarest artefact found in the feature in question is a fragment of a pipe-like artefact that

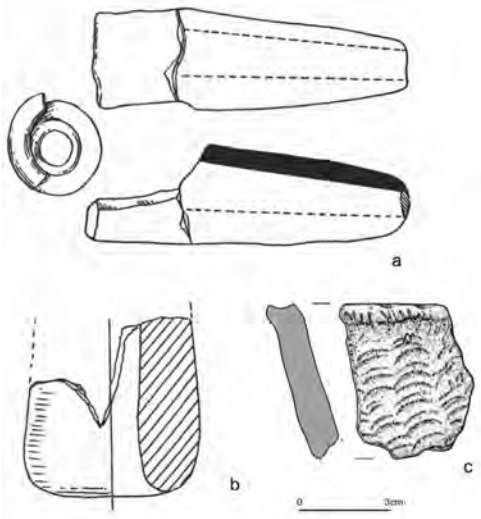

Fig. 6. FBC ceramic tuyères.* a *Podoli, okr. Brno-Venkov;* b *Cimburg, okr. Kutná Hora;* c *Lønt, comm. Haderslev. After Petr Kos and Miloslav Šmíd (*2013*), Milan Zápotocký (*2000*), and Anne Brigitte Gebauer* et al. *(*2021*).

should be interpreted, on the strength of specialist analyses and the analogies referred to above, as a ceramic tuyère used in copper processing. In conclusion, it can be claimed that the tuyère was found in a feature that, at least during a part of the time it functioned, was a metalworking workshop.

An attempt was made to specify more precisely the time the feature was used by carrying out a number of ^{14}C determinations. Unfortunately, the unfavourable course of the calibration curve prevented any narrowing down of the period when the feature was used by indicating a relatively broad interval of 3911–3714 BC (probability of 62%). At present, this series of dates comprises the oldest determinations made for an FBC community in Greater Poland that coincide with the first development horizon of the FBC Eastern group (*Kozłowski, Nowak 2019.107*).

The Kotowo tuyère proves that already in the early FBC advanced metalworking skills were present (for an opposite opinion *see Kowalski* et al. *2016.196*).

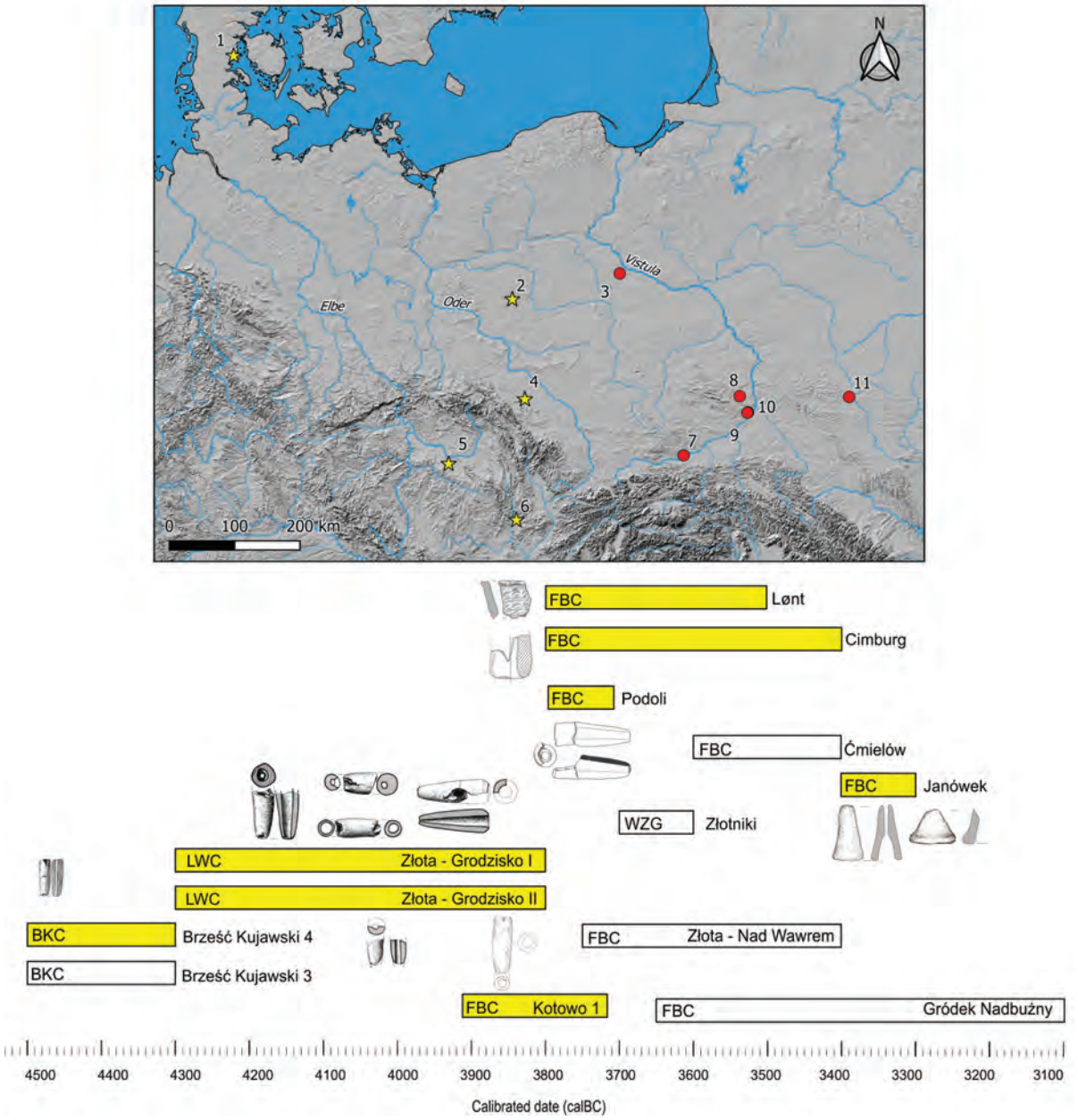

Fig. 7. Chronology of finds attesting to copper processing within the entire FBC oecumene and the dating of ceramic tuyères from the Lengyel-Polgár circle found on the Polish lands. Sites on which ceramic tuyères were found are marked in yellow, and sites that yielded other finds attesting to the knowledge of metallurgy are marked in white.* 1 *Lønt,* 2 *Kotowo,* 3 *Brześć Kujawski,* 4 *Janówek,* 5 *Cimburg,* 6 *Podoli,* 7 *Złotniki,* 8 *Ćmielów,* 9 *Złota – Grodzisko I and II,* 10 *Złota – Nad Wawrem,* 11 *Gródek Nadbużny.

Its design suggests that it was used with bellows rather than as a fireproof ending of a simple blowpipe to be blown by a person, which could be re-used many times until it was damaged, perhaps by a fragment breaking off at its inlet. Similar types of damage are noticeable on other Eneolithic tuyères (Fig. 5.a,e; 6.a). Unfortunately, metalworking in Kotowo cannot be tied now to any specific copper goods. Eneolithic metal goods from central Greater Poland are finds of uncertain archaeological contexts for the most part and are mostly believed to have been influenced by the Baden culture in the second half of the 4th millennium BC. A hoard from Rudki, Greater Poland, is a good example of this (*Kowalski* et al. *2019*).

Ceramic tuyères on central European Eneolithic sites make up a rather small set. Perhaps they were not indispensable for successful copper smelting. In this set, only the Kotowo specimen has been confirmed by spectrographic analyses to have been used in metallurgy. Moreover, the results suggest that it may have been used for purifying, or refining metal that was procured earlier.

The form of the Kotowo specimen, however, does find analogies on other archaeological sites, and the closest specimens in terms of form come from Złota-Grodzisko I (Fig. 5.d) or Podoli, Moravia (Fig. 6.a).

The information presented above justifies the cautious conjecture that there were three types of Eneolithic tuyères:

Type 1. Simple ceramic endings of blowpipes with the diameter of the inner channel not exceeding 10mm, represented by a specimen from Brześć Kujawski (Fig. 5.e).

Type 2. Ceramic tuyères used with single bellows, and this is the type of the Kotowo specimen and most other finds. Its characteristic may be a smaller (by 1/3?) diameter of the mouth than that of the inlet. Admittedly, the current data are too few, making any generalizations of observations from Kotowo almost impossible.

Type 3. Short specimens with a broad inlet that could have been used in a more advanced smelting technology with two bellows ensuring a continuous supply of oxygen and thus a stable and high temperature (*Dziekoński 1962*). Tuyères of this type could have prevented hot embers from being drawn inside inflammable bellows, and it is to this type that the Lønt specimen may belong (Fig. 6.c).

It is difficult to claim that these types of tuyères evolved from each other, with Type 1 being the oldest and Type 3 the youngest, since we still have only a few relevant specimens. Moreover, tuyères of Type 2 and Type 3 are encountered among materials associated with an earlier stage of the FBC (Kotowo and Lønt) and dated to the first half of the 4th millennium BC (Fig. 7).

Finds documenting early manifestations of the knowledge of metallurgy in the Polish lands accumulate in the south and for the most part concern Lengyel-Polgár communities. In fact, most FBC sites where metallurgical relics were recovered were settled earlier by Lengyel-Polgár communities. The sites at Złota (Grodzisko I and II, and Nad Wawrem) provide attestations of metalworking that are close in both time and space. Metalworking was begun there by the populations of the Lublin-Volhynia culture and later continued by FBC communities. Although a more accurate dating of local settlement by the Lublin-Volhynia culture and FBC is not forthcoming, the Złota metalworking attestations are chronologically the closest to the finds from Kotowo (Fig. 7).

A cautious conjecture can be thus made that metalworking skills among FBC populations could have been acquired from the communities of the Lengyel-Polgár circle and that both communities had close relations. This brings us to a broader issue – the nature of cultural change between the two groups (*Kadrow 2015*; *Kośko, Szmyt, Żurkiewicz 2022*).

The information set out above therefore allows us to picture how Eneolithic innovations and accompanying social and economic changes spread, taking into account lands east of the Oder River, which has not always been the case until now (*e.g., Strahm* et al. *2014.Abb. 4*).

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The earliest glass from the territory of Slovenia

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ABSTRACT - *This paper presents the results of the analyses of three glass beads from three Bronze Age sites, Medvode-Svetje, Trata near Škofja Loka and Kamna Gorica near Ljubljana. All three sites belong to the Oloris-Podsmreka horizon, which covers the Middle and the beginning of the Late Bronze Age (*c. *second half of the 16th/first half of the 15th century to 12th century BC). The PIXE and PIGE analyses revealed that only two of the examined beads belong to the Bronze Age. The bead from the Medvode-Svetje site is similar to LMHK beads and is most likely an import from the Frattesina production centre in northern Italy, while the bead from the Trata site has similarities with the eastern Mediterranean or even Mesopotamian area HMg glass. The natron glass bead from Kamna Gorica is probably an Iron Age infiltrate in a Bronze Age layer.*

KEY WORDS – *Slovenia; Bronze Age; Oloris-Podsmreka horizon; glass-beads; PIXE and PIGE analysis*

Najstarejše steklo na ozemlju Slovenije

IZVLEČEK – *V prispevku predstavljamo rezultate analiz, opravljenih na treh steklenih jagodah z bronastodobnih najdišč Medvode-Svetje, Trata pri Škofji Loki in Kamna Gorica pri Ljubljani. Vsa tri najdišča sodijo v horizont Oloris-Podsmreka, ki zajame srednjo in začetek pozne bronaste dobe (od ok. druge polovice 16. stoletja/prve polovice 15. stoletja do 12. stoletja pr. Kr.). PIXE in PIGE analize so pokazale, da le dve izmed analiziranih jagod sodita v repertoar bronastodobnih jagod. Jagoda z najdišča Medvode-Svetje je najverjetneje uvožena iz proizvodnega centra Frattesina v severni Italiji, medtem ko kaže jagoda z najdišča Trata na podobnosti z vzhodno sredozemskim ali celo mezopotamskim območjem. Jagoda iz natronskega stekla z najdišča Kamna Gorica najverjetneje predstavlja železnodobni infiltrat v bronastodobno plast.*

KLJUČNE BESEDE – *Slovenija; bronasta doba; horizont Oloris-Podsmreka; steklene jagode; PIXE in PIGE analize*

Introduction and archaeological background

Extensive archaeological excavations launched due to motorway construction works from the late 1990s onwards dramatically changed our knowledge of the Middle and Late Bronze Age (BA) settlements in Slovenia. Their number has increased notably, especially in the Dolenjska, Štajerska and Prekmurje regions of central and eastern Slovenia. The first synthesis aimed at combining a vast corpus of ceramic finds and radio-

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carbon dates from these settlements was published by Matija Črešnar and Biba Teržan (*2014.681–688*). The changed view on the Middle and early Late BA cultural landscape arises from these data (Fig. 1) with predominant open-air lowland settlements of very diverse dimensions and extremely diverse house structures. Rather sparse sunken huts appear occasionally in these settlements, as well as much more frequent and more dense rectangular houses of different sizes, defined by postholes (see site reports on particular settlements in *Teržan, Črešnar 2014: Kerman 2014. 44–63; Šavel, Sankovič 2014a.65–67; Šavel, Sankovič 2014b; Tomaž 2014; Leghissa 2014; Turk, Svetličič 2014*; *Kerman 2018; Šavel* et al. *2011; 2013*). The first comprehensive synthesis placed this BA horizon chronologically between the phases BA C and Ha A1, *i.e.* between the 14th and 12th centuries BC (*Dular* et al. *2002.170–174*). It became clear due to the subsequent large series of radiocarbon dates that the Oloris – Podsmreka horizon begins already in the BA phase B2, if not even before, *i.e.* from the 16th/15th centuries BC onwards (*Teržan 2010; Črešnar, Teržan 2014.687, Fig. 24; Škvor Jernejčič 2020.450, Fig. 2; Škvor Jernejčič* et al. *2022.94–96, Fig. 2*).

