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Population dynamics and human strategies in Northwestern Patagonia: a view from Salamanca Cave (Mendoza, Argentina)

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ABSTRACT – *In this paper we evaluate the role of human strategies in the Andean Piedmont from northern Patagonia across the Holocene. Specifically, we present the analysis of the Early Holocene-Late Holocene archaeological record of Salamanca cave (Mendoza-Argentina). We identified technological changes that occurred during the Late Holocene and the implications of a human occupation hiatus in the Middle Holocene. We follow a multiproxy approach by the analysis of radiocarbon dates, archaeofaunal remains, ceramic, lithics and XRF obsidian sourcing. We also discuss a detailed stratigraphic sequence by geomorphological descriptions, the construction of a radiocarbon sequence model and summed probability distributions, compared with other archaeological sites in the region. We conclude that after the Middle Holocene archaeological hiatus, human populations grew while guanaco populations dropped. The imbalance between demography and resources boosted the incorporation of new technologies such as ceramics and the bow and arrow, allowing people to exploit lower-ranked resources.*

KEY WORDS – *hunter-gatherers; Northern Patagonia; mid Holocene; late Holocene; intensification; Southern Mendoza*

Populacijske dinamike in človekove strategije v severozahodni Patagoniji: pogled iz jame Salamanca (Mendoza, Argentina)

IZVLEČEK – *V članku ocenjujemo vlogo človekovih strategij v andskem Piedmontu iz severne Patagonije v obdobju holocena. Natančneje predstavljamo analizo zgodnje holocenskih do pozno holocenskih arheoloških podatkov iz jame Salamanca (pri mestu Mendoza v Argentini). Prepoznali smo tehnološke spremembe, ki so se zgodile v času poznega holocena, ter posledice hiatusa v poselitvi v času srednjega holocena. Z analizo radiokarbonskih datumov, arheozooloških ostankov, keramike,*

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kamnitih orodij in iskanja izvora obsidiana z metodo XRF smo sledili pristopu z več kriteriji. Razpravljamo tudi o podrobnem stratigrafskem zaporedju s pomočjo geomorfoloških opisov, pa tudi o izgradnji modela radiokarbonske sekvence in o porazdelitvah povzete verjetnosti, vse to pa primerjamo še z drugimi arheološkimi najdišči v regiji. Zaključujemo, da se je število ljudi po obdobju srednjega holocena povečalo, medtem ko se je število gvanakov zmanjšalo. Neravnovesje med demografijo in viri je spodbudilo vključevanje novih tehnologij kot so lončarstvo ter lok in puščice, kar je ljudem omogočilo izkoriščanje manj pomembnih naravnih virov.

KLJUČNE BESEDE – *lovci-nabiralci; severna Patagonija; srednji holocen; pozni holocen; intenziviranje; južna Mendoza*

Introduction

The archaeological record of arid environments presents specific challenges for preservation and site formation. At the same time, it allows us to acquire a better comprehension of human adaptations to these ecosystems. In South America, the Patagonia region became one of the last refuges of a hunter-gather way of life in the world (*Bettinger 2015; Borrero 1994–1995; 2001; Morgan* et al. *2017*). In Mendoza province, the Patagonia phytogeographic unit extends across the Piedmont of the Andes Cordillera, and widens southwards including the volcanic district of Payunia (*Roig 2000; Villagra* et al. *2010; Oyarzabal* et al. *2018*). Several archaeological sites have been found and studied, leading to debates and discussions in the Andes Piedmont from northwestern Patagonia, Argentina (*Gambier 1985; Durán 2000; Gil* et al. *2005; Neme 2007; Neme* et al. *2011; Barberena* et al. *2010*). These discussions were related to the age of the first human occupations in the region and their probable coexistence with megafauna (*Forasiepi* et al. *2010; Neme, Gil 2012; Barberena* et al. *2010*), and also to the occurrence of a Middle Holocene (7000–4000 ^{14}C years BP) human occupation hiatus (*Gil* et al. *2005; Neme, Gil 2008a; 2009; Barberena* et al. *2015a; Durán* et al. *2016*).

During the Late Holocene there was an intensification process in northern Patagonia due to a demographic increase, which triggered important dietary, technological and social changes (*Neme 2007; Neme, Gil 2008a*). However, hunter-gatherer groups kept inhabiting this area, functioning as a barrier to the farmers settled to the north (*Lagiglia 1968; Gil* et al. *2009; 2011*).

Most of the archaeological sites excavated in the Andes Piedmont of northwestern Patagonia are caves and rock shelters, which record the adaptation of small-scale groups to desert environments. The ecotonal nature of the study area, strongly modelled by altitude, provided a wide set of resources due to the presence of different ecosystems with a diverse geological setting.

A recent systematic survey, which compared the Highlands, Piedmont and Lowlands with the same scale and units of analysis (in the Diamante fluvial basin), proved that the Piedmont was by far the most intensely exploited biogeographic environment, with a higher site density, discard rate, and evidence of longer stays on sites (*Franchetti 2019*). Under this scenario, archaeological information available in this area also indicates a strong use of rock shelters, with rich faunal and archaeobotanical assemblages, intense obsidian use and scant ceramic presence, in comparison with northern and western archaeological records (*Durán 2000; Durán* et al. *1999; Neme* et al. *2011; Sugrañes, Franchetti 2012*).

In the year 2007, the 'Salamanca cave'archaeological site was found as part of a cultural resource management study in the 'Puesto Rojas' oil field (Malargüe-Mendoza province, Argentina). The excavation made it possible to identify a human occupation sequence of more than 7000 ^{14}C years BP, with a dense cultural deposit. The study of Salamanca cave allows us to add new information, improving the chronology and regional sequence, as well as aspects of the dietary, technology and cultural adaptations. In this paper we report the stratigraphy of the cave filling, along with the radiocarbon chronology and its associated archaeological record. We discuss the results obtained through different lines of evidence such as archaeofaunal remains, ceramic, lithic and XRF obsidian sourcing, framed into a regional archaeological context, and a geoarchaeological perspective.

Background

The archaeological record of Gruta del Indio and El Chancho sites, located at the Piedmont (Fig. 1), indi-

cates that the first human occupations in southern Mendoza date to *c.* 11 000 ^{14}C years BP (*Lagiglia 1968; Neme, Gil 2012*). In the Andean Piedmont from northwestern Patagonia, the earliest evidence of human occupation comes from the Grande River valley and dates back to *c.* 9000 ^{14}C years BP (*Gambier 1985; Durán 2000; Diéguez, Neme 2004; Neme* et al. *2011; Barberena* et al. *2010*). The first excavated site in the study area was El Manzano cave (*Gambier 1985*), dated 8100 ^{14}C years BP, with a *c.* 7000–2100 ^{14}C years BP archaeological hiatus (*Neme* et al. *2011*). In the same valley, other excavated rock shelters dated a Late Holocene archaeological record (*Durán 2000; 2002; Durán, Ferrari 1991; Durán* et al. *1999; Campos* et al. *2006*). These archaeological sites include Cañada de Cachi, Puesto Carrasco, Cueva de Luna and Caverna de las Brujas (Fig. 1). The most important changes identified by researchers are the technological innovations, including the incorporation of the bow and ceramics that occurred *c.* 2000 ^{14}C years BP (*Durán 2000*). Moreover, a group of cemeteries (Ojo de Agua, Bajada de las Tropas, and Las Chacras) were excavated (Fig. 1) in the surroundings of Salamanca cave, dated in the last *c.* 3000 years BP (*Novellino, Neme 1999; Gil* et al. *2011; Salgán* et al. *2012*).

After the first arrival of human populations, towards the Late Pleistocene-Early Holocene (*Gradín* et al. *1984; Durán 2002; Berón 2006; Gil 2006; Neme, Gil 2008a; Barberena* et al. *2010; 2015a; Tripaldi* et al. *2017*), occupations increased between 9000 and 7000 years BP. However, the majority of environmental eco-zones show a temporal hiatus during almost the entire Middle Holocene, particularly between 7000 and 4000 years BP (*Berón 2006; Gil 2006; Gil* et al. *2005; Neme, Gil 2009; 2010; Barberena* et al. *2010; 2015a*).

The meaning of this Middle Holocene hiatus is a topic of strong debate. The most accepted hypothesis to explain the absence of radiocarbon dates is a drop in human population as a consequence of environmental deterioration. An increase in the aridity affected the location and effective population size, provoking aggregation of human groups across the region (*Gil* et al. *2005; Neme, Gil 2012*). Volcanic activity is an alternative explanation, and some archaeologists suggest that volcanic eruptions may have been of major magnitude both spatially and temporarily (*Durán, Mikkan 2009; Durán* et al. *2016*), and that such events could affect the environmental availability of the land and its productivity.

In contrast, other researchers question the existence of the hiatus, assuming sampling problems or biases (*García 2005; Garvey, Bettinger 2018*). Finally, another hypothesis is that the lack of archaeological record is a consequence of anthropic behaviour, such as the cleaning of the occupation floors or pit excavation, which resulted in low visibility of the archaeological record (*García* et al. *1999*). At a macro regional scale, a similar Holocene hiatus was also identified with a different magnitude in neighbouring areas (north of Neuquén and central Chile) and other South American regions (*Barberena* et al. *2015b; 2017; Méndez* et al. *2014; Santoro* et al. *2016; Riris, Arroyo-Kalin 2019*).

Strong and increasing evidence of occupations occurred after 4000 years BP in the northern Patago-

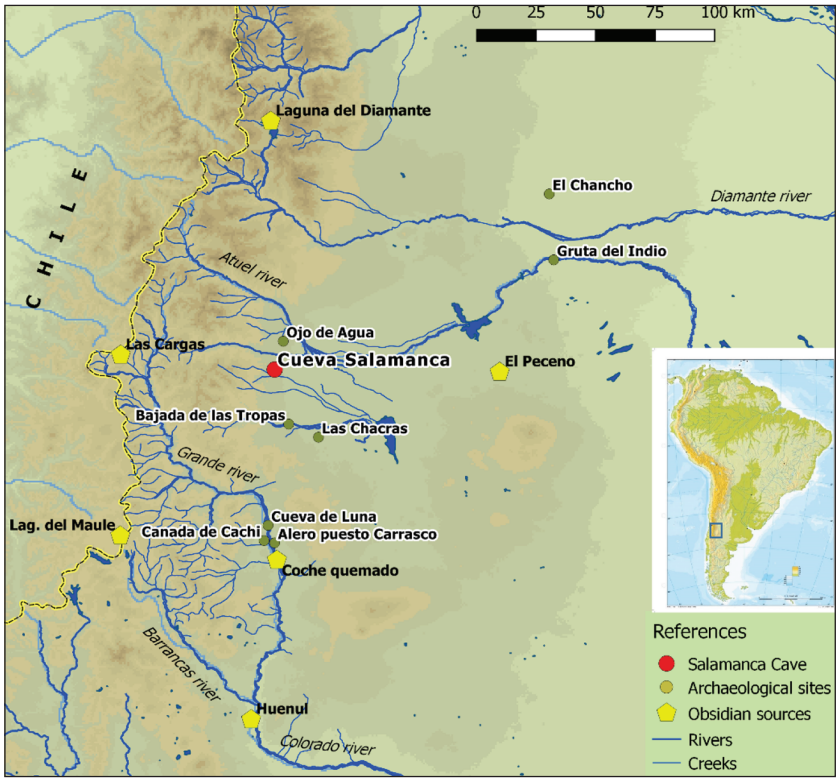


Fig. 1. Salamanca cave location, obsidian sources and the other archaeological sites mentioned in the text.

nia region. During the last 2000 years BP those human occupations spread to all environments including marginal settings, while the dietary breadth expanded (*Gil 2006; Neme 2007; Neme, Gil 2012*). In Patagonia's northern boundary, this process led the human population to incorporate domestic plants, but always as a small part of the diet (*Gil* et al. *2006; 2011; 2020*). While the Patagonian human populations continued with a hunter-gatherer way of life, they adopted a more diverse technological set, more distant social networks, and probably a diminishing residential mobility (*Gil* et al. *2011; Neme, Gil 2008a; 2008b; 2012; Ugan* et al. *2012*).

The archaeological site

Salamanca cave (35°17'4.11"S/69°41'33.34"W) is located in the Andean Piedmont at the rim of a mesa formed by several erosional episodes from the Pliocene to the Present. Following the regional stratigraphic scheme (*Nullo* et al. *2005*), the mesa is made up of a basaltic lava flow (Pleistocene) that buries a 1–2 meter-thick conglomerate (Pleistocene) that unconformably overlies continental Cretaceous reddish sandstones. (Fig. 2a).