Among small finds, diverse ceramic pots and other ceramic objects, such as spindle whorls and loom weights, strongly predominate on the Oloris – Podsmreka settlements. Their formal features are similar to contemporaneous western Transdanubian and Slavonian ceramics from the Middle and early Late BA (*Dular* et al. *2002.182–214*). In the context of the Middle and beginning of the Late BA, the discovery of glass finds is quite exceptional. So far, seven glass beads have been discovered in Slovenia from six sites of this periods: Šiman near Gotovlje[1], Vodice[2], Medvode-Svetje, Trata, Kamna Gorica and Škocjan[3] (*cf. Tomažič, Olić 2009.15,49,G384–385; Leghissa 2011. 157–158; Leghissa 2013.52; Brezigar, Klokočovnik 2018.14, Fig. 17; Svetličič* et al. *in press. G90; Fabec, Vinazza 2023.Sl. 9:9*), three of which are discussed in this article (Figs. 2 and 3).

Materials and methods

The finds of glass beads

Medvode-Svetje

The settlement of Medvode-Svetje is located in the Gorenjska region, in the northwestern part of Slovenia, near the confluence of the Sora and Sava rivers (Fig. 1).

The first archaeological excavation took place in 2007, when an area of about 4300m^2 was explored. Since then, several archaeological excavations have taken place in the very large area of the Medvode-Svetje plateau (*Leghissa 2014; Škvor Jernejčič* et al. *2020. Fig. 7* and references cited therein). During the excavations, a Middle and Late Bronze Age site was discovered, which is assigned to the Oloris-Podsmreka horizon mentioned earlier (*Leghissa 2014.333–343; Škvor Jernejčič* et al. *2020.102–109*). In the NE area of the investigated Medvode-Svetje settlement, excavated in 2007 – and according to finds, horizontal and vertical stratigraphy, radiocarbon dates and also typological classification of individual settlement remains – three separate phases were identified, covering a period between the Br B2/C1 and Ha A phases (*Leghissa 2011.190–191; Leghissa 2014.339–341; Škvor Jernejčič* et al. *2020.102–109*). In this area the settlement remains are best preserved, which include hearths, fireplaces, refuse and storage pits, and numerous postholes. Some of the postholes clearly show the layout of nine simple rectangular huts (*Leghissa 2014.Fig. 19.2; Škvor Jernejčič* et al. *2020.Fig. 8*). The oldest remains include a pit filled with silty clay and stones, charcoal fragments, and numerous fragments of various ceramic vessels. According to the radiocarbon dating analysis, it can be assigned to the period 1660–1497 cal BC (2σ – 95.4 %), which corresponds to the Br B2/C1 phase (*Leghissa 2014. Fig. 19.10*). Three huts, some pits and a hearth are assigned to the second phase of the site (*i.e.* Br C2/D). From the hearth a charcoal sample was taken for ra-

1 Two glass beads were discovered at the site of Šiman near Gotovlje, which was also inhabited during the Oloris-Posmreka horizon (*Tomažič, Olić 2009*). The beads were located in a building from the Late Copper Age. The authors leave open the question of whether these are the oldest beads in Slovenia or possible infiltrates. Due to the proximity to copper mines, they suggest that the beads could be of local production (*Tomažič, Olić 2009.49*).

2 The prehistoric settlement of Vodice is attributed to the Oloris-Podsmreka horizon. The glass bead was discovered in the prehistoric cultural layer US 1017 (*Leghissa 2013.52,54, Fig. 38*).

3 New archaeological finds indicate that the Škocjan hillfort was built at the transition from the Early to the Middle Bronze Age and was inhabited until the Late Bronze Age. The glass bead, discovered in the Okroglica abyss near Škocjan, has not yet been examined in detail (see *Fabec, Vinazza 2023.Sl. 8:9*).

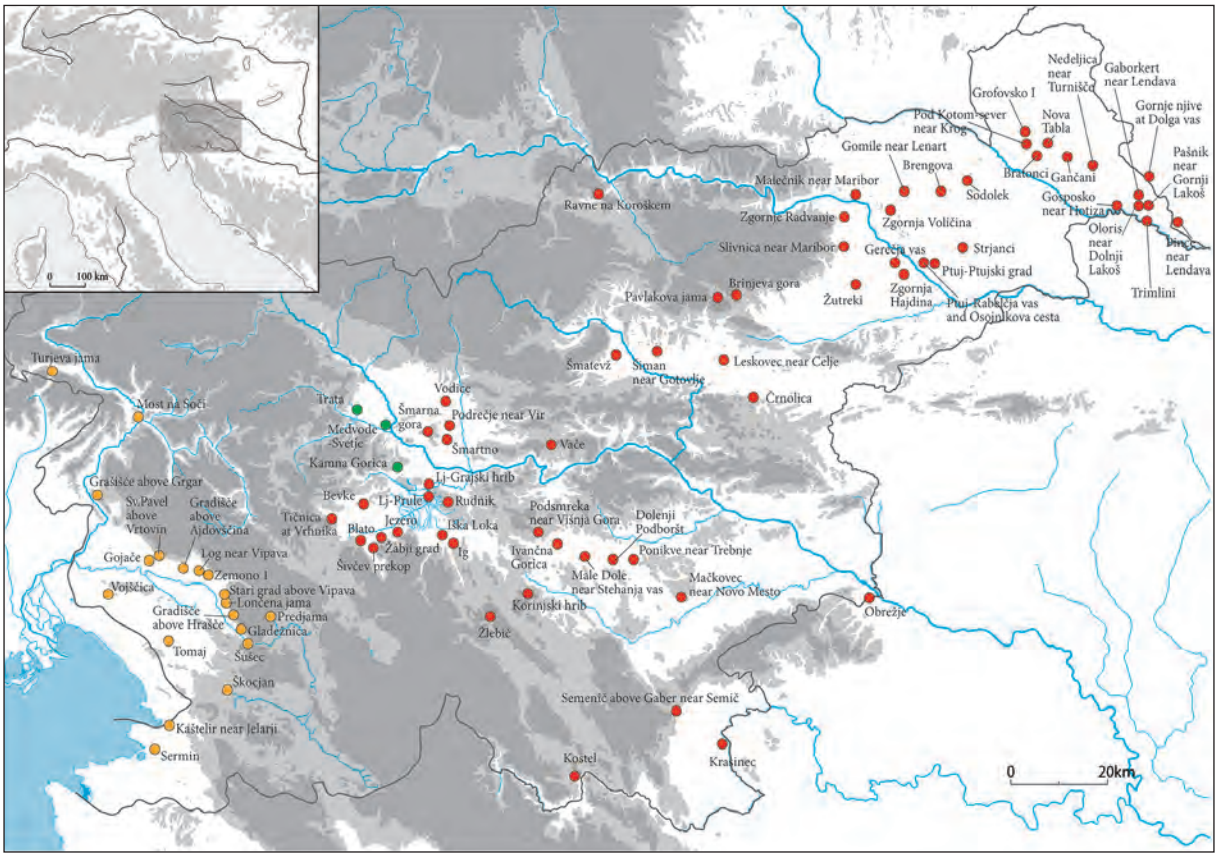

Fig. 1. Map of the settlements in Slovenia dating to the Oloris – Podsmreka horizon (central and eastern Slovenia – the red symbols) and important contemporaneous sites from western Slovenia (the orange symbols). After Škvor Jernejčič* et al. *2022.Fig. 1, with additions. The green symbols indicate the sites from which the glass beads analysed for this article were recovered. Map made by Elena Leghissa.

diocarbon dating, indicating a period between 1436 and 1266 cal BC – 2σ – 95.4 % (*Leghissa 2014.342, Fig. 19.11; Škvor Jernejčič* et al. *2020.Figs. 15,16*). The Medvode-Svetje settlement in the NE area reached its greatest extent in its third phase, the Ha A period, between the 12th and 11th centuries BC. Six of the identified huts could be assigned to this phase based on the finds and stratigraphy (*Leghissa 2014.337–343; Škvor Jernejčič* et al. *2020.Fig. 8*). After the end of the Ha A period, life in the settlement undoubtedly declined, as no finds or remains were discovered that would indicate further occupation of the area.

Among the six huts dated to the third phase, one has been interpreted as a 'weaver's house' (Fig. 5). Inside it, a pit was documented, interpreted as a pit for a vertical loom (*Leghissa 2011.197–199*). A smaller pit, probably a refuse pit, was discovered in the immediate vicinity of the weaver's house, in which several fragments of ceramic vessels, stones, pieces of charcoal, and a glass bead were found (Figs. 2.lower, 3.a, 4.left). The latter glass bead is only half preserved. It is barrel-shaped with a cylindrical perforation and decorated with a spiral-wrapped white band (Fig. 4) and measures 1.2cm in length and 0.85cm in width.

The barrel-shaped beads, together with the eye-bearing beads, were among the most widespread polychrome beads in Europe during the Late Bronze Age

Fig. 2. The glass beads from the Bronze Age settlements of Trata (upper left), Medvode-Svetje (lower) and Kamna Gorica (upper right). © Narodni muzej Slovenije. Photo Tomaž Lauko.

Fig. 3. Three glass beads analysed and discussed in the present article:* a *Medvode-Svetje;* b *Trata;* c *Kamna Gorica. Bar scale 1 cm. © Narodni muzej Slovenije. Photo Tomaž Lauko.

(*Bellintani, Angelini 2020.85–86, Tab. 3*). They were found in extraordinary numbers in northern Italy, where they are concentrated mainly in the Po Valley. Here, the site of Frattesina near Fratta Polesina in the province of Rovigo should be mentioned, dated to the Late Bronze Age (13th to 9th century BC), where a strong production of glass beads is recorded (*e.g., Towle* et al. *2001; Bellintani, Angelini 2020*). Barrel-shaped beads with a white spiral are dated at Frattesina to its phase BF1 (12th century BC), where they first appear, and are most abundant in phase BF2 (11th century BC) and only exceptionally preserved in the last phase BF3 (10th century BC) (*Bellintani, Angelini 2020.84–85*). In the Alps they are also known as *Pfahlbauperlen* (after Vogt) and later as *Pfahlbautönnchenperlen mit Spirale* (*Pfahlbauperlen mit Spirale')*, a designation developed by Thea Elisabeth Haevernick (*Haevernick 1978.145–146*; see also *Towle* et al. *2001.12; Bellintani, Angelini 2020.86*). The distribution of this type of beads covers a wide area in continental Europe. They have been found in large numbers in Switzerland, Germany and parts of Poland, but are also present, albeit rarer, in France, along the Danube, on Adriatic coast, in Greece, and on the coast of Turkey (*Henderson 1988.436; Towle* et al*. 2001.47, Fig. 7; Bellintani, Angelini 2020.86, Tab. 3*). Apart from the bead from Medvode-Svetje, there is only one other example of a barrel- shaped bead from Slovenia, a greenish bead with a white chord found in grave 289 from Dobova (*Stare 1975.34, T. 41: 3; Gabrovec 1983.56, T. VII: 16; Blečič Kavur 2014.63–64; cfr. Šmit* et al. *2020.Fig. 1: 11*).[4]

Trata near Škofja Loka

The BA settlement of Trata near Škofja Loka is located about 5.3km upstream of the Sora River from the Medvode-Svetje site in the Gorenjska region (Fig. 1). During archaeological excavations from 2018 to 2020, numerous settlement remains dating to the Middle BA and the beginning of the Late BA were discovered on an area of 18 868m^2 (*Brezigar, Klokočovnik 2018; Brezigar 2021*). Numerous postholes enabled the reconstruction of ground plans of at least forty-three rectangular buildings in a settlement of the scattered type. Also excavated were a few hearths, numerous storage and refuse pits, and other pits of unknown function. Despite the numerous remains, it is not yet possible to define different phases

Fig. 4 (left). The glass bead from the Medvode-Svetje site, seen from the other side, where the wrapping of the white spiral is visible. © Narodni muzej Slovenije. Photo Tomaž Lauko.

Fig. 5 (right). Medvode-Svetje site: reconstruction of the ground plan of the 'weaver's house' with the postholes and the remains of a pit for a vertical loom in the middle of the building. Photo Matija Lukić (after* Leghissa 2011*).

4 The bead from Dobova was discovered in female grave 289, which is one of the richest graves in the entire necropolis and dates back to the 11th century BC (see *e.g., Blečič Kavur 2014.63-64, fn. 232*).

of the settlement, as the study of the field documentation and finds is still in progress. According to the preliminary data of the typological and chronological analyses of the ceramic finds, the settlement of Trata is assigned to the Oloris-Podsmreka horizon (see also *Škvor Jernejčič* et al. *2022.112*). So far, there are two calibrated dates, one from a refuse pit and one from a pit with loom weights in the interior of one of the houses at the Trata site, which points to the 14th and 13th century BC, that is, to the middle/late phase of the Oloris-Podsmreka horizon (*Škvor Jernejčič* et al. *2022.110,112, Fig. 24*).

The glass bead was discovered in a small concentration of pottery sherds and stones, probably representing a remnant of the prehistoric cultural layer/ground surface (Fig. 6) (*Brezigar, Klokočovnik 2018. 24,85–86, Fig. 27*). The bead has a round shape and is light blue in colour (Figs. 2.upper left, 3.b). The diameter of the bead is 9.4mm, inner diameter of the hole is 4.4mm, and height is 4.8mm (*Brezigar, Klokočovnik 2018.59*).

Kamna Gorica near Ljubljana

The BA settlement was excavated in 2004 as part of rescue excavations on a motorway route with a total area of 4200m² (*Turk, Svetličič 2014*; *Svetličič* et al. *in press*). Two different types of residential structures characterize the settlement: four larger unregularly shaped pits with hearths in the function of sunken huts and six houses or rather huts of small dimensions and rectangular ground plan, defined by postholes. The Kamna Gorica BA settlement is well placed in the cultural milieu of the Oloris – Podsmreka horizon, both in terms of the characteristics of the residential buildings and as regards its pottery shapes.

To some extent, its radiocarbon dates are surprising, indicating an earlier start of this horizon of sites than previously established (*Turk, Svetličič 2014.361–362*; *Svetličič* et al. *in press*). Additionally, the settlement clearly attests the temporal sequence of the two main types of residential buildings. According to radiocarbon analyses, the large pits that function as sunken huts are older than the rectangular postholes huts. We date three of the four sunken huts to the timespan between the 17th and 15th centuries BC. Radiocarbon dating of two of the six identified rectangular huts indicates their chronological setting between the 14th and 12th centuries BC. Some other Oloris – Podsmreka horizon sites indicate a similar temporal sequence of the earlier appearance of sunken huts. Rectangular huts prevail only from the 14th century BC onwards.

We found the glass bead (Figs. 2.upper right, 3.c) in the settlement layer with no clear connection either to sunken huts or rectangular huts (*Svetličič* et al. *in press*. G90; inv. No. P 30419, kept at the National Museum of Slovenia). The blue transparent perforated glass bead is of spherical shape, with a diameter of 0.7cm and height of 0.6cm. According to its colour and shape, the Kamna Gorica glass bead is similar to some Frattesina beads (*Bellintani, Angelini 2020.Tab. 2: 2/2*), but also to the glass beads from the transition period Late BA – Early Iron Age from the Dolenjska region (*Križ, Turk 2003.61–62, cat. no. 5–10; Šmit* et al. *2020.2, T. 1: 5,8, Fig. 1: 5,8*).

Fig. 6. Concentrations of pottery sherds and stones from the Trata site, where the glass bead was found (US 17). Photo Manca Omahen (after* Brezigar, Klokočovnik 2018.Fig. 27*).

Analytical procedure

The beads were analysed by the in-air proton beam of 3 MeV nominal energy provided by the Tandetron accelerator of the Jožef Stefan Institute in Ljubljana. The proton induced X-ray (PIXE) method was used for the analysis of elements from including silicon onwards, while the light

elements of Na, Mg and Al were determined according to the emitted gamma rays (PIGE) induced by inelastic nuclear scattering. A proton beam of a few nA was extracted into air through a 200nm thick foil of silicon nitride and further passed a 7mm long air-gap between window and target; due to energy loss in both media, the impact energy at the target was 2.94MeV. The irradiation time for an individual target was 30 minutes. The induced X-rays were detected by a Si(Li) detector of 140eV resolution at 5.89keV positioned 45mm from the target. The detector was equipped with a pinhole filter made of 0.05mm thick aluminium foil with a relative opening of about 9%. For accurate mathematical description of the pinhole transmission function, it was assumed that the hole also has an inner rim of smaller thickness. Previous calibrations also showed that the detector crystal is covered by an ice layer of 2.5mg/cm^2. Spectral fitting was done by the Xantho code (*Šmit 2023*). The gamma rays were detected by an intrinsic germanium detector of 40% relative efficiency, with germanium crystal dimensions of 5cm x 5cm. The gamma rays used for analysis were 440keV for Na, 585keV for Mg, and 844 and 1014keV for Al. Among them the most critical was measurement of magnesium, as the 585keV line is weak and further coincides with the 583keV line from the natural background. The intensity of the natural background was reduced by lead shielding of the detector, yet the counting rate of 583keV line was taken into account as a correction. In spite of this, the detection limit for MgO was estimated as 0.2%. The detection limit for Na was below 50µg/g, and for aluminium it was below 0.1%. The detection limits for X-ray based elements were dominated by the energy dependence of ionization cross sections and varied between 5–10µg/g for Z<40 to about 50µg/g around Z=50. For the evaluation of concentrations, we relied on the procedure for independent physical parameters for X-rays, while for gamma rays we used the surface approximation calibrated by the NIST 620 glass standard. For normalization of concentrations, we used the RBS signal induced in the gold-foil coated chopper that intersected the beam in a vacuum. The effects of sample misorientation and roughness were monitored according to the argon signal from the air, induced in the air gap between exit window and target. The accuracy of the major concentration was estimated to be better than 5%, but it may increase to 10–15% for elements below 0.1% and trace elements.

Before measurement, the beads were washed with alcohol. The bead from Trata, which has a grooved surface, was oriented in the way that the induced X-rays were not absorbed in the groove walls. The bulk value for the bead from Svetje, which is halved, was obtained on the cleaved surface. The results of the measurement are shown in Table 1.

Discussion

Glass types

The three beads are of different glass types. The bead from Trata is made from the ash of halophytic plants, the bead from Medvode-Svetje is made of mixed alkalis, likely of the type low-magnesium high potassium (LMHK). The bead from Kamna Gorica seems to be made of natron glass.

	Trata	Kamna Gorica	Medvode-Svetje	Medvode-Svetje – white belt
Na_2O	18.6	10.9	5.55	4.23
MgO	5.51	0.19	1.84	n.d.
Al_2O_3	0.75	2.23	1.60	3.80
SiO_2	65.2	76.1	78.6	69.0
SO_3	0.34	0.71	0.29	0.66
Cl	0.32	0.23	0.19	0.81
K_2O	2.51	1.23	6.41	8.94
CaO	4.92	6.46	2.16	8.19
TiO_2	0.059	0.62	0.077	0.96
Cr_2O_3	0.004	n.d.	n.d.	0.007
MnO	0.038	0.016	0.015	0.103
Fe_2O_3	0.58	0.21	0.69	3.16
NiO	0.0035	0.0007	0.024	0.0063
CuO	1.00	0.83	2.37	0.20
ZnO	0.007	0.004	0.017	0.014
As_2O_3	n.d.	0.019	0.021	0.007
Br	0.0023	n.d.	n.d.	n.d.
Rb_2O	n.d	0.0048	0.0110	0.0165
SrO	0.0596	0.0066	0.0189	0.0509
Y_2O_3	n.d.	n.d.	n.d.	0.0026
ZrO_2	0.0039	0.0489	0.0035	0.0035
SnO_2	0.062	n.d.	0.060	n.d.
Sb_2O_3	0.014	0.18	0.029	n.d.
PbO	0.009	n.d.	0.009	0.003

Tab. 1. Concentrations of metal oxides in mass %; n.d. – not detected.

Medvode-Svetje

The bulk of the bead contains 1.84% MgO and 6.41% K_2O, which roughly matches the composition of LMHK beads from Frattesina (*Angelini* et al. *2004*). However, according to Paola Bellintani and Ivana Angelini (*2020*), the content of MgO seems closer to the beads of the Late Bronze and Early Iron Age glasses attributed to Belozerka culture in Ukraine (Fig. 7) (*Ostroverkhov 2002.406ss*). The distinction between the Frattesina and Belozerka groups is nevertheless not so strict, as several glasses from one location may be found in areas usually dominated by others. In this way, some beads and glasses from Frattesina also contain a slightly higher MgO content, similar to the Medvode-Svetje bead (*Angelini* et al. *2004; Bellintani, Angelini 2020.Fig. 10A*). The content of Na_2O of 5.55% and K_2O is consistent with the composition of coloured glass from mixed alkalis, but is not specific to the site. According to the finding of 1.6% Al_2O_3 and 0.69% Fe_2O_3 (which is equivalent to 0.62% FeO), the bead is further located at the border between Frattesina and Belozerka glass. The content of SiO_2 is high, at 78.6%, and a silica concentration above 70% is commonly found in Frattesina and Belozerka beads. The bead is coloured light blue with 2.37% of CuO, which puts it among the blue beads from Belozerka, and the same holds if we consider the content of 0.06% SnO_2. Copper in LMHK beads, though at higher concentrations of about 5%, may also act as an additional glass stabilizer and flux (*Paynter, Jackson 2022*).

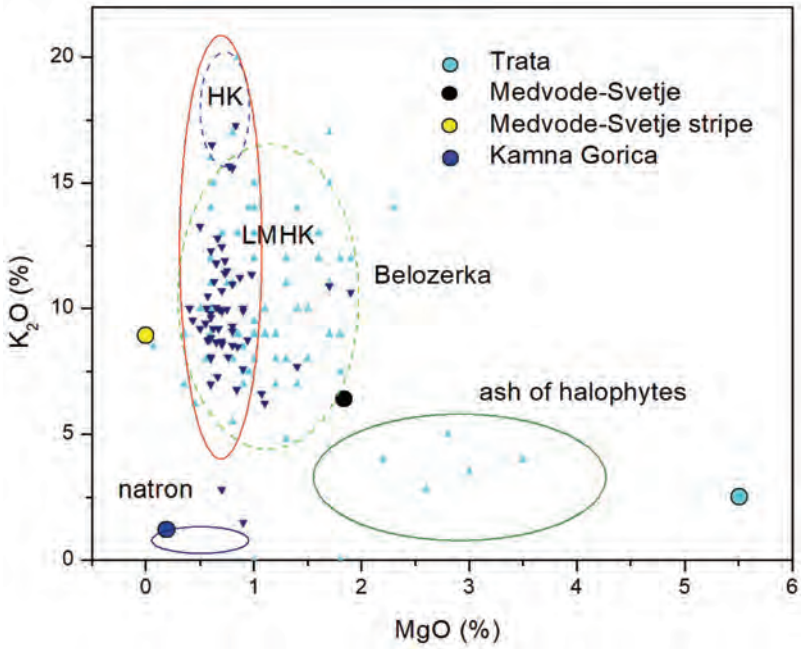

Fig. 7. MgO* vs. *K_2O* with schematically shown glass groups (according to Bellintani, Angelini 2020). *The oval encircling the Belozerka LHMK data is calculated as an ellipse with semiaxes of two standard deviations. Experimental points from literature: for Frattesina Biavati and Verità (*1989*), Brill (*1999*), Santopadre and Verità (*2000*), Towle (*2002*), Angelini* et al. *(*2004*), Henderson* et al. *(*2015*), for Belozerka Ostroverkhov (*2002*).

The measurement on the white belt was done at the surface, so some contamination from the earth may be present. The belt contains slightly more K_2O (8.94%) than the bulk, and no MgO was detected, which is closer to the Frattesina bead composition. Sodium composition (4.23% Na_2O) is slightly lower than in the bulk. On the other side, it contains much higher concentrations of aluminium (3.8% Al_2O_3), calcium (8.19% CaO), titanium (0.96% TiO_2) and iron (3.16% Fe_2O_3), which suggests that minerals (limestone, feldspar) were used as colourants. Antimony as an opacifier was not detected.

It is interesting to note that the bulk contains approximately equal amounts of Rb_2O and SrO, which suggests that the alkalis were obtained by the precipitation procedure, which removed the insolvable oxides from the product. The concentration of SrO is higher in the white belt (509µg/g), and we may suppose that limestone is its source.

Trata

Containing 18.6% Na_2O, the bead is characterized as sodium-type glass. With 5.51% MgO and 2.51% MgO, the alkalis were provided by the ash of halophytic plants. The values of $Na_2O/(Na_2O+K_2O+MgO+CaO)$ = 0.59 and $K_2O/(Na_2O+K_2O+MgO+CaO)$ = 0.08 are close to those in the medieval beads produced from the ash desert plants (*Šmit 2019*), though the ash seems more purified. The other trace elements that may be characteristic are 30µg/g ZrO_2 and 590 µg/g TiO_2, which agrees both with Egyptian glass from Tel Amarna and Malkata, as well as from Mesopotamian glass from Nuzi and Tell Brak (*Shortland* et al. *2007*; *Brill 1999*). The content of 40µg/g Cr_2O_3 (close to the detection limit) is not characteristic, nor is the ratio 1000*Cr/Ti = 77, which covers both Egyptian and Mesopotamian glass (*Varberg* et al. *2015*). The aluminium content (0.75% Al_2O_3) is not significant, although in combi-

nation with the ratio of MgO/CaO=1.12 according to Matt Phelps (*2018*), the bead may be characterized as the Mesopotamian Type II glass; the samples lying nearby in this diagram are from Samarra. In comparison with the much later Islamic glass, the titanium and zirconium concentrations correspond to those seen with the glass from Tyre (*Phelps 2018*).

The bead is coloured with 1% CuO and 0.58% Fe_2O_3, the presence of cobalt was not detected – this type of colouring was found, for example, in BA glass fragments from Sinai (*Kemp* et al. *2023*) and in the blue beads from Nuzi (*Shortland* et al. *2007*; bead 1930.82.17a) – with 0.96% CuO (elemental values were recalculated into oxides), 0.376% Fe_2O_3 and 5.7μg/g CoO; such a low Co value is below the detection limit in PIXE if iron lines are present in the spectrum.

The provenience of the bead thus remains enigmatic, though Levantine or Mesopotamian origin seems more probable than Egyptian.

Kamna Gorica

The low MgO concentration of 0.19% (at the detection limit) and K_2O concentration of 1.23% suggest that the bead was made of natron glass, which excludes it as a BA object. The sodium concentration is reasonably low (10.9% Na_2O), which may indicate that the alkalis were partly leached out. The bead could have been made either in prehistory during the Iron Age or in Late Antiquity; in the latter case, its composition should match one of the known glass types. According to 2.23% Al_2O_3 and 6.46% CaO, the bead would be at the border of HIMT and Foy Série 3 glass (*Freestone 2005*); in our studies of prehistoric glass beads from Slovenia (*Šmit* et al. *2020*), this area also contains glass beads from the Stična, Certosa and Negova horizons. According to the values of Al_2O_3/SiO_2 = 0.029 and TiO_2/Al_2O_3 = 0.28, the bead does not match any of the known glass groups from Late Antiquity (*Freestone 2018*). We also calculated the Euclidean distance for nine principal metal oxides (concerning their mean and 2σ as length unit) and did not obtain any match; the closest groups were Egypt II and HIMT, which are both of Egyptian origin. Egyptian origin may also be indicated by a relatively high zirconium content (489μg/g), which is characteristic of Egyptian sands. The Late Antiquity origin of the bead can be excluded. The bead is very likely of the Iron Age period, as the high TiO_2/Al_2O_3 values above 0.2 are encountered in several prehistoric beads dated to the Podzemelj, Stična and Certosa horizons (*Šmit* et al. *2020*). According to the statistical analysis of Roman Balvanović (*2023*), Zr and Ti concentrations imply likely dating between the 8th and 6th centuries BC. The bead also contains antimony (0.18% Sb_2O_3), and a value in this range suggests the glass was recycled. A low amount of strontium (66μg/g SrO) points to a mineral source of limestone, rather than to mollusc shells in coastal sands (*Freestone 2005*).