The mesa makes up the south valley wall of a minor creek along *c.* 400m. The stream discharge comes from a water spring situated *c.* 500m upstream of the site (Fig. 2.c). The Salamanca cave is developed in the basaltic lava that caps the mesa (Fig. 2.b). It is a chamber-like void (*c.* 8m deep, 1.5m high, 3m wide) of fairly regular morphology (spheroidal in shape), and the entrance is an ample opening (3.5m high, 2.5m wide) (Fig. 2.d). The cave walls are covered by ferric and manganese oxide stains, and show minor spalling. The chamber-like morphology of the cave points to a primary cavity of the basalt formed while the lava flowed on the aggradational land surface made up of conglomerates. During the widening of the valley margin by lateral erosion the volcanic chamber void was gradually opened, and exposed to exogenous processes; eventually it became an available locus for human occupation.

During January 2010 we excavated a 2x1m unit (A-1) at the west part of the cave, close to the wall (Fig. 3). The excavation unit was subdivided into two 1x1m subunits (north and south sector). We removed 20 artificial levels, five centimetres each, following the natural slope of the surface floor. The excavation reached the weathering bedrock of the cave. We found several medium and small blocks from the cave ceiling at the surface and also in the sedimentary filling.

Chronostratigraphy and archaeological components

The cave is filled with *c.* 1.3m of fine sand that is the sedimentary matrix of the archaeological record; a secondary fraction of blocks (main axis *c.* 10cm long) is present, mainly at the lowermost section of the sequence. Several bioturbation structures were identified throughout the sequence (*e.g.,* rodents caves, roots alteration, insect activity) along with human structures (hearth and trash middens) which became the major hindrance in the stratigraphic analysis of the sedimentary filling. Hence, difficulties were apparent when trying to correlate the artificial excavation layers, the radiocarbon dates and the archaeological record.

The sedimentary filling is subdivided into five stratigraphic units (1, 2, 3, 4, 5 from top to bottom) on the basis of the occurrence of discontinuity surfaces of sedimentation (Tab. 1). The NE angle of the exca-

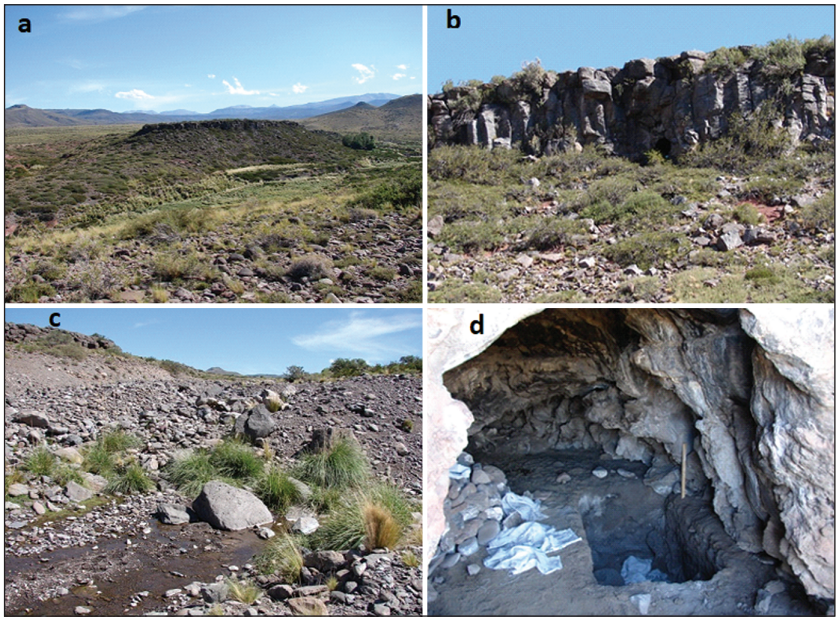


Fig. 2. Landscape at Salamanca cave and the surrounding area:* a *general view towards the north of the mesa;* b *Salamanca cave at the foot of the basaltic lava flow;* c *water spring upstream of Salamanca cave;* d *entrance and the excavation unit.

vation is the less disturbed and relatively complete section (Fig. 4). Units were described following a pedosedimentary approach, a combined sedimentological (grain size, sedimentary structure) and soil description (boundaries, Munsell soil colours).

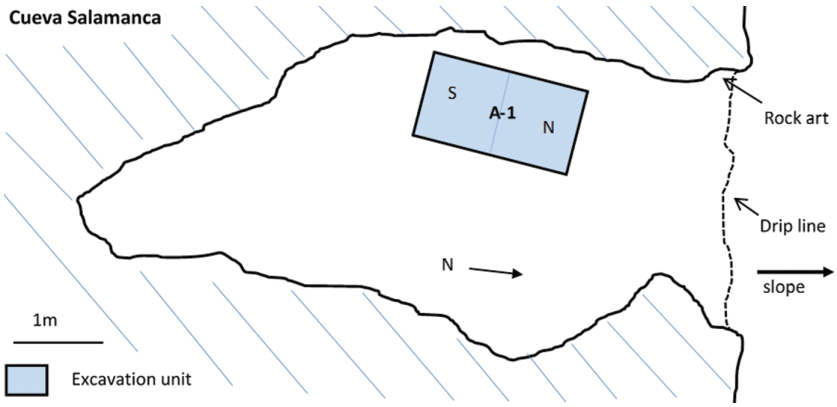


Fig. 3. Salamanca cave view on floor.

The lower boundary of Unit 2 exhibits an irregular shape (deep pocket), the upper part of Unit 3 (erosional surface). In turn, at the NW angle of the excavation the lower boundary of Unit 3 is a well-defined erosional surface carved in Unit 4. It is a *c.* 40cm deep and 50cm wide depression (trash hole, see below) which laterally grades into a depositional boundary (Fig. 4).

Twelve radiocarbon dates were obtained from charcoal samples (Tab. 2). The uncalibrated median chronology ranges from 7335 to 1055 ^{14}C years BP. Considering the stratigraphy and the radiocarbon dates, we defined three archaeological components (younger to older: A, B, C; Tab. 3).

The younger component (A) includes the stratigraphic units 1, 2 and 3. Unit 3 intrudes the NW part of the stratigraphy; the boundary shape and the filling with a chaotic and high concentration of bones along with lithic, charcoal and ceramic remains make it possible to interpret it as a trash hole between 1055 and 1516 ^{14}C years BP (Fig. 4).

The middle component (B) includes the upper section of stratigraphic unit 4 with radiocarbon dates spanning from 1516 and 2200 ^{14}C years BP (Fig. 4).

The lower component (C) comprises the lower section of unit 4. No sedimentary differences were observed between components B and C. However, the presence of much older radiocarbon dates (7100 and 7400 ^{14}C years BP), and differences in the archaeological record (projectile point shape, raw materials, exploited taxa and absence of pottery), lead us to differentiate components B and C.

In the case of component A, even when the radiocarbon dates had ages from the last two millennia, several modern historic remains are present (*e.g.,* goat bones, *etc.*) in the uppermost 20cm. This indicates that part of this component corresponds to occupations of the late historic herders (Fig. 4). In component C, a radiocarbon date yielded 1870±20

Unit	Thickness	Lithological features and archaeological remains	Lower contact
1	0–15cm	Light brownish gray (10YR 6/2) fine sands; moderately compacted to loose,massive; well preserved volcanic ash lenses (1932 Quiza-Pú eruption), thinly laminated on the W wall profile of the excavation.	sharp, irregular
2	15–30cm maximum, average thickness 15 cm	Grayish brown (10YR 5/2) fine sands, massive; goat dung, extensive hearth (20cm long, 12cm thick) in the E wall profile.	sharp, undulating
3	30–50cm	Grayish brown (10YR 5/2) fine sands with coarse clasts; very frequent archaeological remains (organic fragments and lithic artifacts).	sharp, undulating; sharp, smooth
4	(25 to 50cm–100cm) ~70cm maximum thickness	Grayish brown (10YR 5/2) fine sands with basaltic clasts; friable, sedimentary beds dipping towards the central part of the cave; some rodent caves. Abundant archaeological material including organic remains (*e.g.* vegetal macro-remains, vertebrate bones) lithic artifacts, as well as charcoal fragments, several hearths; dark brown (10YR 3/3) silty sand layer, 2cm thick including numerous mm long charcoal fragments.	sharp, smooth
5	(100–110cm)	Light brownish gray (10YR 6/2) very fine sand including coarse basaltic angular fragments; archaeologically sterile. It overlies a weathered basaltic surface.	sharp, irregular

Tab. 1. Lithological features and archaeological remains of Salamanca cave stratigraphic units.

^{14}C years BP. However, considering the identified bioturbation processes, and the resulting discontinuity of layers throughout the sequence, it is highly probable that the charcoal fragment comes from younger layers.

We calibrated the ^{14}C dates in OxCal 4.3 (*Bronk Ramsey 2009*) using the SHCal13 curve, and modelled them as a phased stratigraphic sequence (Tab. 4). These ^{14}C dates are listed in stratigraphic order from top (younger ages) to bottom (older ages) (Fig. 5). Cultural horizons were modelled as phases assuming that they do not overlap and deposited sequentially, and therefore we relied on our stratigraphic interpretations to organize the dates accordingly. We modelled the dates within components (A, B and C) using the command *phase* and estimated its duration with the command *span*. In addition, we separated each phase with the command *boundary*, assuming they were single events and that they occurred between the different cultural occupations. We used the command *interval* to estimate the duration of the Middle Holocene hiatus. The model demonstrated an overall agreement index of 100%, indicating a good fit for the data used (Fig. 5).

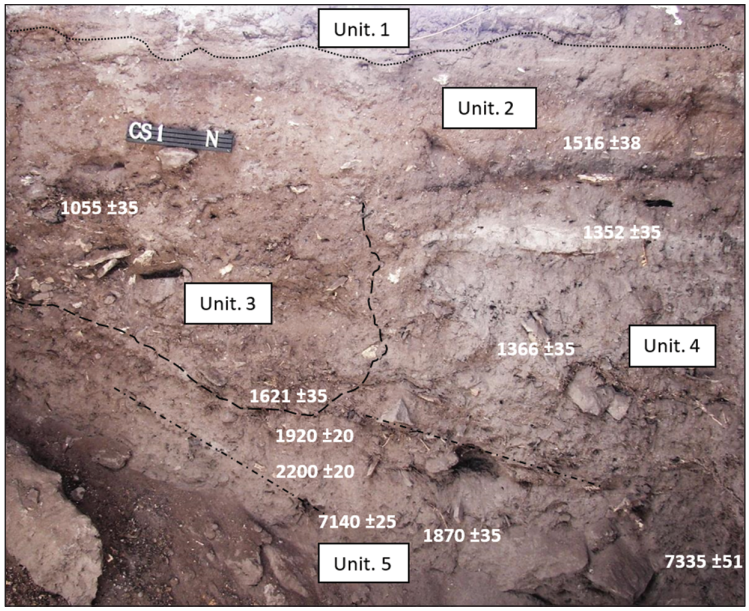


Fig. 4. Stratigraphic units in profile of north wall and the radiocarbon dates.

The archaeological record

Zooarchaeological record

A total of 31 035 bone specimens were analysed, of which 5928 were assigned to some taxonomic category. The results show a wide range of species exploitation, dominated by the Camelidae, Chinchillidae and Chlamyphoridae families (Tab. 5). Taphonomic observation (weathering, fresh fractures, cut marks, burnt surfaces) allowed us to discriminate between the species exploited by humans from those introduced by other predators. We confirm that bone specimens of Didelphidae, Caviidae, Ctenomyidae, Cricetidae and *Lestodelphys sp.* as well as suboscine birds were incorporated by the predatory activity of the common owl (*Tyto furcate*).