Conclusion

Among the three, hypothetically BA glass beads from the Oloris – Podsmreka horizon settlements of Medvode-Svetje, Trata and Kamna Gorica, only the former two proved to be of BA origin.

Based on stratigraphic data and typological comparisons with barrel-shaped beads from Frattesina and central Europe (the so-called *Pfahlbautönnchenperlen mit Spirale*), the bead from the Medvode-Svetje site was assigned to the last settlement phase, *i.e.* phase Ha A. The analyses carried out on the bead confirm its classification in this time frame, since its composition is similar to the beads from the Frattesina site in Italy and also the Belozerka culture in Ukraine. Despite the chemical similarities with the Belozerka beads, we can probably exclude the possibility of import from the mentioned area, as they are typologically not comparable. Most Belozerka beads are of the monochromatic type and have a spiral band only exceptionally (*Ostroverkhov 2002.408*). Typologically more comparable are the type 12 beads from Frattesina (Ital. *perle a botticella con decorazione spiraliforme*) (*Bellintani, Angelini 2020.Tab. 2: 12*).

The archaeological context in which the glass bead from the Trata site was discovered suggests a chronological placement in the time-span from the Middle BA to the beginning of the Late BA, *i.e.* between the 15th and 12th centuries BC. This chronological placement is also confirmed by the similarities in the HMg composition of the bead from Trata with BA beads from the Eastern Mediterranean or even Mesopotamian areas.

Due to its natron glass composition, the Kamna Gorica bead was highly likely infiltrated in the BA settlement layer sometime in the Early Iron Age.

Although the Kamna Gorica bead proved not to be of BA origin, there is still a concentration of glass beads

within the Oloris – Podsmreka horizon in its western periphery (Fig. 1; a further potential BA bead from the close Gorenjska site of Vodice should be mentioned here).[5] This could be a further hint to the import of these extremely rare prestigious items to central Slovenia from the centres of glass production in northern Italy.

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Textiles from the Hallstatt period cemetery in Domasław, Wrocław district (Poland). Textile symbolism of the funeral rite

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ABSTRACT - *The article presents the remains of textiles excavated in Early Iron Age cremated graves in the cemetery in Domasław (Poland). The fragments were preserved in 62 burials, mainly richly furnished chamber graves, on jewellery, dress accessories, tools, and weapons. The analysis of the contexts of the finds reveals that urns were 'dressed up' and textile containers were used. The contextual analysis of the finds provides the basis for the conclusion that their use in funeral ceremonies had a ritualized form. The textiles in the graves confirm the adaptation of the customs of the European Hallstatt elites among the local community.*

KEY WORDS – *archaeological textiles; Hallstatt period; Hallstattization; Domasław; funeral rites; ceremonies; burial practices*

Tkanina s halštatskega grobišča v Domasławu, okrožje Wrocław (Poljska). Tekstilna simbolika pogrebnega obreda

IZVLEČEK – *V članku predstavljamo ostanke tkanine v žarnih grobovih iz starejše železne dobe na grobišču v Domasławu (Poljska). Fragmenti so se ohranili v 62 grobovih, predvsem v bogatih grobnicah, na nakitu, oblačilnih dodatkih, orodju in orožju. Analiza kontekstov najdb razkriva, da so bile žare obdane s tkanino. Kontekstualna analiza najdb omogoča sklepanje, da je bila uporaba tkanine v pogrebnih obredih ritualizirana. Tkanine v grobovih potrjujejo prevzem običajev evropskih halštatskih elit v lokalnih skupnostih.*

KLJUČNE BESEDE – *arheološka tkanina; halštatsko obdobje; halštatizacija; Domasław, pogrebni obredi, ceremonije, način pokopa*

Introduction

The purpose of this article is to discuss in detail the remains of textiles excavated in Early Iron Age cremated burial graves in the cemetery in Domasław near Wrocław and their possible use (concluding *ex nihilo*). It also undertakes to interpret the significance of this element in funeral rites of the local community as well as the potential role of external influences in adopting these practices in the necropolis during the Hallstatt period of its functioning.

In 2006–2008 the Wrocław branch of the Institute of Archaeology and Ethnology, Polish Academy of Sciences, carried out excavations at the multi-cultural site 10/11/12 in Domasław (Fig. 1). Apart from the ev-

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idence of settlement from the Neolithic, Early Bronze Age, La Tène period and period of Roman influence, the excavations revealed a vast cemetery (in use from III period EB to HD3) of the Lusatian culture population (*Anioła* et al. *2012; Gediga, Józefowska 2019.18*). The discoveries made in the part of the necropolis functioning in the Early Iron Age have become the basis for formulating a conception of treating the area of Silesia, part of Greater Poland and perhaps Kuyavia as a regional, north-eastern province of the Hallstatt culture (*Gediga, Józefowska 2019.9 – for older literature*). The provenance of the objects retrieved from the richly furnished graves in Domasław confirms that the top stratum of the local population maintained extensive contacts with the important centres in the sub-Alpine circle of the Hallstatt culture and thus – indirectly – with the Mediterranean region – mainly northern Italy (*Gediga 2010; 2016; Gediga, Józefowska 2019.214*). The community burying their relatives in the Domasław necropolis strove to maintain the living standards and emulate the lifestyle of the'aristocracy' from those areas (*Gediga 2010.193–209; Gediga, Józefowska 2019.210–211*).

A total of 803 graves from the Hallstatt period, including *c.* 300 chamber ones, were excavated in the cemetery in Domasław (*Gediga* et al. *2020.plan*). In most chamber graves the presence of a layer of organic substance was observed beside the urns and around metal grave goods. The substance was not solely the remains of chamber wooden casings but also of covers, wrappings and possibly even the padding of the chests, most probably consisting of plant fibres and/or hide/fur.[1]

Remains of textiles in graves

Description of the evidence

The information about the preserved textiles comes from the observations made during the exploration of the grave pit fills, analysis of the field records and laboratory work. Those fragments of textiles which could be subject to examination were subjected to specialist analyses (*Maik, Rybarczyk 2015; 2016)*.

The number of grave objects where fragments of textiles were observed was greater than that presented in Table 1 (see bellow). Some of them were only documented in photographs and/or drawings, while most had only survived in fragmentary form, which prevented any analysis. Some were destroyed during conservation.[2]

The analysis of this category of artefacts from an inventory of sepulchral nature is especially difficult. Prehistoric graves rarely offer conditions enabling

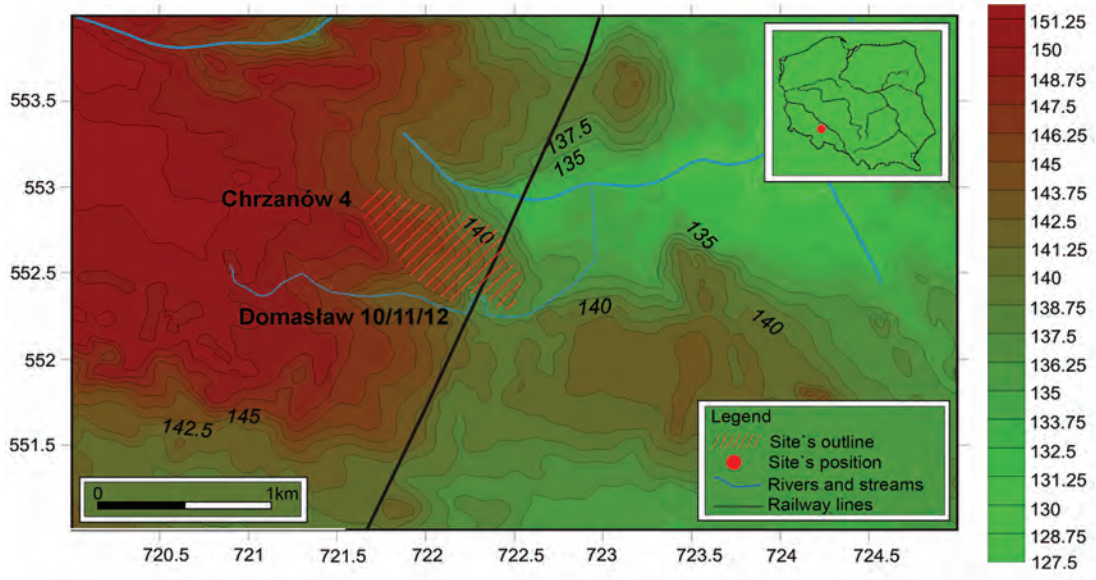

Fig. 1. Domasław 10/11/12, Wrocław district, and location of the site (drawing by K. Sadowski and L. Kamyszek).

1 The conserved substance present in the vicinity of the metal objects from the cemetery was the remains of organic substances of plant (mats, wattle as well as containers/baskets made from wicker, grass, roots, bark, phloem and leaves) and animal (hide, fur) origin. Others are the decomposed remains of wood from the chamber constructions (*Sady-Bugajska 2020*).

2 Some textiles were destroyed during conservation or were varnished over together with the metal objects.

preservation of organic materials, *e.g.*, textiles, as the environment ideal for their survival is a humid, oxygen-deficient soil substratum. Because of the nature of funeral rites, the preserved textiles are not fragments of the clothes worn by the dead cremated on a pyre, but were deposited together with the grave goods after the cremation.

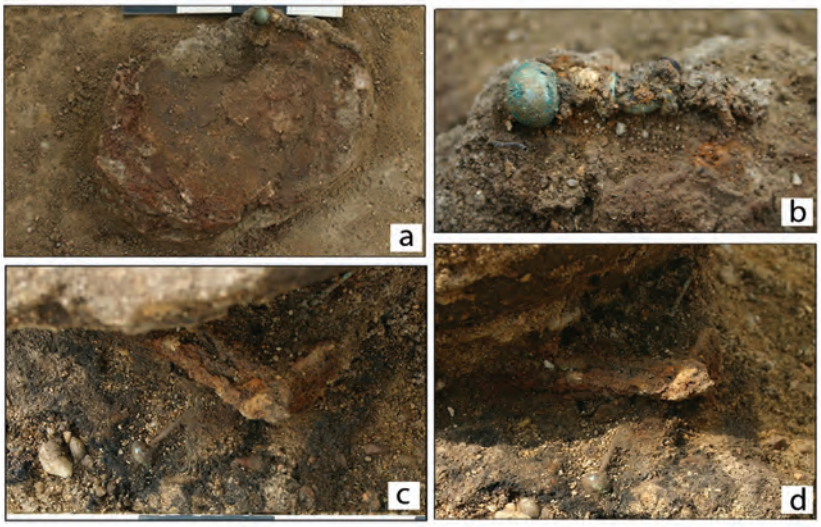

Fig. 2. Domasław 10/11/12, Wrocław district. Remains of textiles on pins:* a,b *grave 4273;* c,d *grave 4270 (photo by A. Woźniak).

All 93 fragments of textiles found in the necropolis in Domasław were preserved in 62 graves (Tab. 1), of which as many as 53 objects were richly furnished chamber graves of extraordinary construction. Only eight burials lacked internal wooden structures.[3] The textiles in the graves were preserved on jewellery and dress accessories, tools and weapons deposited in the grave pits and urns. The fact that textiles were discovered in 22 urns prompts the conclusion that products wrapped in textiles or textile pouches containing the bones from the pyre were placed inside them. Additionally, the evidence of wrapping/'dressing' the urns was observed. The textiles on the urns were preserved in the space between their ceramic surface and metal as well as on the objects deposited on and beside them, especially on pins and toiletry sets.

The specific arrangement of the metal artefacts proves that they were originally placed in wrappings or were stuck into the textiles. Fragments of wrappings and containers from tree bark were also preserved on knives and jewellery sets.

All the discussed finds are corroded fragments of textiles discovered exclusively on metal objects, mainly made from iron, except for the fragment from grave 8963[4] (Tab. 2). Iron oxide conserved the fibres by permeating them, which in effect were totally mineralized, and this prevented determining what raw material they were made from. They were probably made from wool, while the specimen from grave 543 may have been woven from flax (*Maik, Rybarczyk 2016.28*). It is impossible to make assumptions as to the original size, appearance and colour of the textiles. It was concluded that two different types of textiles had been deposited in graves 283, 543 and 5970.

Textiles were most frequently discovered on pins (in 22 graves, Fig. 2.a-d), which were most probably stuck into the cloth. The remains of textiles were also frequently present on knives (in 17 graves), which were sometimes deposited beside the urns (graves 3423, 6680, 10315 and 10816), or – more frequently – at a certain distance from them. In three cases specimens covered by textiles were found in urns. The direction in which the textile was wrapped may be identified on the knives from graves 8899, 8956 and 10 315 (Fig. 3.a-c), which is especially clearly visible on the blade from grave 10 315, where three layers of textiles were preserved. In the case of the large knife from grave 8943, the remains of the textile seem to have constituted an outer layer of the sheath (Fig. 3.d). The remains of textiles have also been preserved on toiletry sets deposited beside or on the urns (in 12 graves, Fig. 4.a-d). Probably normally worn on belts, in the graves they may also have been fastened to the textile tied around the urn. Apart from the above, the remains of textiles were also found on needles (two graves), bracelets (six graves), necklaces (four graves), arrowheads (two graves), chisels (two graves), a fibula, a sickle, an axe, and plaques.

3 Such significant *overrepresentation* of chamber objects may result from the fact that metal objects were frequently deposited there.

4 It is difficult to explain why textile remains were discovered in a vessel, not an urn, without any traces of the object thanks to which the textile was preserved.