Component A is the most diverse considering the exploited species (NTAXA=10), even when their sample size (NISP=431) is not much larger than that of

Sample ID	Deep (cm)	Context	Stratigraphic unit	Archaeological component	Material	Lab code	^{14}C age (yrs. BP)	Calib. (‰)	δ^{13}C
CS-1	35	North profile	2	A?	Charcoal	AA-94003	1352±35	1284±19	–23.1
CS-2	25	North profile	2	A?	Charcoal	AA-94004	1516±38	1425±58	–23.2
CS-3	39	North profile	Trash top 3 3	A	Charcoal	AA-94005	1055±35	982±38	–22.9
CS-4	39	North profile	4	A	Charcoal	AA-94006	1366±35	1297±16	–22.8
CS-5	50	North profile	Trash floor 3	B	Charcoal	AA-94007	1621±36	1497±54	–23.4
CS-6	60	East profile	4	B	Charcoal	AA-94002	1561±38	1461±47	–22.9
CS-8	75	Level 15	4	B	Charcoal	UGAMS-7006	2200±20	2234±60	–23.7
CS-9	65	Level 13	4	B	Charcoal	UGAMS-7007	1920±20	1867±23	–22.1
CS-10	95	Level 19	4	C	Charcoal	UGAMS-7004	7140±25	7973±17	–22.9
CS-11	95-100	Level 19–20	4	C	Charcoal	UGAMS-7005	1870±20	1815±41	–23.8
CS-7	100	East profile	4	C	Charcoal	AA-94001	7335±51	8135±67	–24.2

Tab. 2. Radiocarbon dates from Salamanca cave. The calibration was performed by the OxCal program with the southern hemisphere calibration curve (*Hogg *et al.* 2013*).

component B (NISP=405 and NTAXA=7). On the other hand, component C is the less diverse (NTAXA =5) but it must be mediated by the sample size (NISP =66). With the exception of the domestic taxa (Caprininae) registered and the smaller NTAXA, few differences occur between components A and B (Fig. 6). The most important changes take place between components C and B, which reflect a more intensive exploitation of Chlamyphoridae during the earlier occupation (component C), and a dominance of Chinchillidae and Camelidae families in component B. The latter trend is maintained in component A (Fig. 6). The mollusc fragments identified in component A correspond to marine taxa, probably from central Chile. This is a common scenario identified in the southern Mendoza archaeological record, where we observe molluscs used as tools, containers, and necklaces beads (*Lagiglia 1977; Neme 2007*).

Nine camelid bone samples were analysed to extract ancient DNA. Two of them were not considered due to the low coverage. The remaining seven samples confirmed our identification as *Lama guanicoe* specimens (*Abbona* et al. *2020*) in the three defined

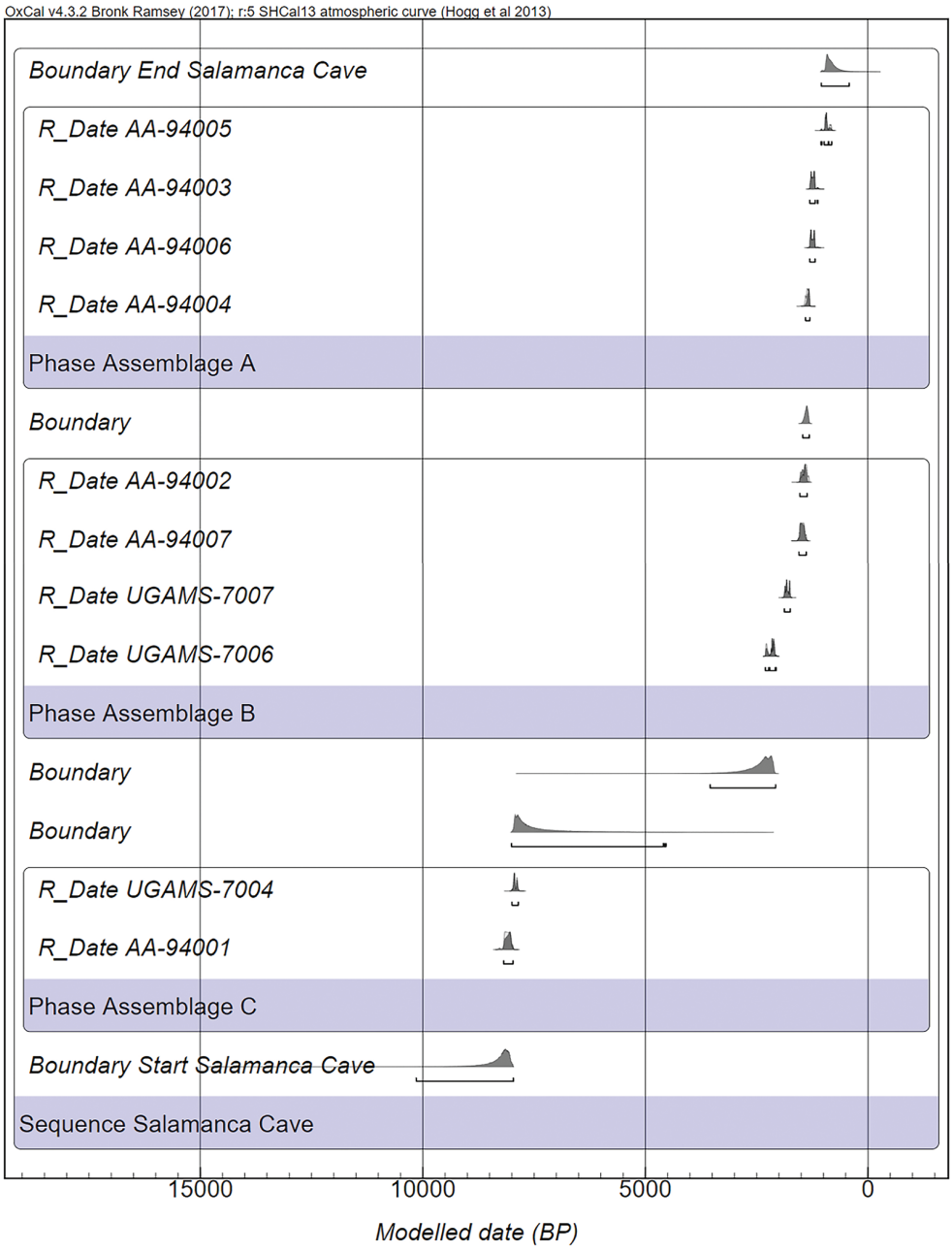


Fig. 5. Chronological model for 11 ^{14}C dates from Salamanca cave. The grey lines show probability estimates trimmed or shifted based on constraints of the Bayesian chronological model developed here. The overall agreement index for this model is strong (Amodel:100).

components (A, B and C). It is important to discard the proposed hypothesis about the existence of domestic camelid (*Lama glama*) in the southern Mendoza region (*Bárcena 1997*).

Lithic analysis

The lithic analysis includes 4987 artefacts of which 2331 (46%) belong to component A, 2608 (53%) to component B and 48 (1%) to component C. Silica or cryptocrystalline was the most used raw material at the site (57%), followed by obsidian (39%) and then basalt (3%). By silica we mean rocks with microcrystalline structure, composed primarily of quartz and including chert, chalcedony, agate, and silcrete. However, their use over time shows changes – silica dominated component C (%), while obsidian was dominant in component A (%) (Fig. 7). The low-quality raw material (mostly basalt) decreased over time (3% A, 4.5% B and 6.5% C). *Debitage* is the most frequent category, with an increase of the discard rate of tools by year during the last two millennia, from 0.1 in the component C to 3 in the component A (Tab. 6). Projectile points and scrapers are the best represented tool category (Fig. 9). The projectile points are the regional triangular types related to Late Holocene human occupation, however in the older component a stemmed one was found (Fig. 8.1). This last point type has no similarities with any other projectile point in the regional context.

Another difference is the increase in the number and diversity of tools over time. Component C includes only one tool; component B encompasses 28 tools within five tool classes; and component A, presents 49 tools within four tool classes. The differences are not due to the sample size. On the contrary, compo-

Date code – Commands	Modeled BP 2σ cal range
Boundary End Salamanca cave	1043–415
Span Phase A	277–543
R_Date AA-94005	1050–809
R_Date AA-94003	1302–1119
R_Date AA-94006	1301–1182
R_Date AA-94004	1396–1299
Boundary	1460–1313
Span Phase B	608–903
R_Date AA-94002	1525–1360
R_Date AA-94007	1545–1381
R_Date UGAMS-7007	1879–1745
R_Date UGAMS-7006	2305–2064
Boundary	3552–2070
Interval Middle Holocene	1837– 5850
Boundary	8010–4529
Span Phase C	0–291
R_Date UGAMS-7004	7998–7854
R_Date AA-94001	8185–7972
Boundary Start Salamanca cave	10 233– 7952

Tab. 4. Modelled radiocarbon sequence for Salamanca cave.

Archaeological component	Excavation units	Stratigraphic units	Chronology (^{14}C years BP)
A	1 to 9	1, 2 and 3	1055–1516
B	10 to 16	4	1561–2200
C	17 to 21	4	7100–7400

Tab. 3. Archaeological components defined in the paper.

	Archaeological components		
	A	B	C
Eudromia elegans #	0	1	0
Phalacrocorax #	1	0	0
Anatidae #	1	0	0
Suboscine	1	0	0
Rheidae #	7 (561)*	8 (180)*	0 (26)*
Rhea pennata #	0	0	1
Thylamys pallidior	92	83	7
Lestodelphys halli	1	11	0
Chlamyphoridae #	2	4	0
C. vellerosus #	0	5	6
C. villosus #	14	65	11
Z. pichiy #	12	7	205
Hystricomorpha indet.	252	265	32
Ctenomys sp.	23	53	6
Galea leucoblephara	3	0	1
cf Galea musteloides	1	0	0
Microcavia australis	9	16	1
Chinchillidae #	148	160	0
Lagidium sp #	0	0	1
Lagidium viscacia #	0	1	1
Cricetidae indet.	1468	175	152
Akodon iniscatus	9	16	9
Paynomys macronix	1	1	0
Phylotis xantopygus	71	90	1
Calomis musculinus	1	14	0
Eligmodontia sp.	161	254	23
Reitrodon auritus	40	50	3
Euneomys petersoni	17	45	2
Carnivora #	0	0	1
Lycalopex griseus #	2	0	0
Lycalopex sp. #	0	5	0
Puma concolor #	2	1	0
Puma cf P. yaguaroundi #	2	0	0
Artiodactila #	90	29	6
Camelidae #	5	7	0
Lama sp. #	99	110	15
Lama guanicoe #	43	49	3
Caprininae #	18	0	0
Mollusk	4	0	0
Total	**2600**	**3099**	**487**

Tab. 5. Faunal taxonomic list and abundance (NISP) in Salamanca cave. *Rheidae eggshell fragments in brackets; # Consumed species.

nent B consists of more artefacts but less tools and categories, while component A has less artefacts but more tools and categories (Tab. 7). In addition, the artefact discard rate increases over time (from one to 46). In component B, there is a higher debitage/instrument index, which implies increased transport of raw materials to the site and a possible increase in manufacturing. On another hand, component A shows an increased discard of tools (Tab. 7). Finally, no cores were recorded in the sequence, and 93% of the debitage has no cortex reserve.

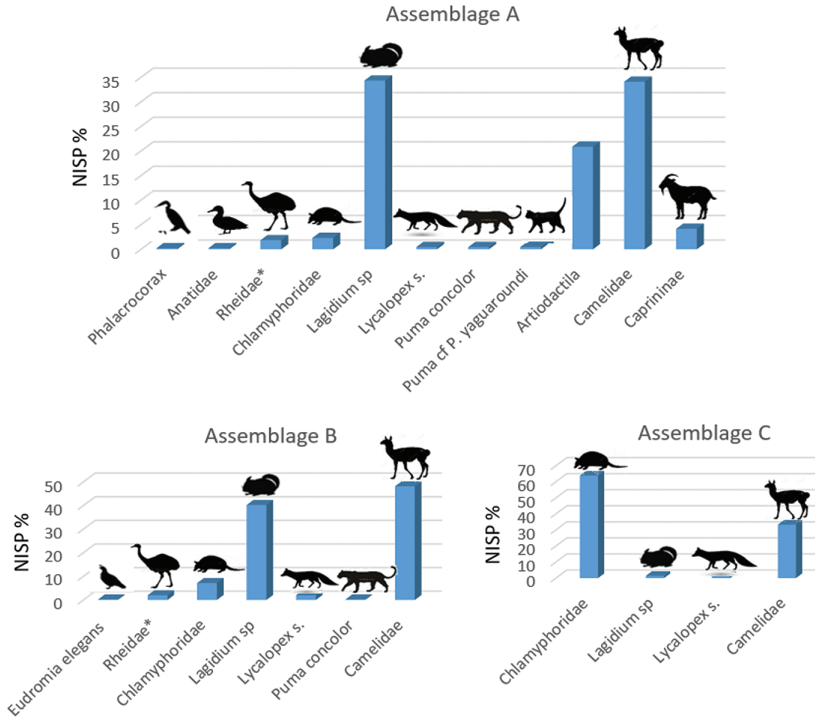


Fig. 6. Proportion of each consumed animal taxa in the Salamanca cave components

XRF analysis

A total of 88 obsidian artefacts were analysed by XRF following the methodology of the University of Missouri Research Reactor Laboratory (MURR) (*Glascock, Ferguson 2012*). The results were compared using the database available in MURR, including seven obsidian sources from northern Patagonia (Fig. 9). We could identify four known obsidian sources and two unknown ones (Tab. 8). The most represented obsidian source is Coche Quemado (72%), located on the south bank of the Grande river, 100km to the south (*Salgán* et al. *2020*), followed by Las Cargas source (11%), located *c.* 70km at the Argentina-Chile border in the Andes (*Salgán* et al. *2015*) (Fig. 1). The other obsidian sources identified are El Peceño (3%), located 100km away, on the plains (*Salgán, Pompei 2017*), and Laguna del Maule (3%), 100km away on the Argentinean-Chilean border in the Andes (*Barberena* et al. *2019*). The unknown source represents 10% of the samples.

The Coche Quemado and Las Cargas sources are present in the three components, in categories asuch as debitage, bifacial artefacts, and artefacts with complementary traces. There was no evidence of cores or unifacial artefacts (Tab. 8). In component B, unknown Group A (*Giesso* et al. *2011*) as well as unassigned artefacts are added, both present as debitage. In component A, the evidence of sources located at distances greater than 100km (*e.g.,* El Peceño and Laguna del Maule) is recorded as bifacial artefacts and debris. Tools are always projectile points, as reported in la Payunia and the Atuel river basin (*Salgán* et al. *2012; 2014; Pompei 2019*).

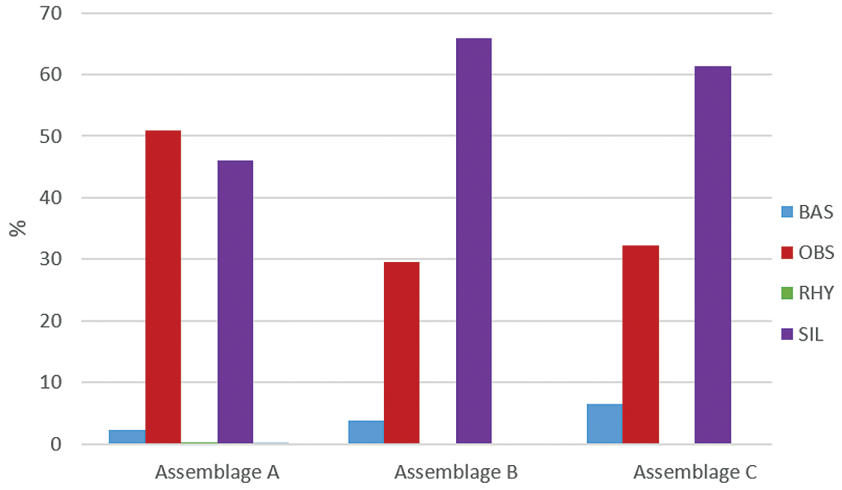


Fig. 7. Raw material by component in Salamanca cave (*BAS *basalt;* OBS *obsidian;* RHY *rhyolite;* SIL *silica).

Ceramic analysis

The ceramic record (Tab. 9) includes 66 sherds from component A (N=62) and B (N=4). The high frequency of sherds

Component	Raw material	Debitage	Bifacial tool	Unifacial tool	Non formal tool	Other art.	Total classes
A	Cryptocristalline	96.2% (628)	1.4% (9)	2.1% (14)	0.3% (2)		653
	Obsidian	95.3% (688)	2.5% (18)	0.7% (5)	1.4% (10)	0.1% (1)	722
	Basalt	84.8% (28)				15.2% (5)	33
	Rhyolite	100% (6)					6
	Others RM					100% (5)	5
Subtotal A		**95.14% (1350)**	**1.90% (27)**	**1.33% (19)**	**0.85% (12)**	**0.77% (11)**	**1419**
B	Cryptocristalline	98.3% (1173)	0.5% (6)	0.7% (9)	0.3% (3)	0.2% (2)	1193
	Obsidian	98.3% (525)	1.5% (8)		0.2% (1)		534
	Basalt	89.9% (62)	1.4% (1)			8.7% (6)	69
	Rhyolite	100% (7)					7
	Others RM	50% (3)				50% (3)	6
Subtotal B		**97.84% (1770)**	**0.83% (15)**	**0.50% (9)**	**0.22% (4)**	**0.61% (11)**	**1809**
C	Cryptocrystalline	94.7% (18)	5.3% (1)				19
	Obsidian	100% (10)					10
	Basalt	100% (2)					2
Subtotal C		**96.77% (30)**	**3.23% (1)**				**31**
Total (n)		**3150**	**43**	**28**	**16**	**22**	**3259**

Tab. 6. Artefact classes by raw material in each component. References, other raw materials: andesite, quartz, vulcanite and indeterminate raw material.

assigned to the Chilean typology highlights the presence of PAT (Early Pottery Period) and 'Marrón Pulido' (Brown polished) types (Figs. 10 and 11). Those Chilean traditions are well dated in Chile between 1800 and 800 years BP (*Falabella* et al. *2016*). PAT style is highly polished black ceramics with utilitarian forms, with conspicuously reduced firing, and fine-grained temper size. Brown polished style is a utilitarian ceramic with brown colours, sometimes with incised decoration, and commonly with a polished surface treatment. Temper size is well selected, consisting of fine grains of sands. The red polished style has similar characteristics to the brown polished style, the only differences is the use of colour. Overo style is a utilitarian ceramic with brown and grey colours, sometimes with incised decoration in the neck section, smoothed surface treatment, oxidized and oxidized incomplete firing. Temper size is poorly selected, medium to large and generally consists of sand.

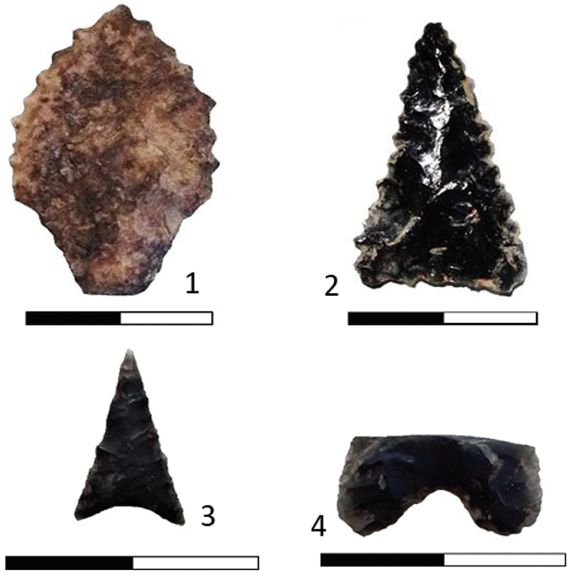


Fig. 8. Projectile points in Salamanca cave:* 1 *component C;* 2 *component B;* 3, 4 *component A.

Only a small part of the ceramic record (16%) belongs to the local 'Overo' typology (*Lagiglia 1997*), suggesting that ceramics were mainly acquired by extra-local exchange systems, in agreement with other sites of the region (*Sugrañes 2019*). The small size of the ceramic component reinforces this idea, and is coherent with the mobility constraints on north Patagonia hunter-gathers way of life. The ceramic record presents thin sherds (average 4.9mm), predominantly polished surface treatment (79%), fine temper size (63%) and reduce firing (40%).

We consider some macroscopic characteristics in the ceramics as a proxy of labour investment. The use of fine temper size impacts the wall thickness and therefore implies more labour and skill by the potter to produce a piece (*Eerkens 2008*). Reduced firing involves more investment, as the process needs more supervision and precision to acquire the expected effect. A polished surface treatment involves more labour and time once the piece has dried.

Discussion

The Salamanca cave archaeological record suggests a long human occupation sequence at the Andean Piedmont, starting 7335 ^{14}C years BP, with a noto-

rious Middle to Late Holocene hiatus from 7140 to 2200 ^{14}C years BP. The sedimentary analysis and the numerical ages indicate major, important post-depositional processes affecting the archaeological record. We defined three archaeological components to identify changes or continuities in the archaeological record. The earliest component (C), radiocarbon dated between 7335 and 7140 years BP, is characterized by a low archaeological depositional rate (0.1lithic/year), with a narrow set of subsistence activities that involved hunting, cooking, tool making and maintenance. This evidence suggests that the cave was occupied by small hunter-gatherer bands during short stays. Chlamyphoridae (armadillos) and Camelidae (guanaco) were the most important faunal resources exploited, followed by some few Rheidae and Chinchillidae specimens. Local raw materials represent *c.* 70% of the lithic record in component C, coming from a less than 20km radius. Obsidian represents less than 30% of the total used raw material. The sourcing analysis indicates that it was obtained from sources located 70–100km away (Tab. 8 and Fig. 1).

The radiocarbon dates discontinuity of more than 5000 years (from 7973 to 2234 cal years BP) is similar to the gap identified in El Manzano cave (from 7907 and 2105 cal years BP; *Neme* et al. *2011*) and Huenul cave (*Barberena* et al. *2015a; 2015b*) located 70km and 180km away, respectively, in the Andean Piedmont. A sum probability curve (Fig. 12) was done using the radiocarbon calibrated dates from Salamanca cave (Tab. 2) and from the two other cave sequences (*Neme* et al. *2011; Barberena* et al. *2015b*). It shows a bimodal curve with Early and Late Holocene occupations. At the same time, it defines a significant occupational gap, including most of the Middle Holocene and the Early-Late Holocene from 7400 to 2400 cal years BP, suggesting the existence of a very similar regional pattern.

Component	A	B	C
Debitage/tools	29.3	73.8	30.0
Temporal span (years)	460	640	200
Artifact discard rate/years	3.1	2.8	0.2

Tab. 7. Lithic discard rates in Salamanca cave.

In the case of Salamanca cave, this discontinuity appears to be chronological and stratigraphical (*Veth* et al. *2017*). The obtained radiocarbon dates indicate that there may be a stratigraphic gap with no sedimentation between 2200 and 7140 years BP (see Fig. 4). This absence of sedimentation makes it difficult to make definitive assumptions related to the Middle Holocene gap regionally considered.

Different explanations have been proposed to understand this regional gap. Plausible explanations include a regional depopulation, settlement reorganization, changes in mobility, or in site size (*Neme, Gil 2009*), although aridization is accepted as the most plausible (*Gil* et al. *2005; Neme, Gil 2008a; Barberena* et al. *2017*). Other researchers discuss the significance of local volcanism and glacier events with regard to the regional productivity (*Durán, Mikkan 2009; Durán* et al. *2016*). However, the human response to drier climatic conditions remains undetermined and debatable. Based on obsidian hydration data, mitochondrial DNA and radiocarbon trends, other authors suggest a continuity in human occupation throughout northern Patagonia (*Garvey, Bettinger 2018; Gordón* et al. *2019; Pérez* et al. *2016a*). Nonetheless, the Patagonian human demography seemed to be non-homogeneous, with non-inhabited areas (*Pérez* et al. *2016b*).

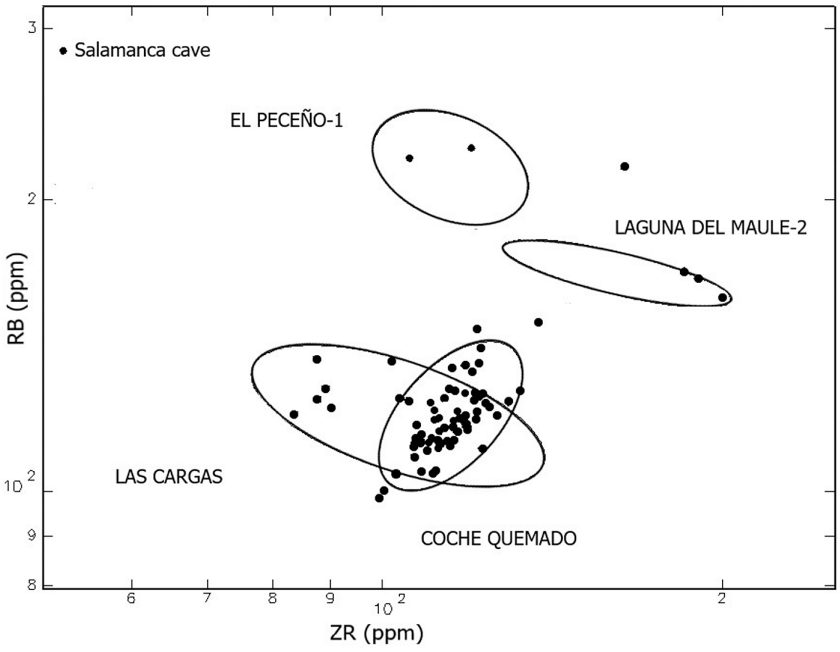


Fig. 9. XRF obsidian source analysis from Salamanca cave site artefacts. Ellipses are the 90% confidence interval around each source.