Category of object	Number of graves	Grave number
knives	17	390, 1015, 2127, 3423, 6366, 6680, 7408, 8891, 8892, 8899, 8926, 8943, 8956, 10000, 10315, 10883, 12739
toiletry sets	12	283, 366, 417, 1694, 3311, 4267, 4270, 5970, 6690, 8949, 8959, 10816
pins	22	360, 384, 543, 1271, 1698, 3767, 3797, 4269, 4273, 4297, 5611, 5964, 6023, 6026, 7472, 8926, 8956, 8960, 8961, 10000, 11622, 12739
needles	2	1849, 2789
bracelets	6	5975, 6690, 7464, 8891, 8893, 11622
necklaces	4	5611, 6029, 8893, 8954
chisels	2	6680, 8899
arrowheads	2	402, 8956
sickle	1	6675
fibula	1	8919
tutuli-like buttons	1	460
plaques	1	4269
spiral	1	570
tools, others	2	3313, 8905

Tab. 2. Domasław 10/11/12, Wrocław district. Presence of textiles in the context of different categories of objects deposited in graves, and quantitative comparison.

Quite possibly, the pins and needles discovered in the urns had originally fastened the pouches containing the bones. The pins and the fibula discovered on, beside or under the urns may have fastened together the edges of the urn's symbolic dress. Two kinds of textiles were preserved in grave 283 – one may have covered the urn, while the other may have been a strip to which a toiletry set was fastened (Fig. 4.a-c). An organic layer surrounding the urn's bottom part in this grave was most probably the remains of the textile originally covering the vessel.

Traces of textiles were sometimes preserved on more than one metal object deposited in a grave, which was the case of 14 graves (366, 384, 5611, 4269, 4297, 6680, 6690, 8956, 8893, 8891, 8899, 8926, 10 000, 12 739; Tab. 1). Except for knives, these objects were nearly always deposited in the grave pit's western part, where the remains of the dead were placed.

As the textiles were preserved only thanks to the corrosion of the metal objects placed in the vicinity of the urns, it is difficult to determine whether the textiles lined the chambers' bottoms or decorated their walls. On the basis of the recorded evidence, when the objects were deposited together it is impossible to conclude whether they were 'covered' with one piece of cloth or each was wrapped separately. The knives may have been treated individually as the textiles were recorded only on their blades. The fragmentary form of the textiles preserved solely in the vicinity of metal objects prevents an assessment of the size and purpose of the cloth. It is thus not clear whether they were shrouds, urns' 'clothing' or wrappings of grave goods. In the impressive grave 4270 the remains of textiles were preserved on the toiletry sets beside the urns, which were atypically deposited – in the grave's western and eastern parts. However, it is impossible to conclude whether they were separate textiles or one bigger fabric.

Apart from metal objects, ceramic urns were also wrapped. Examples of such practices were directly recorded in at least seven graves, while in others their evidence is suggested by a specific – defying the laws of physics – arrangement of the artefacts on the vessels' walls observed during the exploration of the grave pits.

In grave 5611 an organic substance was found on the urn as well as on and around the objects deposited on it (Fig. 5.a). A bronze and iron necklaces were placed on the vessel, while two bronze bracelets and three pins (bronze, iron and iron-bronze ones) were deposited beside the urn. Traces of textile have been preserved on the pin and the iron necklace, which might prove that originally the container with the bones was completely wrapped in a cloth. Similarly, in graves 360 and 384 the organic matter was preserved beside the urns and the objects deposited in their vicinity, while the remains of the textile were preserved between the iron objects and the vessels' walls (Figs. 5.b,h; 8.a,f).

An urn covered with a cloth was also recorded in grave 4297, which is substantiated by the gold spirals and pins (an iron one with a silver-plaited head and an iron-bronze one) discovered on the vessel's wall, where fragments of textile were preserved on their

surface (Fig. 5.c,d,f). Fragments of bark were also observed in this part of the burial.

Similarly, in grave 360 two gold spirals surrounded by organic matter (interpreted as textile according to field observations) were uncovered (Fig. 5.h). Their position, perpendicular to the vessel's wall, proves that originally they stuck into the textile. During the field work the remains of textile were also observed on urn 5995 beside a golden spiral.[5]

In grave 4269 an urn and a set of decorations – originally probably deposited in a wooden or wicker box – were found surrounded by an organic substance. The container was probably originally covered with a piece of bark. The remains of delicate textile, woven in two different weave types (in tabby and repp; *Maik, Rybarczyk 2015; 2016*), were preserved on an iron-bronze pin and an unspecified iron object placed on the urn together with other metal objects (Fig. 5.e,g). A textile was deposited on the urn, and it may have been a kind of belt or headband with at least 200 delicate bronze staple plaques stuck densely in three rows[6] (Fig. 5.g). Bronze rings were also found beside them.

Fig. 3. Domasław 10/11/12, Wrocław district. Remains of textiles on knives.* a *Very delicate fabric in twill weave 2/2 from grave 8956;* b *thick fabric in tabby from grave 8899;* c *medium thickness fabric in tabby from grave 10315;* d *medium thickness fabric in twill weave 2/2 from grave 8943 (photo by I. Dolata-Daszkiewicz).

The urn in grave 543 contained fragments of two kinds of textile – one was probably made from wool and the other, very delicate, from flax (Fig. 9.g-h). The woollen piece is wound around a fragment of an iron pin found among the bones. The bronze fibula stuck out over the urn's rim, while the cremated bones, weighting *c.* 200g, did not fill even half of the vase. In the upper part of the filling of vessel 17 mid-trunks of beetles threaded onto a stalk of grass, a wattle from thin sticks, possibly wicker and probably braided plants were preserved. The fibula must thus have been stuck into the textile or wickerwork, which held it at the urn's rim. A piece of oval shaped birch bark displaying regularly arranged holes, evidence of sewing, was found above the fibula.

Indirect evidence of presence of textiles in graves

Even when textiles were not physically preserved, their presence in at least a dozen graves may be confirmed with a great degree of probability. The custom of wrapping urns is substantiated by the elements of attire specifically 'fixed' to the walls of the vessels: pins, fibulae, and rings, which would have fallen off the ceramic surface if they had not been stuck into the textile (*e.g.*, in graves 1017, 1849, 2877, 3311, 3318; 3312, 5995, 5996[7], 8919, 8888, 8946; Figs. 6, 7.a-b). The pins discovered on the bones in the urns may also have been stuck into the textile (*e.g.*, in graves 6048, 7409).

5 During the field work the remains of textile were also recorded on an urn in grave 5995, which – however – was not preserved.

6 In two caps of plaques fragments of textile were preserved.

7 Quite significantly, field observations revealed that gold spirals from graves 360, 4297, 5995, 5996 were stuck into the textile. The excavations exposed many more instances when the presence of textiles was recorded.

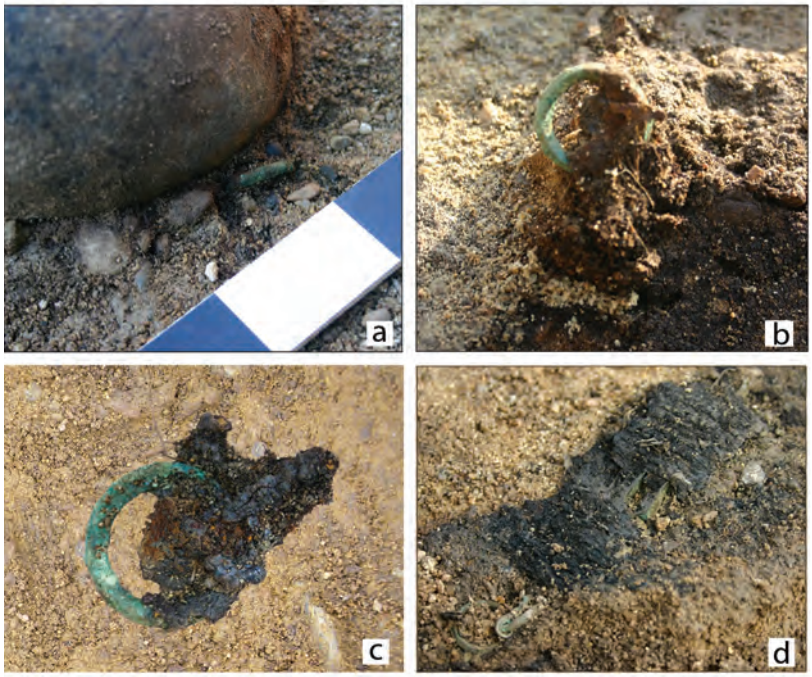

Fig. 4. Domasław 10/11/12, Wrocław district. Remains of textiles on toiletry sets. **a,b,c** ***Grave 283 (photo by A. Woźniak);*** **d** ***grave 4267 (photo by A. Józefowska).***

Organic substances, which during the field work were identified as textiles, were frequently observed in the vicinity of urns and the objects deposited around them (*e.g.*, graves 4297, 8888; Figs. 6.c; 7.c; 8). Sometimes the substance survived in the form of a binder/adhesive gluing the artefacts to the vessels' walls (*e.g.*, in graves 3311, 1849; Fig. 6.e). The imprints of a fabric and wickerwork are visible on the wood preserved under the binocular pendants from grave 3797 (Fig. 7.d).[8]

The functionality of some groups of artefacts suggests that they were originally sewn on or suspended, which proves that textiles or hides were originally deposited in the graves. In 19 graves delicate bronze spirals consisting of a few coils were uncovered. As substantiated by the finds from skeleton graves, spirals were used as decorations for the hair or headbands or mobcaps (*Szydłowska 1963.46–53; Rhomiopoulou, Kilian-Dirlmeier 1989.101–107; Hansen 2008.155–157; Kozubová 2018.32–33, 39–40; Słomska, Antosik 2018.58–61*). A piece of textile preserved on a spiral from grave 570 was probably part of a band.

Relatively frequently discovered semi-circular looped buttons were most probably sewn onto textiles. Their cuplike heads measure 8–15mm in diameter. They were usually made from bronze (graves 3788, 3797, 417, 6678) with the exception of only one specimen made from iron (grave 2121). They were found as single specimens or (more frequently) in groups consisting of a few specimens. Such buttons were discovered beside the putative belt in grave 543. In two graves tutulilike buttons were found, elements decorating a horse harness. In grave 460 they were discovered together with the remains of textiles, while in grave 4857 they were found surrounded by an organic substance (Fig. 7.c). It is assumed that small buttons were used to decorate robes/clothes, mobcaps or diadems (*Bukowski 1960; Kaczmarek 2002.174–175*), while the bigger ones and are considered to be elements of a horse harness. Analogous specimens from modern Germany, Austria and Italy decorated the robes of the dead, sewn onto their surface (*Słomska, Antosik 2018.60–61*). A spectacular example of a ceremonial robe is the specimen from Stična in Slovenia from grave 27, barrow 48, where the buried noble woman was dressed in an exceptionally richly decorated costume reaching her ankles and elaborate headwear with gold applications (*Hellmuth 2008 (2010)*). Bronze plaques on her attire, arranged in triangles, rosettes and rhombuses, formed extraordinary decorative elements.

Glass and amber necklaces from Domasław were as a rule arranged around urns and in some of them strings or stalks of grass had been preserved in the holes. However, it is quite possible that in some cases individual beads were sewn onto textiles. They may also have served as pendants or decorations of a string/belt, especially when they were found beside toiletry sets (graves 283, 2170, 3311, 3412, 3795, 4270, 4852, 4857, 6696; Fig. 7.e-f). Bigger amber rings found in 11 graves may have been fixed in a similar way or used as belt fasteners or hangers for toiletry sets in graves 619, 1017, 3412, 3798, 8905, where were placed next to them.

8 In the case of the bracelet from the urn in grave 612 the impression of textile was visible on the bronze patina preserved on the organic material. Plant fibres were imprinted on the organic material above the knives in grave 366.

Production technology of textiles from Domasław as compared with similar finds from central and southern Europe

The fragments of textiles subject to laboratory analysis come from 19 graves (Tab. 1; *Maik, Rybarczyk 2015; 2016*). The analysis of 36 corroded fragments of textiles and woven ribbon showed that they were spun solely in Z-twist, generally single yarn.[9] Eleven were woven in tabby (graves 283, 402, 460, 521, 1694, 1849, 7464, 8893, 8899, 10 315, 11 622; Fig. 9.c,e), two in repp weave (graves 5964, 5970; Fig. 9.i), one in tablet weave (grave 5970, Fig. 9.b), while a delicate textile from grave 4269 was woven with the use of both weaves (tabby and repp), which in effect produced elongated strips. In one case the weave was not identified. The textiles woven in 2/2 twill found in six graves (graves 283, 384, 543,

Fig. 5. Domasław 10/11/12, Wrocław district. Remains of textiles beside urns. **a** ***Grave 5611;*** **b** ***grave 384;*** **c,d,f** ***grave 4297;*** **e,g** ***grave 4269;*** **h** ***grave 360 (*****a,c-g** ***photo by L. Nowaczyk;*** **b,h** ***by A. Woźniak).***

9 In the Western Hallstatt Province fabrics with plied yarn, sometimes in combination with single yarn weft, are typical and for the East Hallstatt Province generally single yarn fabrics were the rule. Although there are remarkable differences between East and West Hallstatt Culture textiles, they still have in common twill and secondly tabby as the basic weave patterns, as well as tablet weave (*Grömer 2005.32-33; 2014.Fig. 34*).

6690, 8943, 8956; Fig. 9.a,d) are the oldest finds of this kind in the area of modern Poland, which have their numerous analogies in the Hallstatt culture, *e.g.*, the sites in Austria (*Grömer 2012*): the salt mine in Hallstatt and the site in Dürrnberg near Hallein, and the sites in Switzerland (*Rast-Eicher 2012*) – Matran, Langenthal, Ersingen, Subingen. Similar textiles were also found in the princely grave in Eberdingen-Hochdorf in southern Germany (*Banck-Burgess 1999; 2012a; 2012b*) and in northern and central Italy (*Gleba 2008; 2012*) – Verucchio, Saso di Furbara, Vedretta di Ries, Tarquinia and San Basilio (*Maik, Rybarczyk 2016.35–36 – for further literature*). Quite significantly, textiles woven in 2/2 twill were unknown in the areas occupied by the Lusatian culture population, who probably never learnt this skill. In this context the finds from Domasław are exceptional and confirm the claims put forward by many scholars that the site belongs to the group of the north-eastern Hallstatt culture (*Słomska-Bolonek, Antosik 2022.234*).

The textiles woven in 1/1 tabby are medium-thick, while two may even be considered very fine. Considerable density is accompanied by small thread diameter of warp and weft. The warp in a thick textile in repp weave was spun from S/2Z-plied yarn and the weft is in Z-single yarn (Fig. 9.i). It seems that the warp repp weave with plied yarn weft was used to optically compensate for the difference in thickness

Fig. 6. Domasław 10/11/12, Wrocław district. Indirect evidence of presence of textiles in graves. **a** ***Grave 1017;*** **b** ***grave 8919;*** **c** ***grave 8888;*** **d** ***grave 2877;*** **e** ***grave 1849;*** **f** ***grave 8946 (*****a-c,e,f** ***photo by A. Józefowska,*** **d** ***by G. Daszkiewicz).***

between warp and weft. The textiles woven in 2/2 twill display a great density of threads. In one case it is 20/14 threads per 1cm and in two it is between 10 and 15 threads per 1cm. Their yarn is between 0.5 and 1.0mm thick, while the threads in the textile of great density are less than 0.5mm thick (*Maik, Rybarczyk 2016.29*).

In grave 5970 fragments of textile woven in repp weave and the remains of a tablet-woven ribbon were found on a toiletry set from the urn (Fig. 9.b; *Maik, Rybarczyk 2016.38*). The ribbon is in a very bad condition, but nevertheless there were two instances when it was observed that two weft threads had been put through a slot formed after the tablets were turned. Single yarn with Z-twist was used in the warp and weft (*Maik, Rybarczyk 2016.29*). The set may have been fixed to the ribbon (strip) with a ring or the ribbon may have tied a pouch with bones. The use of tablet-woven ribbons is known from Hallstatt and Eberdingen-Hochdorf (*Grömer 2010.272–275; Banck-Burgess 2012a.43–55*), where numerous fragments of very spectacular and intricate ribbons were found. A tablet-woven ribbon was also observed on

Fig. 7. Domasław 10/11/12, Wrocław district. Indirect evidence of the presence of textiles in graves. **a** ***Grave 3311;*** **b** ***grave 3318;*** **c** ***grave 4857;*** **d** ***grave 3797;*** **e,f** ***grave 3795 (photo by A. Józefowska).***

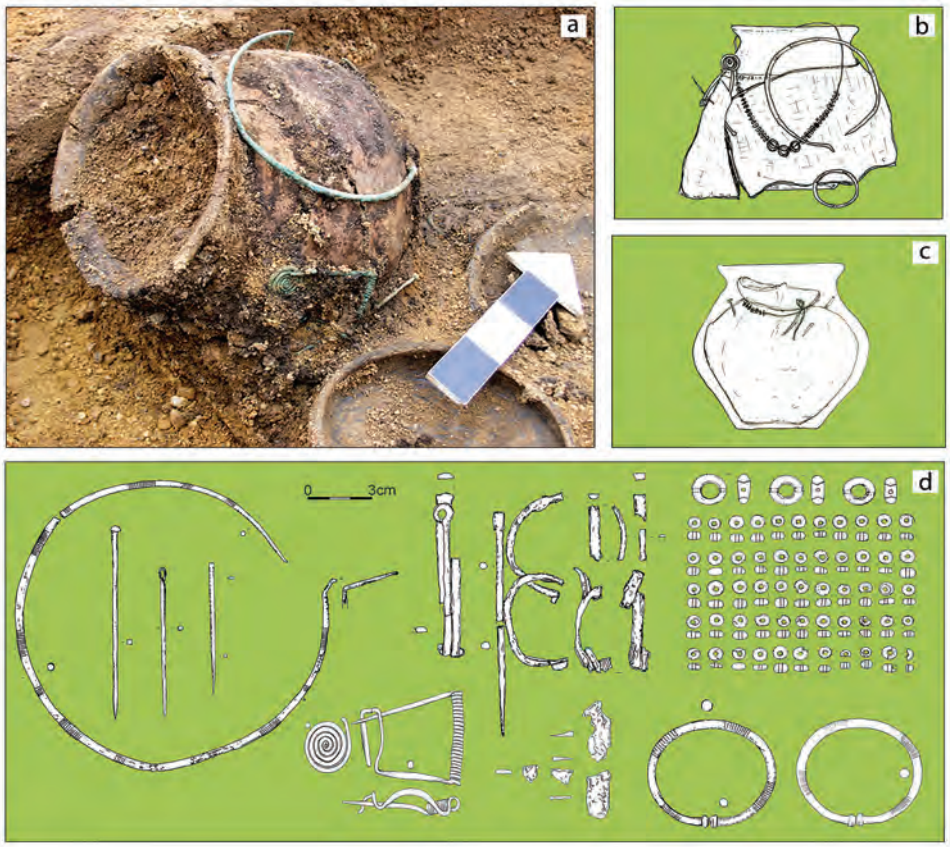

Fig. 8. Domasław 10/11/12, Wrocław district.* a *Grave 8888 (photo by A. Józefowska);* b,c *reconstruction of use of textiles (drawing by A. Józefowska);* d *metal and amber artefacts from grave 8888.

an iron sickle in grave 289 in Zakrzew, Sieradz district (*Maik 2005.227–228*).

These features testify to the contacts between the local population and producers representing advanced textile production skills, and similar products were found in Domasław.

Quite probably, the custom of wrapping objects in textiles was encountered in grave 75 from the cemetery of Lusatian culture population in Łódź-Ruda Pabianicka, which yielded the remains of textiles and string preserved on two sickles (*Antosik, Słomska 2013.181*). Textiles were also discovered in cremation burials in the cemeteries in Domaradz, Opole district (on an iron bracelet) and in Stare Kolonie, Brzeg district (on an iron greave) (*Antosik, Słomska 2014.105–106*). The greatest collection of textile products identified with the Lusatian culture population comes from the necropolis in Świbie – including 79 fabrics woven in tabby, as well as plaited materials, those made using the sprang technique, and threads (*Słomska-Bolonek, Antosik 2022*).

Role and significance of textiles in funerary rites

General remarks

Textiles, like other objects of material culture, serve the purpose of satisfying basic needs in daily life. Clothes, in life and after death, are a non-verbal means of communication, a medium informing about a person's status, identity and even age (*Grömer 2016.428–445*). In pre-historic cultures as well as in the so-called folk culture, attire has been an exceptionally expressive means of constructing, representing and projecting a social and cultural identity, a platform of communication and a carrier of important information.[10]

Precious textiles were an easily recognizable manifestation of material wealth, and some may have testified to supraregional networks across Europe.

10 The communicational connotations of attire have survived until today, as seen in the *dress codes* observed at work or ceremonial events, especially during various kinds of rites of passage or religious holidays (*Kantor 1982*). This is best manifested in funeral ceremonies, when any instance of deviation from the *dress code*, binding for the mourners and the 'central figure' of the ceremony, is met with strong social disapproval.

Therefore, such materials were used in daily life as an essential element in a wide spectrum of behaviours which served the purpose of initiating and/or maintaining relationships by causing particular reactions in others (*Eibl-Eibesfeldt 1987*). Homer's *Odyssey* tells that in a catalogue of gifts, referred to as *xeinēion/xeinion* or *dōron*, precious textiles – apart from gold, weapons and horses – played an important role among the objects handed over in the ceremony of bestowing (*Banasiak 2009.3; Wagner-Hasel 2020.80–96*). Bestowing was an important stage in a visit to someone's household, but it acquired a fully ritualized form only among elites, following a specific 'diplomatic' protocol (*Banasiak 2009.4*). In the decidedly 'masculine' Homeric world the concept of hospitality and the guest/host relation are implemented by conciliatory/endearing, caring-nursing and impressive behaviour (*Wagner-Hasel 2020.113–122*). Objects of very high material and emotional value, which also included certain

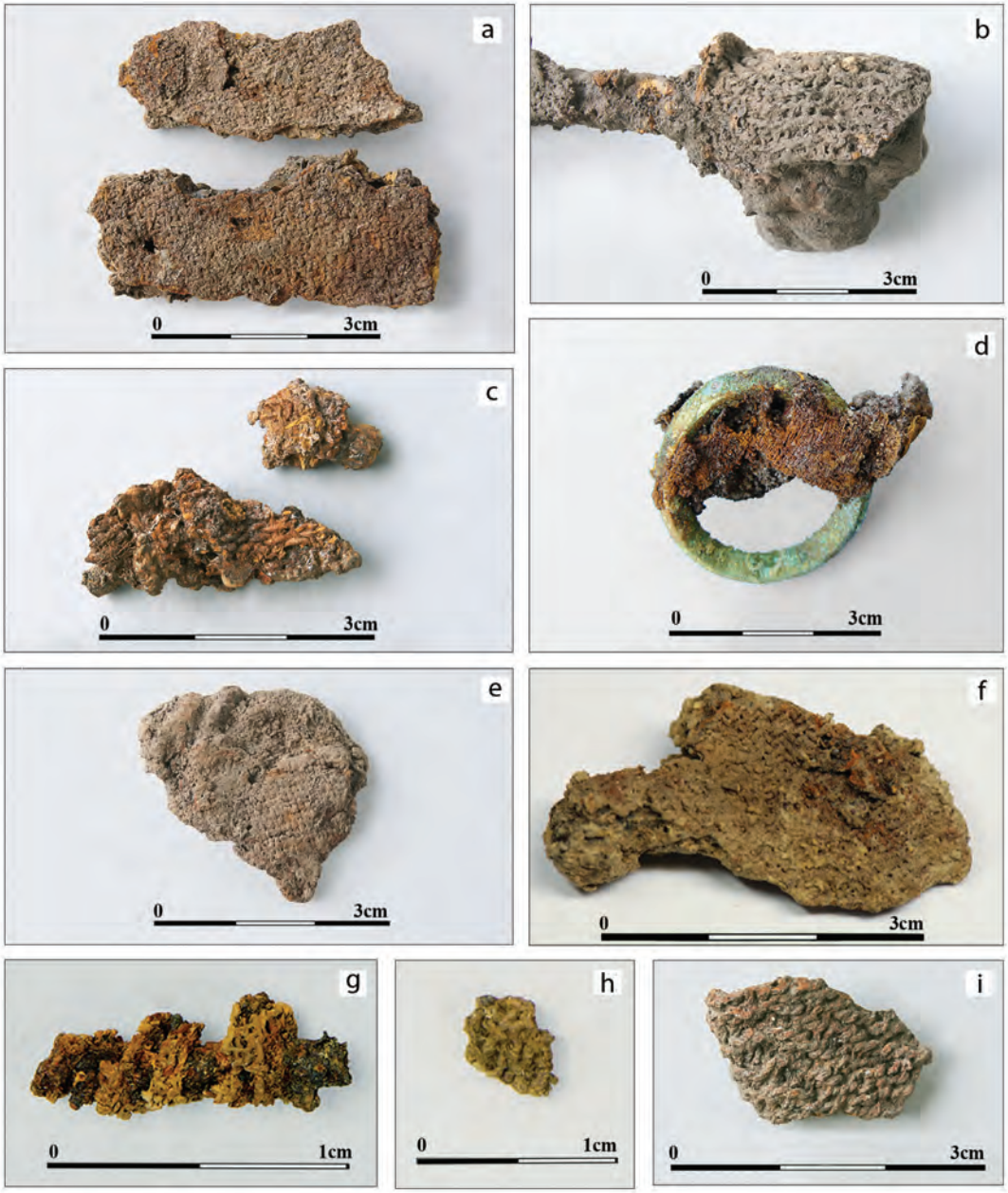

Fig. 9. Domasław 10/11/12, Wrocław district. Types of textiles. **a** ***Grave 384, medium thickness textile woven in 2/2 twill on an iron object;*** **b** ***grave 5970, ribbon woven on tablets;*** **c** ***grave 402; delicate textile in 1/1 tabby;*** **d** ***grave 283, very delicate textile woven in 2/2 twill;*** **e** ***grave 8893, medium thickness textile in 1/1 tabby;*** **f** ***grave 360, textile from vessel no. 17;*** **g** ***grave 543, textile of unidentified density of threads woven in 2/2 twill, wound on pin;*** **h** ***grave 543, textile in 1/1 tabby, possibly flax;*** **i** ***grave 5970, textile in repp weave (*****a-e, g-i** ***photo by J. Słomska, after*** **Maik, Rybarczyk 2016.Figs. 4-15; f** ***by I. Dolata-Daszkiewicz).***

categories of textiles/clothes, played a very important role in this process.

The presence of textiles in graves, as in daily life, also has a multifaceted dimension and is inseparably bound with the sphere of funeral rituals (*Gleba 2014; Grömer 2015*). Textiles were not only a form of decoration, but also an element co-creating a funeral rite. The theme of spinning and weaving, mainly manifested by depositing spindle whorls in graves, has long been present in the symbolism of funeral rites, having strong connotations with its magical-ritual perception (*Mierzwiński 2019*).

In every society death is an event to which each individual and the whole community must react according to appropriate rules. Funeral rites belong to the so-called rites of passage and consist of performing a series of ritual acts which prepare the deceased for departure from this world and help them integrate with the next, while they also help the living in restoring order, *e.g.*, make it easier for them to become reconciled with the loss of a loved one and return to normal life (*Gennep van 2006.36, 151–166*). What is discovered during archaeological excavations is only a small fragment, that which is materially discernible, of the funeral behaviour performed by the mourners at various stages of a ceremony. The grave – a place of burial, remains of the dead and grave goods as well as their spatial arrangement – constitute a specific 'social sphere', which may be understood as a specific form of representation and communication, whose visual aspect, *i.e.* visualization of actions and objects, has a great significance (*Stähli 2005.86*). As with pictures, graves have an exceptional formative and suggestive impact, both are 'visual artefacts', which do not show what is displayed but have the potential of creating what should be seen (*Augstein 2018.72*).