Components	Artifact classes	Coche Quemado	Las Cargas	El Peceño 1	Laguna del Maule-2	Unassigned	Unknown group A
A	Debitage	39% (11)	11% (3)	4% (1)	11% (3)		
	Bifacial tool	25% (7)		4% (1)			
	Non formal tool	7% (2)					
	Total	**71% (20)**	**11% (3)**	**7% (2)**	**11% (3)**		
B	Debitage	57% (16)				4% (1)	4% (1)
	Bifacial tool	32% (9)	4% (1)				
	Total	**89% (25)**	**4% (1)**			**4% (1)**	**4% (1)**
C	Debitage	70% (7)	10% (1)				
	Bifacial tool		10% (1)				
	Non formal tool	10% (1)					
	Total	**80% (8)**	**20% (2)**				

Tab. 8. Artefact classes present in the obsidian components analysed from XRF Salamanca cave.

The analysis of Neuquén province (northern Patagonia) fauna shows an increase in guanaco dependence during the Middle Holocene (*Rindel 2017*), similar to the Middle Holocene pattern of southern Mendoza (*Neme, Gil 2009*). The guanaco demographic curve, reconstructed using mitochondrial DNA from the entire Patagonia, indicate a population increase during the beginning of the Middle Holocene *c.* 7500 years BP (*Pérez* et al. *2017; Moscardi* et al. *2020; Abbona* et al. *2021*), which could explain the human focus on this resource. Guanacos are adapted to cold and grassland environments (*Puig* et al. *2011*), and changes in the environmental conditions that favour guanaco populations can reduce plant productivity in environments outside the Andes, as well as smaller animal populations, leading humans to focus on this target.

The suggestive contemporaneity in the Middle Holocene radiocarbon hiatus among all the Andean Piedmont from northern Patagonia Piedmont sites (El Manzano cave, Huenul cave and Salamanca cave), needs to be explored and explained. More importantly, this trend is also identified at a larger regional scale in other archaeological sites with a noticeable decrease in the archaeological record (*Neme, Gil 2009; 2012*). Even if we consider the obsidian hydration from the area in El Manzano cave (*Garvey, Bettinger 2018*), the number of obsidian samples assigned to the Middle Holocene is much smaller than those compared with the Early and Late Holocene from the same site. This suggests a human depopulation process or changes in the settlement pattern related to a rearrangement to the new environmental conditions.

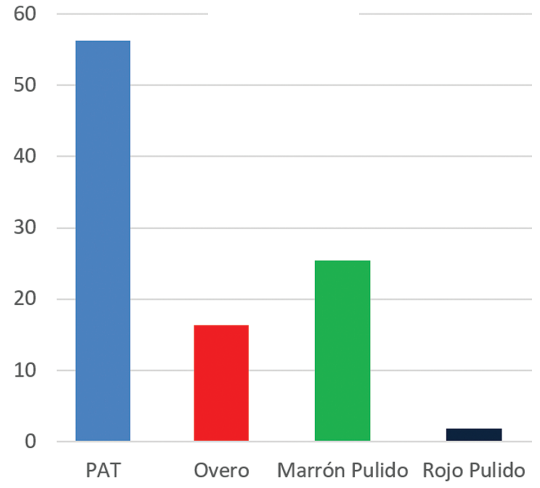


Fig. 10. Percentages of ceramic types in Salamanca cave site.

After this long discontinuity in the Salamanca cave archaeological record, the human occupations rise again during component B with an increase in the faunal and lithic diversity as well as in the deposition rate (2.8 lithic artefacts discarded by year), and probably more reoccupation events. In the lithic record the use of local raw materials in older components is also recorded. It is associated with a Late Holocene increase in the use of obsidian and an increase in the number of obsidian sources exploited. In El Manzano cave, the Laguna del Maule source is recorded in the oldest components (*Barberena* et al. *2019*), while in the Late Holocene there is a significant increase in obsidian over local resources, incorporating the Las Cargas obsidian source (*Neme* et al. *2011*). In Huenul cave, the infrequent use of Laguna del Maule subtypes 1 and 2 is incorporated in the Late Holocene, together with a Huenul local source (*Fernández* et al. *2017*).

Two technological innovations are evident in component B: ceramics and the bow and arrow, as suggested by the projectile point size (*Martínez 2003; Ratto 2003; Banegas* et al. *2014; Castro 2015*). The projectile points change from stemmed to triangular notched types (Fig. 9). A more diverse use of raw material is apparent, with silica increasing and ba-

salt decreasing. Four ceramic sherds were recovered in this component. But even when the chronology is coherent with the regional arrival of ceramics dated at *c.* 2000 years BP (*Marsh 2017; Sugrañes 2017*), these sherds, which share the same characteristics, are more likely the result of vertical migration by some post-depositional disturbance.

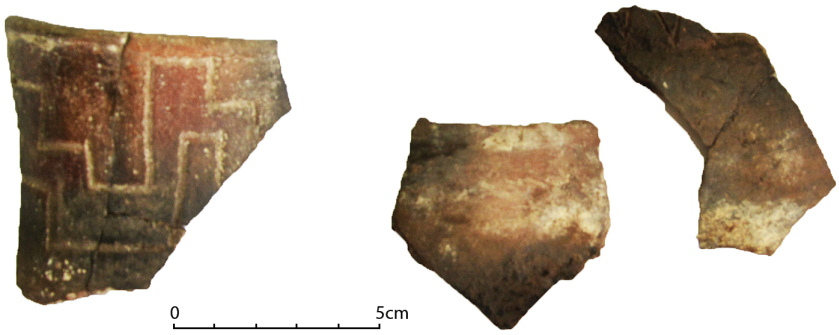


Fig. 11. Ceramic sherds from Salamanca cave. Types: PAT, Early Ceramic Period (left), Brown Polished (centre), and Overo (right).

The exploited faunal resources increase from NTAXA =5 in component C to NTAXA=7 in component B. There is an increase in chinchilla hunting, a smaller species, uncommon in the regional zooarchaeological record. Framed within the diet breadth model, chinchilla is lower ranked among the rest of species in the region (*Corbat* et al. *2021*). This taxon replaces the Chlamyphoridae as the most abundant small mammal on the site. This increase in the number of consumed taxa and the incorporation of smaller animals agrees with the regional northern Patagonia trends (*Neme 2007; Otaola* et al. *2015; Rindel 2017*). However, the guanaco continues as the main faunal resource at Salamanca cave and in the other sites of the region.

Component A is the most diverse in terms of fauna exploitation, lithic and ceramic types, with the highest depositional rate of the sequence (3 lithic artefacts discarded by year) and a decrease in the waste discard rate in relation to the tools. This implies a change in the mode of transport of raw materials, from preform in component B to the transport of tools in component A. This evidence is the result of a higher reoccupation pattern and a larger number of activities carried on. The faunal record shows a strong dependence on guanaco and chinchilla, but several carnivores, birds and armadillos could be part of the diet too, as the taphonomic observations suggest. Only the small rodents (Cricetidae and Sigmodontinae) were clearly introduced to the site by avian predators (mainly owls).

Components A and B are difficult to discriminate due to the stratigraphic complexity, the absence of a clear unconformity, and the presence of crossing radiocarbon dates. Alternatively, both units (A and B) might be a single component instead of two. However, on the basis of the presence of older radiocarbon dates, and the absence of historic remains in component B as well as other archaeological aspects (*e.g.,* zooarchaeology, proportion of lithics raw materials) support the identification of two components.

Variable		Style							
		PAT		MP		OV		RP	
Thickness average mm		4.8		5.6		5.8		4.3	
Residues		3		1		1		0	
		Count	%	Count	%	Count	%	Count	%
Temper size	F	18	64.3	8	72.7	4	50	0	0
	M	10	35.7	3	27.3	4	50	1	100
Surface treatment	S	2	6.3	2	14.3	7	77.8	0	0
	P	30	93.8	12	85.7	2	22.2	1	100
Section	S	27	84.4	11	78.6	9	100	1	100
	R	5	15.6	3	21.4	0	0	0	0
Decoration	I	9	90	0	0	0	0	0	0
	P	1	10	0	0	0	0	0	0
Firing	O	2	6.3	1	7.1	1	11.1	1	100
	OI	13	40.6	7	50	4	44.4	0	0
	R	17	53.1	6	42.9	4	44.4	0	0

Tab. 9. Ceramic sherd properties from the Salamanca cave site. References:* F *fine;* M *medium;* P *polished;* S *smoothed;* PAT *Early Ceramic Period;* OV *Overo;* MP *brown polished;* RP *red polished;* O *oxidized;* OI *oxidized incomplete;* R *reduced;* I *incised;* P *painted, in section* S *sherd,* R *rim.

Obsidian trace element analysis indicates an increase in the use of raw material sources during the Late Holocene. Component C has the presence of Coche Quemado and Las Cargas sources, while components A and B incorporate at least four obsidian sources in low frequencies. Specifically, in component A, obsidian artefacts from Laguna del Maule 2 are recorded. This source was located in the Barrancas and Colorado rivers at a distance between 100 and 160km (*Barberena*

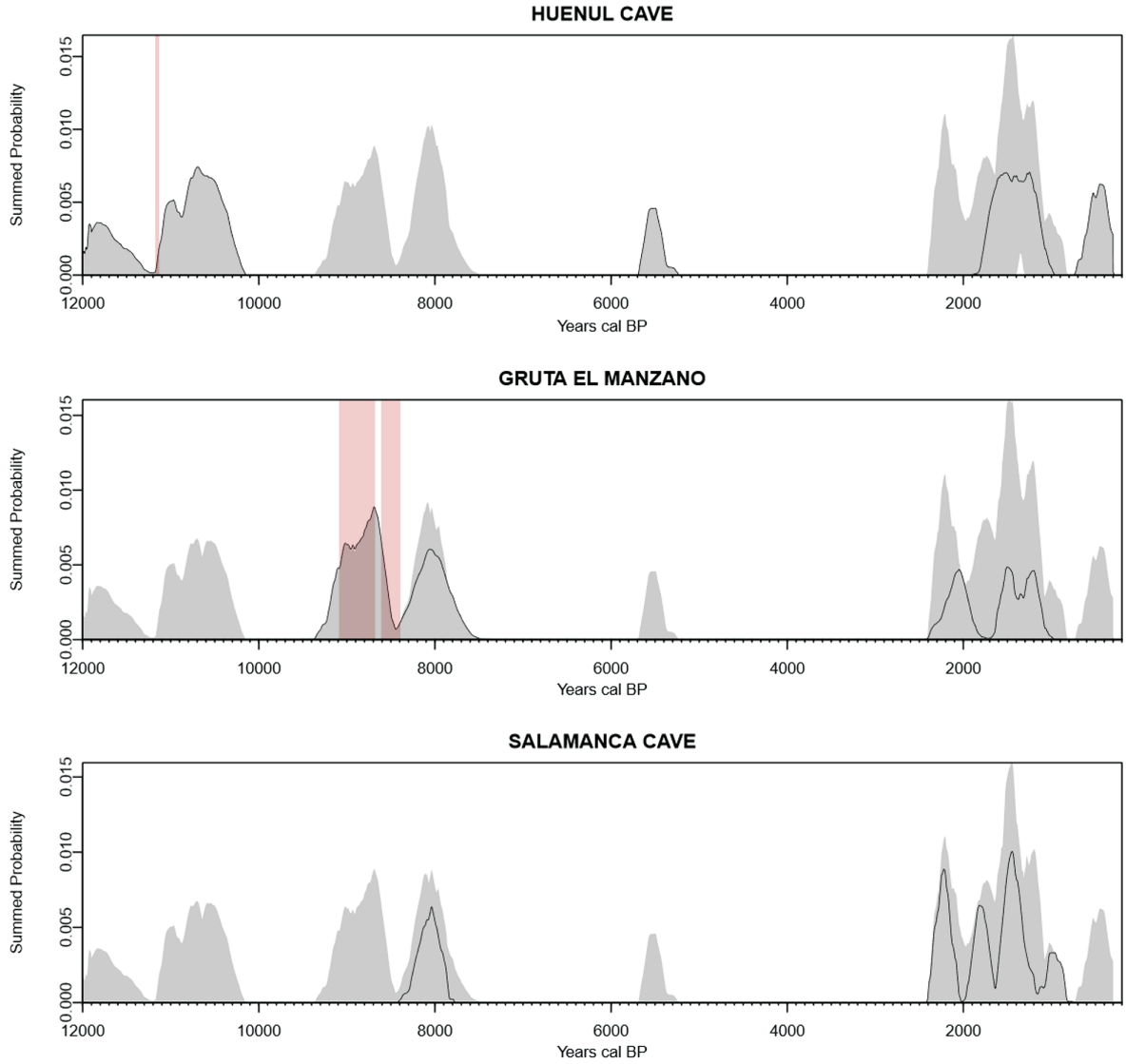


Fig. 12. Permutation tests showing variation between regional population growth. Grey areas represent the confidence envelope for the null model, red areas represent where the empirical SPD significantly deviates from the null model. The black line represents the empirical SPD for each archaeological site (*Crema, Bevan 2021*).

et al. *2019*). The presence of debitage from this source could indicate a home range increase, or greater human interaction with populations located to the south.