The deposited artefacts as well as their spatial and contextual arrangement are an integral and active component of the complex system of symbolic communication in a grave's social sphere. After a funeral, the body of the deceased is separated from the world of the living, while the grave becomes an 'excluded space' (*Schweizer 2015.934*). The objects accumulated there are removed from daily circulation and become semiophores (*Pomian 1998.20*). On being placed in a grave they become the property of the deceased in the other world. Although the concrete objects existing in the material world can no longer be accessed, they still remain useful. They are valuable because as semiophores they possess a cognitive value, which they have acquired as a result of a cognitive transformation. They thus function in the non-material world, becoming a link, bridging the gap between the material world and the spiritual one, between the *sacrum* and *profanum* (*Wideł*, http://varietes-artgallery.blogspot.com/2015/06/czym-sa-semiofory.html). During the process of this transformation the presence of textiles in a grave also has a symbolic-performative dimension. A textile – a material object used to isolate a concrete artefact in the funeral space – changes its properties and becomes *materia magica* in the process of transforming a grave into 'excluded space'. Another question is the purpose of using textile to isolate a special space out of the already existing and defined space of a grave: did the created boundary have an apotropaic dimension, was it exclusionary, or to the contrary, inclusionary in nature?

Spectrum of funeral practices involving textiles observed in the graves in Domasław

Due to cremation practices the remains of the textiles identified in the graves in the cemetery in Domasław cannot be the remains of clothes, but they were almost certainly used to wrap grave goods deposited at the post-cremation stage.

The contextual analysis of this category of finds provides the basis for the conclusion that their use in funeral ceremonies had a ritualized form. Textiles were both the furnishing of a grave and an element of its structure, constituting an indispensable part of the funeral rites of an early Iron Age local community. Field observations made during the excavations and specialist examination enable partial reconstruction of textiles' role and significance in the funeral ceremony.

Margarita Gleba (*2014.135*) proposed a division of practices involving the use of textiles in funeral rites into a few archaeologically perceptible stages, concerning the treatment of the corpse and the objects deposited with it. In the case of cremation burials these include wrapping fragments of bones placed in urns, whole urns with cremated remains, selected grave goods and systematic wrapping of all the objects placed in a grave. The discoveries made in the cemetery in Domasław confirm both directly and indirectly that all of the above-mentioned funeral

practices, except for the last of all the ones involving mentioned textiles, were exercised. This by no means excludes the possibility that all the discovered artefacts were wrapped. However, it is practically impossible to confirm this, except for the rare cases when appropriate hydrographic conditions of the soil existed. Objects wrapped in textiles were found in, for example, the cemetery in Hallstatt (*Kern 2005.8*). In the grave in Eberdingen-Hochdorf textiles were used to wrap the body and all the elements of the rich furnishing of the grave, consisting of a wagon, among others (*Biel 1985; Grömer 2010.272–275; 2012.39, Fig. 1.10; 2016; Banck-Burgess 1999.18–32; 2012a.143*). A famous princely grave excavated in Vix in France may have been subject to the same ceremonial ritual. During the excavations textiles on the chariot's wheels and various bronze applications were observed. In the grave with the chariot in Apremont in France, a bronze cauldron, iron sword, iron razor and all the chariot's iron parts displayed evidence of use of textiles (*Masurel 1990; Gleba 2014.143*).

There is no doubt that textiles were used to wrap urns. These practices are confirmed by Homer's descriptions of funerals of Patroclus and Hector – after the cremation of the body, comrades in arms, male friends and relatives collected the bones and placed them in gold vessels, which were wrapped in flax textile (Patroclus) or a purple piece of cloth (Hector) (*Iliad XXIII.251–254; XXIV.792–795*). On the basis of clearly discernible aggregations of cremation remains at Domasław and concluding *ex nihilo* we may assume that human remains were also deposited in the containers made from organic materials, possibly also from textiles. This was probably the case of compact aggregations of bones (at least 18), excavated in grave pits. It is also possible that some burnt remains were deposited in urns in textile pouches. Fragments of textiles placed in urns (situla and case/box) made from bronze and silver were found in the barrow grave in Loiret, Mardié 'Reuilly' (France) and in the 'Tomba del Duce' in Vetulonia (Italy) (*Duhn 1924.239; Ferdière 1984.245*). The remains of cremation in the Etruscan grave were wrapped in linen textile additionally fastened with two fibulae.

In the graves in Domasław metal objects were wrapped in textiles, individually or in bunches of a few. It is clear that knives' blades were wrapped in textiles, plants or tree bark. Textiles were very often preserved on toiletry sets, and may have been the remains of bits of cloth wrapping them or fragments of pouches where they were placed. The remains of textiles frequently found on pins suggest that the latter were stuck into the cloth, while the textiles were draped on urns or served as pouches for bones. Some metal ornaments may have been (additional?) decorations of walls and attire, *e.g.*, sewn on buttons, beads and suspended fibulae, the latter were also used to fasten fragments of textiles together.

Wrapping urns and grave goods may have had many meanings, reasons and intentions. It is not clear whether the phenomenon had solely ceremonial significance in the funerary context (decorating, 'dressing up' urns, moving, storing and depositing bones and objects) or if it was a regular/ritual practice of protecting valuable objects (*e.g.*, those made from metal) or securing sharp ones. Some objects may simply have been wrapped for practical reasons at the stage of moving and depositing in the graves (especially knives and swords).

It is impossible to differentiate unequivocally between ritual wrapping and ordinary securing of objects. The swords from Domasław – significant visualizing-symbolic elements in the grave's space – bear no traces of textiles. The specimens from objects 7429 and 8905 were deposited in wooden scabbards with bronze fittings. Fragments of wood, possibly from the sheath, were preserved on the specimen from grave 8956 and traces of wood were observed on the blade's upper part as well as the leather covering the cutting edge was found on the sword from grave 390. It is not clear whether the remaining swords from this cemetery were deposited without a 'wrapping', or if any organic scabbards or textiles were not preserved.[11] Interestingly, this way of securing weaponry was a common practice, constituting an integral part of funeral rites of the aristocracy in Europe in the Iron Age (*Grömer 2016.296–297; Möller-Wiering 2011*), *e.g.,* the sword/scabbard from a grave in Matran (Switzerland) wrapped in a 2cm wide tablet-woven band (*Grömer 2016.297; Rast-Eicher 2012.384–385*), the sword from the cemetery in Hallstatt (Austria) wrapped in cloth (*Kern 2005.Fig. 10; Grömer 2012.45, Tab. 1.1; Gleba 2014.Fig. 7.5*), the sword from Prague-Letňany, also on parts of the

11 The remains of textile were observed on the knife and iron axe from the graves with swords 390, 8905 and 8956.

wagon and on a horse harness (*Trefný* et al. *2019)*, and iron knives from the graves in Vassallaggi and Cales (Italy) (*Gleba 2012.229*).

Even if this custom/ritual was observed only to provide protection, it must have been very significant for a local community. Wrapped artefacts became invisible, possibly losing their power. This way of handling utilitarian metal objects may be connected with the ritual 'killing' or protection of grave goods after depositing (*Gleba 2014.141–142*). In the case of urns the use of textiles had an opposite effect. 'Dressing up' urns or decorating them with ribbons highlighted their significance in the grave setting, and at the same time constituted a material base for exhibiting/fixing the objects deposited in the grave.

Apart from the use of textiles to wrap human remains and elements of grave furnishing, which was the case in the necropolis in Domasław, it is also possible that they were deposited as grave goods in their own right (cloth/clothes), decorative elements of grave chambers (lining of grave chamber floors and possibly even their walls: *Banck-Burgess 1999; 2012a; 2012b*) or integral parts of other objects (*Grömer 2015.99–100*). In the latter case the textile's visualizing-symbolic function *per se* became less important (in the grave setting it may even have been totally lost).

Textiles from the cemetery in Domasław as compared with similar finds from the early Iron Age

The elements of funeral practices archaeologically perceptible in Domasław have their exact analogies in funeral customs recorded in the widely understood Mediterranean-Alpine zone, which also probably concerns the function and significance of textiles in funeral rites. The first association that comes to mind when textiles are observed in graves is their function as funeral attire. In inhumation graves it reflected the status, sex, age and social background of the dead (*Gleba 2012.232; 2015.264*).

In Etruria urns with the bones of relatives were wrapped, or possibly burnt bones were put in pouches which were in turn placed in urns. Sheets of textiles were also put on urns and the objects deposited on top of them, constituting an equivalent of a shroud covering the body of the deceased. A similar role was played by the remains of shawls and a kind of belt wrapped around urns. The objects deposited by the Etruscans together with the body, *i.e.* usually knives, weapons, *strigils*, mirrors, also displayed traces of textiles because they were intentionally wrapped or covered with cloth (*Ferdière 1984.245; Aigner-Foresti 2010.138–140; Gleba 2012.232–233; von Hase 2013.72; Maik, Rybarczyk 2016.36*).

The circle of Mediterranean cultures abounds in written, epigraphic and iconographic sources, which illustrate the role played by textiles at various stages of funeral ceremonies preceding entombment (*Myszkowska-Kaszuba 2016; Wypustek 2009*). In the case of Greek, Etrurian and Roman funerals there is evidence of the use of cloth, canopies, umbrellas and curtains. Thus an important element in the scenes of *prothesis* and *ekphora* on Greek geometric pottery is a chequered rectangle interpreted as a funeral textile, a kind of canopy, a grave pavilion suspended over the bier or held over the body (*Ahlberg-Cornell 1971; Stampolidis 1996.113, 118; Gleba 2014.143*). Numerous Etrurian painted ceilings of tombs were decorated with ornamental motifs, which undoubtedly are textile patterns. Complete tombs look like tents or pavilions with textile roofs (*Gleba 2014.143–144, with further references*). A similar role may have been played by the textiles in chamber graves, which decorated the 'chambers' emulating the houses of the dead (*e.g.,* Eberdingen-Hochdorf, *Banck-Burgess 1999*). Textiles were commonly used not only in the Greek and Roman Antiquity (*Gleba 2014.135*), but also constitute one of the elements of communal funeral rites in the cultural sphere of the Hallstatt Culture (*Fath 2012; Grömer 2015; Huth, Kondziella 2017.146–149; Schumann, Vaart-Verschoof 2017.21*).

Numerous examples of the presence of textiles in graves come from the cemeteries dated to the early Iron Age, mainly from central Europe (*Banck-Burgess 1999.222–223; 2012b; Bender Jørgensen 2005.140–145; Rast-Eicher 2008; Gleba 2012; Grömer 2012; Lau 2021*). An especially wide spectrum of artefacts connected with spinning, weaving as well as textiles themselves has been found in the cemeteries dated to the early Iron Age in northern Italy (Bologna, Padua, Este and Verucchio) and the necropolises in the south-eastern Alpine zone (Frög, Kleinklein, Magdalenska Gora, Most na Soči, Novo Mesto) connected with the following cultural formations: Dolenjska, Carinthian (Breg/Frög) and Styrian-Pannonian (Kleinklein-Martijanec-Kaptol) (*Fath 2012*).

Apart from well preserved textiles, graves, especially those in northern Italy and the Eastern Hallstatt

Culture, contained tools for their production, including ones made from rare materials such as amber and glass, and iconographic presentations of scenes showing spinning and weaving. They occurred as single specimens or in groups. The considerable significance of this area of production in the social and economic life of northern Italy and the Alpine zone is testified by iconographic presentations of production of textiles, which – next to the scenes depicting battles, hunting, feasting and processions – are one of the most important narrative motifs of situla art (*Eibner 2018*).[12] In the funeral ritual of the Etrurian and Este cultures the presence of symbols or presentations of spinning and weaving in the grave setting testifies to women's high social status and important economic role (*Briggs 2003.251–252*). In northern Italy the occurrence of artefacts with such connotations coincided with a marked increase of production of high-quality textiles. Beside other luxury goods, the textiles made in Etruria and the clothes made from them may have been the first products to cross the Alps (*Haynes 2000.214–255*).

Conclusions

The exceptional conditions in the graves in the Etrurian necropolis Verucchio enabling the preservation of textiles prove that such materials may have been used in funeral ceremonies much more frequently than it would appear on the basis of the documented archaeological sources. In the case of Verucchio they may be considered a permanent feature of burials (*Fath 2012.78*). A funeral model, similar to the northern-Italian one with a considerable presence in the graves of the elements closely associated with spinning and weaving, emerges in the period HaC and HaD in the areas east and north of the Alps in local cultural groups of the eastern-Hallstatt circle. The fragments of textiles discovered in this region correspond to the older Italic finds in terms of the applied weaving patterns, colours and dyes. The element missing in this cultural sphere is iconographic representations on graves. According to Barbara Fath (*2012.80*), the accumulation of elements identified with textiles and their arrangement in the graves' structure prove that in the early Iron Age there was a transfer of technical knowledge concerning textile production from Upper Italy to the east and north of the Alps; at the same time this 'know-how' was accompanied by the symbolic-performative significance of the use of textiles in graves. Thus, it would have been one of the elements of the wide spectrum of beliefs adopted by the local communities in the European interior from the Mediterranean Basin. This intensive transfer of objects, rites and ideas, together known as 'Mediterraneanization', affected all spheres of life (*Kimmig 1983.71; Dietler 2006.557*). Their implementation initiated the emergence of a group/elite who incorporated into the existing funeral customs new elements of narration and visualization highlighting and solidifying their role. Even though stratification of the society of the early Iron Age reached its high point at the end of the period, a hierarchic structure of society may already be seen in the older phase of the Hallstatt period (*Schumann 2015*).

This picture emerges from the analysis of the funeral rites of the population buried in the cemetery in Domasław. It shows a society, or at least part of it, considerably reformatted by the impulses arriving from the circle of Hallstatt cultures. As seen from the research into other sites in Lower Silesia, the changes embraced all spheres of cultural behaviour, not only the *sacrum* (*Bugaj, Kopiasz 2008*). Adaptation of new values considerably disturbed the existing structures and in effect formed a completely new model of material culture and a new social and political system, highlighting the significant role of the elite, who emerged as a result of the process of stratification of the society on the unprecedented scale (*Chochorowski 2009.90; Gediga 2010; 2011; Gediga, Józefowska 2019.210–214; Gediga, Bugaj 2022*).

These elites were instrumental in disseminating new ideas in the central-European interior. The process of Hallstattization was similar to that of 'Mediterraneanization' of the Alpine sphere, where local populations interacted directly with ancient European cultures and the transformation was more profound. However, the process itself was very similar. The objects distributed all over Europe also carried inherent ideas/symbolism. The implementation of similar funeral symbolism in vast areas of central Europe may be attributed to the ideological community rooted in similar strategies of creating, presenting and legitimizing the elites from the Hallstatt circle (*Fontijn, Vaart-Verschoof 2016.524, 531*). The instruments to achieve the above were economic domination (control of the influx of prestigious goods), a wide spectrum of subordinating behaviour (redistribution) and creation

12 It is commonly believed that the events presented by situla art were intended to legitimize authority (*Sassatelli 2013*).

of the ideological message in the world of *sacrum* and *profanum*. The most obvious manifestation of the above seen today in the cemetery in Domasław is the funeral model of chamber graves, sometimes surrounded by ditches, and the presence of imported goods in less impressive sepulchral objects (*Józefowska 2018; Gediga, Józefowska 2019; Józefowska* et al. *2022*).[13] Naturally there are certain differences, which show that these burials were rooted in local funeral practices and thus over-contextualized in a regionally specific way (*Schumann, Veert-Verschoof 2017.21*). This local 'taint' may be seen in a clear reduction of the occurrence of artefacts connected with spinning and weaving in relation to the burials from the Bronze Age in Domasław (*Zarzycka-Anioła* et al. *2022*), which is a phenomenon diametrically different from the situation observed in the Alpine sphere. Quite possibly within the funeral tradition of the local community from the Bronze Age the symbolism of these objects had already been firmly established and served the purpose of presenting the social role or profession, and thus did not fall into the new concept of visualizing funeral behaviours. The locally specific character may also be seen in not 'concealing' swords with textiles, as their symbolic significance was so considerable that they were intentionally exhibited in the setting of the grave. In the world of the early Iron Age, one based on physical strength and violence, the sword – unlike any other instrument of war – highlighted the domination of the elites (*Gralak 2022*).

The analysis of the contexts of the preserved textiles presented in this article reveals that elements of attire, headbands, and belts, possibly specially prepared for the funeral ceremony, were deposited in the graves in Domasław. Urns were 'dressed up' and decorated and textile containers were used. In view of the discoveries of the remains of textiles and many other premises provided by the sources found during the excavations in the cemetery, which confirm the adaptation of southern-European customs by the Hallstatt elites, it seems probable that the local community from Domasław adopted textiles as one of the elements of the symbolic meaning of their graves.

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13 In the world of *profanum* separation of part of the settlement in Milejowice may be seen as an equivalent of the funeral model (*Bugaj, Kopiasz 2008.111*).

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Tab. 1. Domasław 10/11/12, Wrocław district. Catalogue of textiles discovered in the graves.

No.	Grave number	Type of grave	Place of depositing textile	Type of find
1	283	urn-urnless chamber grave	on iron-bronze toiletry set, beside urn	fragment of textile in 1/1 tabby; warp: *c.* 0.3-0.4mm single yarn, Z-twist; weft: *c.* 0.3-0.4mm single yarn, Z-twist
				fragment of 2/2 twill; warp: *c.* 0.2-0.3mm single yarn, Z-twist; weft: *c.* 0.2-0.3mm single yarn, Z-twist
2	360	urn-urnless chamber grave	on iron pin, beside urn	fragment of mineralized textile
3	366	urn chamber grave	on iron toiletry set, under bracelet, beside urn	fragment of mineralized textile
4	384	urn-urnless chamber grave	on iron pins, in urn	3 fragments of 2/2 twill; warp: 0.5-0.7mm single yarn, Z-twist, 12 threads per cm; weft: 0.7-0.8mm single yarn, Z-twist, 11 threads per cm
5	390	urn-urnless chamber grave	on iron knife, in vessel	fragment of mineralized textile
6	402	urn chamber grave	on iron arrowhead, in urn	fragment of textile in 1/1 tabby; warp: 0.4-0.6mm single yarn, Z-twist, 20 threads per cm; weft: 0.4-0.6mm single yarn, Z-twist, 12 threads per cm
7	417	urn-urnless chamber grave	on iron toiletry set, beside urn	fragment of mineralized textile
8	460	urn chamber grave	beside tutuli-like buttons, under urn	fragment of textile in 1/1 tabby; warp: 0.5-0.7mm single yarn, Z-twist, 20 threads per cm; weft: 0.6-0.9mm single yarn, Z-twist, 12 threads per cm
9	543	urn-urnless chamber grave	on iron pin, in urn	fragment of textile in 1/1 tabby; warp: 0.5-0.6mm single yarn, Z-twist, 10 threads per cm; weft: 0.5-0.6mm single yarn, Z-twist, 10 threads per cm; flax?
			on iron pin, in urn	fragment of 2/2 twill; warp: 0.5-0.6mm single yarn, Z-twist; weft: 0.5-0.6mm single yarn, Z-twist
10	570	urn chamber grave	on bronze spiral, beside iron bracelets, in urn	fragment of mineralized textile
11	1015	urn chamber grave	on iron knife, in urn	fragment of mineralized textile
12	1271	urn chamber grave	on iron pin, beside urn	fragment of mineralized textile
13	1694	urnless chamber grave	on iron toiletry set and fragment of iron pin, under urn	2 fragments of textile in 1/1 tabby; warp: 0.5-0.7mm single yarn, Z-twist, 14 threads per cm; weft: 0.6-0.8mm single yarn, Z-twist, 10 threads per cm
14	1698	urn chamber grave	on iron-bronze pin, away from urn, in western part of grave pit	fragment of mineralized textile
15	1849	urn chamber grave	on iron needle, in urn	fragment of textile in 1/1 tabby; warp: 0.6-0.8mm single yarn, Z-twist, 14 threads per cm; weft: 0.6-0.8mm single yarn, Z-twist, 10 threads per cm
16	2127	urn grave	on iron knife, in urn	fragment of mineralized textile
17	2789	urn chamber grave	on iron needle, in vessel with bones	fragment of mineralized textile
18	3311	urn-urnless chamber grave	on iron toiletry set, on urn	fragment of mineralized textile
19	3313	urn grave	on iron objects, in urn	fragment of mineralized textile
20	3423	urn chamber grave	on iron knife, beside urn	fragment of mineralized textile
21	3767	urn chamber grave	on bronze pin, beside urn	fragment of mineralized textile

Tab. 1. continued

22	3797	urn chamber grave	on bronze pin, with other objects, in urn	fragment of mineralized textile
23	4267	urn chamber grave	on iron toiletry set, beside urn	fragment of ribbon
24	4269	urn chamber grave	on iron-bronze pin, with other objects, on urn	fragment of textile in tabby + repp; warp: 0.3-0.4mm single yarn, Z-twist, 22 threads per cm; weft: 0.3-0.7mm single yarn, Z-twist, 22 threads per cm
			on bronze plaques	2 fragments of mineralized textile
25	4270	urn-urnless chamber grave	on iron-bronze toiletry set, beside urn	fragment of mineralized textile
26	4273	urn chamber grave	on iron pin, beside urn	fragment of mineralized textile
27	4297	urn chamber grave	on iron pin, on urn	fragment of mineralized textile
			on iron-bronze pin, on urn	fragment of mineralized textile
28	5611	urn-urnless chamber grave	on iron pin, on urn	fragment of mineralized textile
			on iron necklace, on urn	fragment of mineralized textile
29	5964	urn chamber grave	on iron pin, under urn	fragment of textile in rep-weave; warp: 0.6-0.7mm single yarn, Z-twist, 12-14 threads per cm; weft: 0.6-0.7mm single yarn, Z-twist, 6-7 threads per cm
30	5970	urn grave	on iron toiletry set, in urn	4 fragments of textile in warp rep-weave; warp: 1.0-1.2mm plied yarn, S/2Z-twist; weft: 0.7-0.8mm single yarn, Z-twist
				fragment of ribbon woven on tablets; warp: 1.0-1.2mm single yarn, Z-twist; weft: 0.7-0.8mm single yarn, Z-twist
31	5975	urn grave	on iron bracelets, in urn	fragment of mineralized textile
32	6023	urn chamber grave	on iron pin, in urn	fragment of mineralized textile
33	6026	urn chamber grave	on bronze pin, on urn	fragment of mineralized textile
34	6029	urn grave	on bronze necklace, in urn	fragment of mineralized textile
35	6366	urn chamber grave	on iron knife, in NW part of chamber	fragment of mineralized textile
36	6675	urn grave	on iron sickle, in urn	fragment of mineralized textile
37	6680	urn chamber grave	on iron chisel, beside urn	fragment of mineralized textile
			on iron knife, beside urn	fragment of mineralized textile
38	6690	urn chamber grave	on iron-bronze toiletry set, beside urn	fragment of mineralized textile
			on iron bracelet, beside urn	fragment of 2/2 twill; warp: 0.3-0.5mm single yarn, Z-twist, 12-14 threads per cm; weft: 0.3-0.5mm single yarn, Z-twist, 12-14 threads per cm
39	7408	urn chamber grave	on iron knife, in urn	fragment of mineralized textile
40	7464	urn chamber grave	on iron bracelets, in urn	fragment of textile in tabby; warp: 0.5-0.6mm single yarn, Z-twist, 14 threads per cm; weft: 0.5-0.6mm single yarn, Z-twist, 8 threads per cm
41	7472	urn chamber grave	on iron pin, in urn	fragment of mineralized textile
42	8891	urn chamber grave	on iron bracelets, in urn	fragment of mineralized textile
			on iron knife, under urn	fragment of mineralized textile
43	8892	urn chamber grave	on iron knife, beside urn	fragment of mineralized textile
44	8893	urn chamber grave	on iron bracelet, beside urn	fragment of mineralized textile
			on iron necklace, beside urn	fragment of textile in 1/1 tabby; warp: 0.5-0.6mm single yarn, Z-twist, 12 threads per cm; weft: 0.5-0.6mm single yarn, Z-twist, 10 threads per cm

Tab. 1. continued

45	8899	urn chamber grave	on iron knife, under vessel in northern part of chamber	fragment of textile in 1/1 tabby; warp: 0.7-1.0mm single yarn, Z-twist, 10 threads per cm; weft: 0.8-1.1mm single yarn, Z-twist, 7 threads per cm
			on iron chisel, under vessel in northern part of chamber	fragment of mineralized textile
46	8905	urn chamber grave	on iron axe, beside urn	fragment of mineralized textile
47	8919	urn chamber grave	on iron and bronze fibulae, beside urn	fragment of mineralized textile
47 48	8926	urn chamber grave	on iron knife, in urn	fragment of mineralized textile
			on iron pin, in urn	fragment of mineralized textile
49	8943	urn chamber grave	on iron knife, beside urn	fragment of 2/2 twill; warp: 0.4-0.6mm single yarn, Z-twist, 14 threads per cm; weft: 0.6-0.8mm single yarn, Z-twist, 14 threads per cm
50	8949	urn chamber grave	on iron toiletry set, beside urn	fragment of mineralized textile
51	8954	urn chamber grave	on bronze necklace, beside urn	fragment of mineralized textile
52	8956	urn chamber grave	on iron knife, in western part of chamber	fragment of 2/2 twill; warp: 0.3-0.5mm single yarn, Z-twist, 20 threads per cm; weft: 0.4-0.6mm single yarn, Z-twist, 14 threads per cm
			on iron pin, in western part of chamber	fragment of mineralized textile
			on iron arrowhead, in western part of chamber	fragment of mineralized textile
53	8959	urn chamber grave	on iron toiletry set, beside urn	fragment of mineralized textile
54	8960	urn chamber grave	on iron pin, in urn	fragment of mineralized textile
55	8961	urn chamber grave	on bronze pin, partly under urn	fragment of mineralized textile
56	8963	urn grave	under/in vessel	fragment of mineralized textile, damaged – visible threads; warp: *c.* 0.3-0.4mm, Z-twist; weft: *c.* 0.3-0.4mm, Z-twist
57	10000	urnless chamber grave	on iron knife, in north-eastern part of chamber	fragment of mineralized textile
			on iron-bronze pin, in western part of chamber	fragment of mineralized textile
58	10315	urn-urnless chamber grave	on iron knife, under vessel in southern part of chamber	fragment of textile in 1/1 tabby; warp: 0.5-0.6mm single yarn, Z-twist, 14 threads per cm; weft: 0.6-0.8mm single yarn, Z-twist, 12 threads per cm
59	10816	urn grave, in the ceiling of chamber grave	on bronze toiletry set, on urn	fragment of mineralized textile
60	10883	urn chamber grave	on iron knife, under vessel in north-western part of chamber	fragment of mineralized textile
61	11622	urn chamber grave	on iron objects (bracelets, pins), in urn	9 fragments of mineralized textile in 1/1 tabby; warp: 0.5-0.6mm single yarn, Z-twist; weft: 0.7-0.8mm single yarn, Z-twist
62	12739	urn-urnless chamber grave	on iron knife, in eastern part of chamber	fragment of mineralized textile
			on iron pin, away from urn	fragment of mineralized textile