The ceramic sherds appear from level one to level twelve, radiocarbon dated in 1530 years BP. The presence of ceramics in the latter components could reinforce the idea of a higher number of subsistence activities, reflected in the mentioned number and diversity of both the faunal and lithic records. In addition, the ceramics recovered show high manufacture inversion, as reflected in the average thickness (4.9mm), surface treatment (79% polished), temper size (63% fine) and firing (40% reduced). Following Sturm *et al.* (*2016*) this conjunction of traits on the ceramic assemblage suggests a high reuse of vessels, probably for several years. The high proportion of non-local ceramic (mainly from the Chilean side of the Andes) indicates a high value of this technology in the area, not only for subsistence but also for trade networks. These networks could have worked like the Hxaro system (*Weisner 2020*), in which the interchange of gifts assured the access to complementary environments when conditions of rainfall and resources got harsh (*Neme, Gil 2005; Eerkens 2011*). El Manzano cave (90km to the south) registers a highly diverse ceramic assemblage made up of non-local types, suggesting that the northwestern Patagonia ceramic assemblages were obtained mostly from neighbouring societies. The sites located in the Andean Piedmont from northwestern Patagonia

are among the more diverse in faunal taxa, and probably plant resources too (*Neme* et al. *2011; Llano 2011; Llano, Barberena 2013; Otaola* et al. *2015*).

The Late Holocene archaeological record in Salamanca cave (components A and B) suggests a major change after the Middle Holocene gap. The described species faunal consumption in component C indicates a narrow dietary focus on guanaco and armadillos. These two species are placed at the top of the regional faunal ranking (*Corbat* et al. *2021*), and represent more than 90% of the total NISP in component C, while in later components A and B, those species represent only 50% and 40%, respectively. This change shows a broader diet later, and an increase in the consumption of lower return rate species such as chinchilla, birds and probably carnivores too. This change in favour of a broader diet in later components is in agreement with the intensification process proposed for the region for the last 2000 years BP (*Neme 2007; Neme, Gil 2008a*). This intensification process was criticized by latter research, arguing that it could be an effect of the spatial scale considered, instead of the diminution in guanaco population by human hunting pressure (*Otaola* et al. *2015; Wolverton* et al. *2015*). However, the faunal changes that took place from the same sequence in Salamanca cave are in agreement with the intensification process. A recent ancient DNA guanaco study (including some samples from Salamanca cave sequence) also demonstrate the existence of a decline in guanaco population in northwestern Patagonia during the las 2500 years BP (*Abbona* et al. *2021*), reinforcing the proposed regional intensification process.

The implications of these intensification processes move beyond the faunal, and are in line with other changes identified in Salamanca cave. Among them are the increase in obsidian use, the presence of Pacific mollusc shells, and the introduction of Chilean pottery during the last 2200 years. Those records show the inclusion of more diverse and distant sites of acquisition, including new obsidian sources, molluscs, and Chilean ceramics, suggesting the establishment of a stronger regional network, which allowed regional hunter-gatherers access to non-locally available resources. The increase in utilitarian pottery, especially in component A, indicates new resources being processed (including plants not yet analysed in Salamanca). The human occupations are more redundant and possibly longer than those from earlier times, which is concordant with the increase in the discard rate mentioned in this paper.

The presence of shelters, water, raw materials, and the biological diversity could favour human occupation in places like Salamanca cave, El Manzano cave, Cueva de Luna, El Chacay, Cañada de Cachi or Puesto Carrasco. There is an important plant record in the sequence, some burnt, but not analysed yet. Perhaps, the vegetal resources at the site can explain the occurrence of ceramic sherds, with the ceramics used to process, transport or store seeds.

Final remarks

The Andean Piedmont in northwestern Patagonia has diverse and rich resources. Located between the Andean foothills and the Lowlands, it allows access to wide and varied faunal, plants and lithic resources. The predominance of Patagonia phytogeography province ensures an abundant guanaco presence, as well as armadillos, and Rheidae, the three top ranking animals of the region. The characteristics of the Salamanca archaeological record agree with most of the Piedmont excavated caves, which shows a wide diversity in their faunal, lithic and ceramic record, and intense signal of human occupations (*Gambier 1985; Durán* et al. *1999; Durán 2000; Neme* et al. *2011; Barberena 2015*). The chronological sequence follows a common pattern among the caves in the region. After a first increase of human occupation, during the colonization *c.* 7300 years BP, the archaeological record discontinues until *c.* 2200 years BP.

In Salamanca cave, the observations made on the stratigraphy shows different post-depositional processes that altered the sediments and disposition of archaeological materials. Human groups carried out a diverse set of activities on the site, including those related to food (animal and plant) acquisition and processing, as well as lithic tool preparation and maintenance. The ceramic diversity indicates that cooking, transport and storage were part of the subsistence activities.

The fauna analysis shows a strong exploitation of middle size mammals at the beginning of the sequence, especially armadillos, which changes in favour of chinchilla towards the last two millennia. Beyond this trend, as in many other northwestern Patagonian environments, camelids were the base of human subsistence.

The lithic assemblage shows an increasing use of non-local raw materials, consistent with the observations in other sites from the region. The artefac-

tual categories suggest the presence of the last stages of the operative sequence, formalisation and reactivation of tools. The few ceramic sherds and their attribution to styles from the western side of the Andes reinforce the idea of the high investment and low production scale for this type of technology, incorporated mainly from exchange.

Finally, the archaeological information from Salamanca cave indicates that the site was occupied by hunter-gatherer groups which colonized and occupied the Andean Piedmont environment, facing environmental constraints, especially during the Middle Holocene. The lack of a Middle to Late Holocene sedimentary record is a hindrance to interpreting cultural discontinuities (*Veth* et al. *2017*). Salamanca cave also provides insights on the important challenge related to the resource structure and demographic dependent factors, and especially the intensification process, which forced changes in resource use, technology and human relations with neighbouring populations, increasing long distance exchange. Future excavations, as well as the use of new methodology, will allow us to confirm and reject some of the ideas presented here, and improve our comprehension of the complex site formation processes.

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Knap & keep: Late Palaeolithic-Neolithic caches, Far East

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ABSTRACT – *The tradition of lithic caches illustrates a special strategy of storing lithics which were extracted from* chaîne opératoire *for some time to be kept/hidden in a special place with/without subsequent return and use. For the Palaeolithic – Neolithic/Jōmon of the Far East (Russian part and the Japanese Archipelago) within the frame of 35 000–2400 cal BP, this tradition demonstrates an impressive multiplicity (more than 400 cases), high diversity, duration, dynamics, and local variability. Such an abundant source of data opens rich perspectives for detailed technological analysis, functional interpretations, and interregional correlations, with analogies in the Stone Age cultures of the Near East, Europe, and North America.*

KEY WORDS – *Far East; Late Palaeolithic; Neolithic; Jōmon; lithic caches; technology*

Odbij in shrani: pozno paleolitski-neolitski depoji na Daljnem vzhodu

IZVLEČEK – *Tradicija depojev kamnitih orodij ponazarja posebno strategijo shranjevanja teh predmetov, ki so bili za nekaj časa izvzeti iz operacijske sekvence z namenom, da se jih shrani/skrije na posebnem mestu z/brez naknadne uporabe. Ta tradicija iz paleolitika-neolitika/obdobja Jōmon na Daljnem vzhodu (del Rusije in otočje Japonske), ki je trajalo od 35 000 do 2400 pr. sed., kaže na impresivno število teh depojev (več kot 400), njihovo veliko raznolikost, trajanje, dinamiko in lokalne posebnosti. Tako bogat vir podatkov nam odpira širok vidik za podrobne tehnološke analize, razlage o funkciji in medregionalne povezave z analogijami v kamenodobnih kulturah na Bližnjem vzhodu, v Evropi in v Severni Ameriki.*

KLJUČNE BESEDE – *Daljni vzhod; pozni paleolitik; neolitik; Jōmon; depoji kamnitih orodij; tehnologija*

Introduction

Caches of various types of artefacts are one of the most interesting and intriguing archaeological finds. In many cases they are unpredictable, unexpected and, very often, accidental, especially, when we are dealing with the Stone Age period. While extremely spectacular, examples of lithic caches consisting of highly elaborated bifacial points are known for the Solutrean culture (Volgu) in Europe (*Thévenot* et al. *2019*), and for the Clovis (Anzick, Fenn, Richey-Roberts *etc*.) in North America (*Frison, Bradley 1999; Huckell, Kilby 2014*). There are also many manifestations of caching strategy in other parts of the World (Eastern Europe, Near East, Mesoamerica, Siberia, Central Asia and Far East). Chronologically lithic caches are mostly connected with the Middle-Late Palaeolithic and the Neolithic periods; they illustrate special technological decisions both for mobile and sedentary users, and, in terms of econo-

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mical context, lithic caches are typical both for the hunter-gatherer and agricultural societies.

So far, the data about lithic caches dated by the Palaeolithic – Neolithic/Jōmon times on the territories of the Russian Far East and the Japanese Archipelago is presented only in a preliminary form in a series of articles. Most of these, with a very few exceptions (*e.g., Dyakov 1997; Kanomata, Tabarev 2020*), are in the Russian and Japanese languages and not known by a wide archaeological audience.

It is noteworthy, however, that the first information about the accidental find of a lithic cache (Narukasanka) comes from as early as the second half of 19th century. According to the publication of Nobutaro Ono (*Ono 1897*)[1], somewhere between 1865–1867 and while digging an irrigation channel near the villages Naruka and Sanka (Fukui prefecture), local farmer Kanji Nozawa discovered a huge stone axe (54cm) arranged upon two chipped pebbles and about 30 arrow-points (Fig. 1.1–2)[2].

The evidence of possible lithic caches in the Russian Far East appeared in the archaeological literature only in the 1950s and 60s due to the later start of wide-scale field investigations in the region as a whole. One of the first hints of caches is connected with the finding of a large leaf-shaped biface artistically made from the local grey chert on Sakhalin Island[3] – its length (32.5cm), thickness (0.7cm), and sophisticated technology of pressure flaking puts this find on a par with the best Solutrean and Clovis (Paleoindian) bifacial points. Note also the general morphological similarity of the point from Sakhalin with the points from Narukasanka cache (Fig. 1.3).

Since these early discoveries the information on lithic caches in the Russian Far East (Amur Region, Maritime Region, Sakhalin Island, Kamchatka Peninsula) and, especially, on Japanese Islands (from Hokkaido to Kyushu) significantly increased, and a concentrated focus on the archaeological collections and reports of excavations allowed us to identify data on numerous (more than 400) finds and features of the Late Palaeolithic-Neolithic/Jōmon sites which match the characteristics of a 'lithic cache'[4]. This list includes only finds that are not related to the burial context, and are not the part of burial offerings.

On the one hand, such rich material requires detailed technological use-wear analysis, classification and contextual subdivision, regional and inter-regional correlation. On the other, and the authors put a special emphasis on this, it creates unique prerequisites for the interpretation of behavioural attitudes (the 'knap & keep' strategy) within the economic and ritual activities of hunter-gatherers-fishers. The following overview of the caches in the Russian Far East will be done in more detail, while for the caches on Japanese Islands we will try to demonstrate the statistical data, contextual tendencies and local technological variabilities.

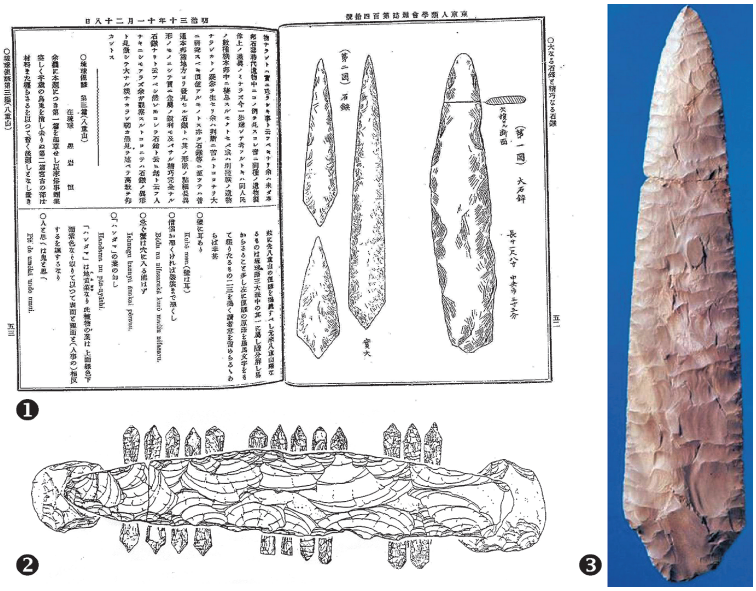


Fig. 1. **1,2** ***First publication and reconstruction of the Narukasanka cache, Japan; 3 bifacial point, Sakhalin Island.***

1 The detailed story about the Narukasanka cache, along with photos and drawings, was published in a special paper in late 20th century (*Matsui 1980*).

2 If the dates (1865–67) are correct the cache in Japan was found even earlier than the famous Volgu cache in France (1874).

3 The artefact has no documentation, but with high probability was located within a destroyed archaeological site near Nogliki village (Sakhalin Island) in the mid-1950s and could be dated to the Early Neolithic (11 000–9000 BP). Currently the biface is on show in the Archaeological Museum, Institute of Archaeology and Ethnography, Novosibirsk, Russia (*Tabarev 2012*).

4 The language aspect of the problem is also important: the Russian word 'klad' means "*something very precious for the owner and hidden, buried in the ground*". The term 'cache' in the translations of Russian archaeological articles into English is in recent use, and before this the authors preferred another word – 'hoard' – for special finds of bronze or gold items. In the Japanese language the English word 'cache' is equivalent to 'Intoku Ikou' and 'Heitan ikou' (caching feature).

Evidence of a caching strategy on the territory of the Russian Far East

It would be logical to preface an overview of lithic caches on the territories of the Russian Far East with some information about similar complexes known in Siberia and Mongolia. They confirm the very early and wide geographical spread of this tradition.

Several finds were mentioned in the archaeological literature devoted to the Palaeolithic of Kemerovo District (Western Siberia) in 1960 – *e.g.*, a complex of 19 preforms and tools near Ail village, and a possible cache of eight tools near Shestakovo village (*Okladnikov 1968*).

Another remarkable discovery was made during the excavations of Tumulur site (Aldan River, Yakutia)[5] in Strata IV within the Upper Palaeolithic context belonging to Dyuktai culture. Eight lenticular bifaces (from 7 to 13cm long) were located in a compact cluster (20x25cm), and due to the absence of any dwelling or hearth features the researchers interpreted them as a possible cache (*West 1996.197–198*).

The first Palaeolithic cache within a clear stratigraphic context was found in Northern Mongolia (the Tolbor river valley) in 2010 – it consists of 57 standard flakes carefully piled in a shallow pit (30x30cm), and could be connected to the local hunting activities within the frame of 27 000–17 000 cal BP (*Gladyshev* et al. *2011; Tabarev* et al. *2013*). Recently, one more cache (11 core preforms from local jasper) was found in Southern Mongolia (Gobi) by a joint Polish-Mongolian expedition and preliminary dated by the Middle Palaeolithic (*Masojc 2019*).

Directly on the territory of the Russian Far East, several sites with lithic caches of various type, content, and location have been recorded there (Fig. 2). The most obviously interesting of these is Novopetrovka-II, one in a series of sites excavated in the Middle Amur stream near Blagoveshchensk during the 1960s. These sites belong to the Novopetrovka Neolithic culture (Novopetrovka 'blade culture') which is dated by charcoal and charred remains on pottery to between 12 600 and 10 800 cal BP (*Derevianko* et al. *2020*). The first cache was found on the floor of dwelling #2 in a small pit (40cm in diameter), and consists of seven blade cores with the negatives of recent removals and one blank for the core (Fig. 3.1; *Derevianko 1970.42–44*). Two more similar pits with lithic caches (about 10cm deep and 35cm in diameter) were described in dwelling #4 – both included three blade cores each in the initial stage of the exploration (*Derevianko 1970.66–67*).

The next evidence of caching is connected to the Lower Amur region (near Khabarovsk), where since the 1920s archaeologists have studied the sites of the Osipovka culture. It was successively identified as Palaeolithic, then Mesolithic, and – after the discovery of early pottery – as the Initial Neolithic, and dated between 14 200–9900 cal BP. Despite the long history of exploration and representative archaeological collections a data connected to the lithic cache only appeared in 2015 in the course of the excava-



Fig. 2. Russian Far East. Sites with the caches listed in the text. **1** ***Novopetrovka-II;*** **2** ***Osinovaya Rechka 10;*** **3** ***Ustinovka IV;*** **4** ***Ustinovka III;*** **5** ***Ushki I.***

5 Tumulur site was discovered in 1964 and studied during 1964–1982. It is dated between 16 600–13 600 cal BP.

tions at Osinovaya Rechka 10 site[6]. Three bifacial artefacts (axes) were found stacked in a pile in the very southeast part of the unit in layer 4 (*Hashidume* et al. *2019.27, 36–37, Pl. 2*). The context does not point to any special pit or dwelling floor (Fig. 4.1–3).

Two examples of lithic caches are known in the Maritime Region. Both were recorded at the sites of the Ustinovka group (complex) in the Zerkalnaya River Valley. The sites are dated between 18 000–10 000 cal BP, and demonstrate the transition from the Final Palaeolithic to Early Neolithic periods. In 1997 Vladimir I. Dyakov (Fareastern Federal University, Vladivostok) published a short paper in English about the excavations at the Ustinovka IV site with a brief description of the compact complex (30x 30cm) of eight bifaces grouped around the biggest one which, possibly, was set vertically. According to the author, this complex was located between the depressions of dwellings #1 and 3, although no photos or drawings have been presented which confirm this observation (*Dyakov 1997.20*). In a later version, Dyakov clarified that the central biface (10.3cm) was erected on a small 'pedestal' with a height of 6cm. He again gave no photos or figures with the original position of the complex, but only the plan of the unit and schematic drawings of only seven (of eight) bifaces (*Dyakov 2000.41–42, 193*). Unfortunately, there are no carbon dates for the sites and its age (14 000–12 000 cal BP) is determined solely based on analogies with neighbouring complexes in Zerkalnaya River Valley.

Another location about 1.5km from Ustinovka IV site, namely Ustinovka III, was discovered during the early 1960s and excavated over several research cycles. The last one was conducted by a joint Russian-Japanese expedition and took place from 1992–1997. It was crowned with the discovery of the earliest Neolithic pottery for the Maritime Region[7]. Moreover, according to the related publications during the 1995 field season in the northwestern part of the unit specialists located *in situ* a concentration (44x36cm) of lithics, including 171 flat flakes (11x8–7x7cm) in a very dense context, which was interpreted as a "*cache of flakes hidden in container, possibly a kind of leather bag*" (*Derevianko, Kononenko 2003.68–69; Kononenko 2001.47*). Unfortunately, even in this case only a description, statistical data and an approximate drawing are available to readers (Fig. 3.2).

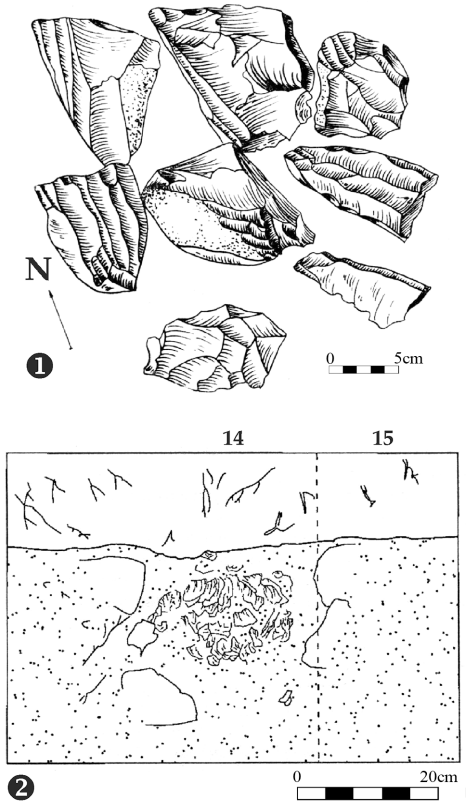


Fig. 3. Russian Far East.* 1 *Cache of cores at Novopetrovka II;* 2 *Cache of flakes at Ustinovka III.

A large cluster of multilevel settlements near Ushki Lake on Kamchatka Peninsula has been under permanent archaeological research since 1961. All levels (VII-I) vividly illustrate the development, evolution, and peculiarities of the Final Paleolithic-Neolithic cultures (various types of dwelling constructions, burials with rich offerings, adornments, working areas, storage pits, *etc.*). In 1983 during the excavation of the entrance of sub-terranean dwelling #9 (*i.e.* cultural complex of Level VI, 12 200–11 600 cal BP; *Ponkratova, Chachula, and Clausen 2021*) at the Ushki I site, archaeologists met with a compact set of 12 bifacial preforms for microblade cores. They were made from local grey chert and technologically are very similar to the microblade cores explored in frames of the Yubetsu technique which is typical for the Final Palaeolithic of the Japanese Islands. These cores were described in several articles about Ushki I Site, but the exact context of the feature became known only recently after the pub-

6 Osinovaya Rechka 10 was a part of multi-year joint Russian-Japanese archaeological project. There are two carbon dates for the site: 11 150–10 930 cal BP and 13 094–12 952 cal BP.

7 The authors published two dates for Ustinovka III site – 10 500 (OSL) and 9305±31 BP (^{14}C) (*Kononenko 2001.46–47*).

lication of the photos and drawings from the original field report (Fig. 5.1–3; *Fedorchenko, Belousova 2020.314*).

Thus, despite the small number and incomplete documentary support for all the finds (exact provenience, detailed photos, and drawings, *etc.*), the strategy of lithic caches on the territory of the Russian Far East demonstrates a long technological tradition and contextual/functional variability. There are caches of preforms (cores, flakes) and finished tools (bifaces, axes), caches in association with dwelling constructions and without it, technical (prosaic) caches kept for further use, and caches of ritual arrangements.

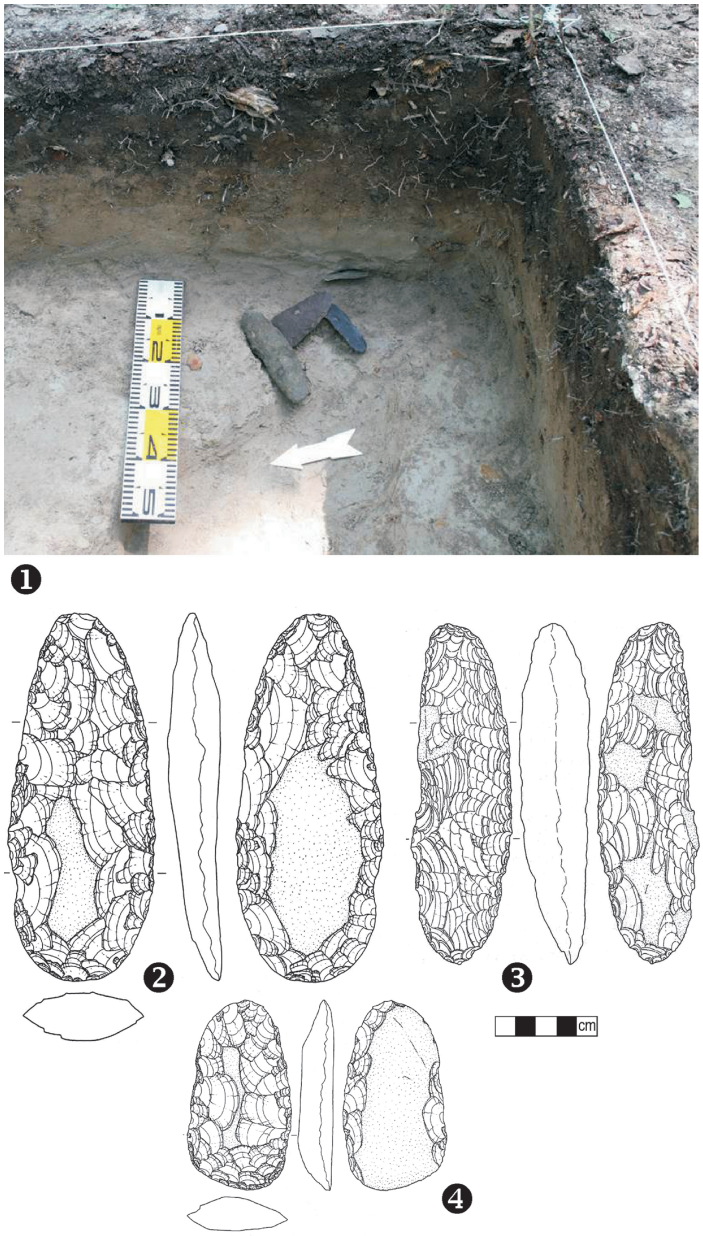


Fig. 4. Russian Far East. Osinovaya Rechka 10.* 1 *Position of the cache;* 2-4 *tools from the cache.

Lithic caches in the Palaeolithic-Jōmon, Japanese Islands

In comparison with the continental part, the archaeological data on the number of lithic caches on the Japanese Archipelago is impressive – even according to the preliminary statistics for the Late Paleolithic-Neolithic (Jōmon) period there is information about at least 420 features. A total of 316 features at the sites and in the form of separate complexes have clear provenance and field documentation. This number will be used for the statistics[8] in the current study, and some major sites illustrated in the text are marked on the map shown in Figure 6.

At least 13 caches are recorded in the archaeological literature and reports for the Late Palaeolithic (35 000–16 000 cal BP) – some of them are presented by concentrations of tools (axes with polishing edges and trapezoidal flakes) (Hinatabayashi site, Nagano; *Tsuchiya, Tani 2000*), but most of these finds consists of raw material (obsidian in particular; Shirataki-Hattoridai 2 site, Hokkaido; *Naoe, Suzuki 2007*) or preforms of cores (Onbara 1 site, Okayama; Fig. 7.1; *Inada* et al. *2009*), which correlates with the strategy of highly mobile hunter-gatherers.

The amount of data on lithic caches increases significantly in the subsequent period of the Stone Age on the Japanese Islands – Jōmon (16 000–2400 cal BP)[9]. Twenty-three cashes are known for the Incipient Jōmon (16 000–10 000 cal PB) and 24 for the Initial Jōmon (10 000–7000 cal PB). Climatic changes and the gradual transition to a sedentary way of life are logically reflected in the evolution of the lithic technology and hunting gear. This is vividly illustrated by the spectacular caches with artistically made spear points (Fig. 7.2; Mikoshiba site, Sonoda site; *Hayashi* et al. *2008; Tahira, Nohira 2004*), large bifacial cores and bifacial tool blanks (Nogawa, Kashiwabara, Sendai-Uchimae, Iwase), and big polished and chipped axes (Fig. 7.3; Hinata Cave, Nana-

8 In our article we prefer to use the data from multiple reports of the excavations.

9 Chronological frames for Jōmon and its sub-periods (Incipient, Initial, Early, Middle, Late, and Final) according to Omoto *et al.* (*2010*).

tsuguri, Karasawa B site) found in the southern, central, and, especially in the northeastern parts of Honshu Island (*Sagawa, Suzuki 2006; Kanomata 2008; Hayashi* et al. *2008; Nakamura, Tsuiki 2008; Shimamuro* et al. *2009*). Another group of caches is represented by compact features with raw material cobbles, preforms of cores and tools, flakes, and instruments (arrowheads, scrapers, knives, adzes, *etc.*) in special pits directly in the dwellings or near the living areas.

In the case of caches with polished axes some specialists suggest their symbolical meaning and connection with ritual exchange by analogy with stone and shell axes in Island Southeast Asia and Oceania (*Kaner, Taniguchi 2017.328*). In turn, large bifacial cores and points attracted the attention of experts due to the amazing similarity with the artefacts in Clovis caches, and the discussion about the origin of the latter in Solutrean technological complex in Western Europe (*Kornfeld, Tabarev 2009*).

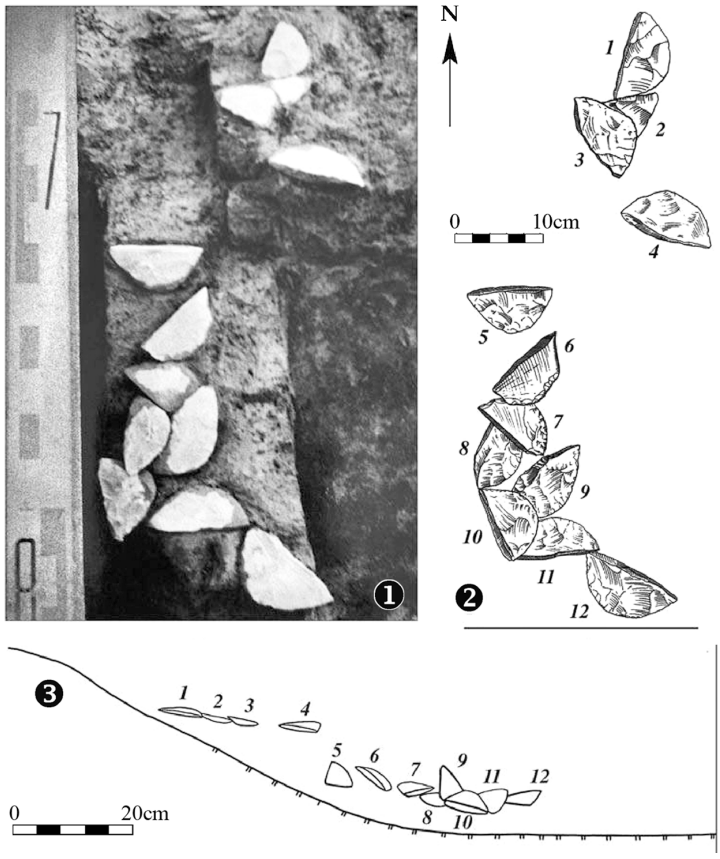


Fig. 5. Russian Far East. Ushki I. 1 Position of the cache with the microcores preforms; 2-3 drawings of the feature.

The significant shift to sedentism with the development of large multi-dwelling settlements in the inland and, first of all, coastal areas, took place in the Early Jōmon (7000–5400 cal PB). The number of known lithic caches is growing (33), and the overwhelming majority of them are connected with the special pits in dwelling structures – *e.g.*, specialized caches of six adzes at the Minamitashiro site (Kagoshima; *Miei* et al. *2005*), caches with various tools and blanks at the Karasuno-uwadai site (Akita; *Shinkai* et al. *2006*) and the Ondashi site (Fig. 7.4; Yamagata; *Sato* et al. *1990*), caches of flakes and raw material (obsidian) at the Shutoyabayashi site (Nagano) (*Kobayashi, Naoi 1982*) and the Choshichiyachi site (Aomori; *Kurimura* et al. *1982*).

Middle Jōmon (5400–4300 cal PB) was the most comfortable time in terms of climate and variety of biological resources. This is confirmed by various data on population growth, the number and size of settlements along with the evolution of social complexity. Therefore, despite the shorter than Initial or Early Jōmon duration, Middle Jōmon presents information on about 137 lithic caches (more than 40% of the total amount) recorded all over the territory of the Japanese Islands. The variety of caches is connected to the multiplicity of activities of hunters, gatherers and fishers, while it also corresponds to local differences in raw material quality and availability. The tradition of caches of bifacial blanks and tools continues in Northeastern Japan, *e.g.*, a cache of 29 items at the Tsukinoki site (Fig. 7.5; Aomori; *Ichimachida, Hatakeyama 1983*), while the other caches demonstrate the deposits of obsidian cobbles (Obora site, Nagano; *Ichizawa* et al. *1987*) or flakes (Ota site, Akita; *Yachi, Osanai 1991*)[10], adzes (Kabuttsuppara site, Yamanashi; *Yamamoto, Imahuku 1992*) or points (Ueshimizu 4 site, Hokkaido; *Koshida* et al. *1991*), or even special tool-kits, hidden in clay vessels (Musashidai site, Tokyo and Tsukakoshi-mukoyama site, Saitama; *Sakazume* et al. *1991*).

The Late (4300–3200 cal PB) and Final (3200–2400 cal PB) Jōmon sub-periods are characterized by colder temperatures, visible decrease in population and a local fragmentation of cultural characteristics, and more than 50% of all the Final Jōmon sites are in northern Honshu. The lithic caching is confirmed by

10 From several dozens to several hundred in each cache.

66 examples at the Late and at least 20 at the Final Jōmon sites from Kyushu in the south to Hokkaido in the north. In terms of content, lithic caches demonstrate the keeping of raw materials and flakes (Komakino site, Aomori; *Kodama 2006*), core preforms and tool blanks (*e.g.*, Ichinohara site, Kagoshima; *Shigemasa* et al. *2006*), along with caches of arrowpoints and axes/adzes (Fig. 7.6; Fujiishi site Shizuoka, Ahyou 6 Ku site, Iwate; *Katsumata* et al. *2012; Segawa* et al. *2000*). Of special interest are caches of neatly polished axes and chisels placed as precious and prestige items in ceramic vessels (Shudainojo site, Akita; *Sugawara, Yasuda 1992*).

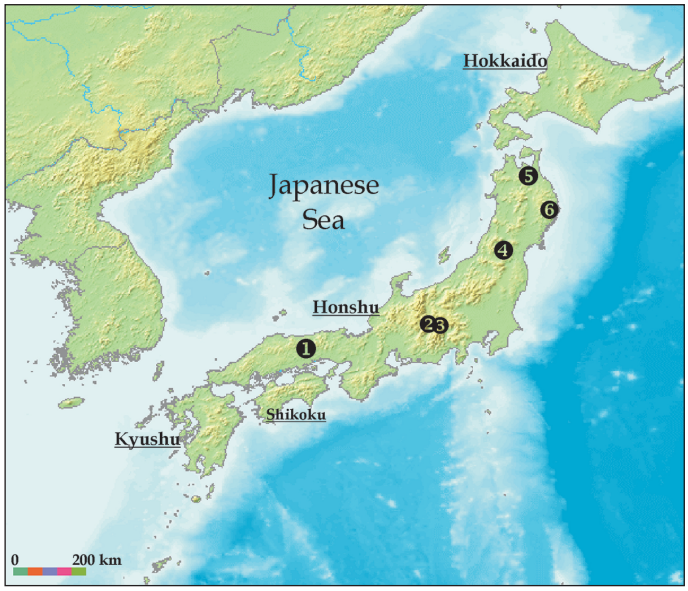


Fig. 6. Japanese Islands. Sites with caches illustrated in the article.* 1 *Onbara 1, Okayama;* 2 *Mikoshiba, Nagano;* 3 *Nanatsuguri, Nagano;* 4 *Ondashi, Yamagata;* 5 *Tsukinoki, Aomori;* 6 *Ahyu 6 Ku, Iwate.

This review of the Palaeolithic – Jōmon lithic caches clearly shows that these materials are an extremely informative research base. It is clear that the high acidity of far eastern soils prevents the preservation of any organic materials in the caches (bone, antler, wood, *etc.*), which could represent instruments for knapping and pressure[11], leather or bark containers for keeping items, and, in some cases, burial contexts and burial offerings. Despite this, lithic caches illustrate the wide range of technological and behavioural aspects of culture.

Conclusions and perspectives

The tradition of lithic caches in the Palaeolithic – Neolithic of the Far East demonstrates their multiplicity (more than 400 cases), high diversity, duration, dynamics, and local variability. As a historical phenomenon it fully meets the longue durée model requirements. In terms of archaeology, we are dealing with the special strategy of storing lithics which were extracted from *chaîne opératoire* for some time to be kept in a special place with/without subsequent return and use.

The further research perspective includes three important directions. First of all, it is necessary to study the 'biography and anatomy' of lithic caches which suggest the detailed technological analysis of the artefacts, dating of caching features, raw material tracking, contextual data, and use-wear study. The last method, for example, can help to figure out if some of the tools were in use right before caching (*Kanomata 2010*).

Secondly, it is extremely important to understand and interpret the functional division of lithic caches. There are several theoretical approaches to this problem in the archaeological literature devoted to the caches in the other regions of the world. For exam-

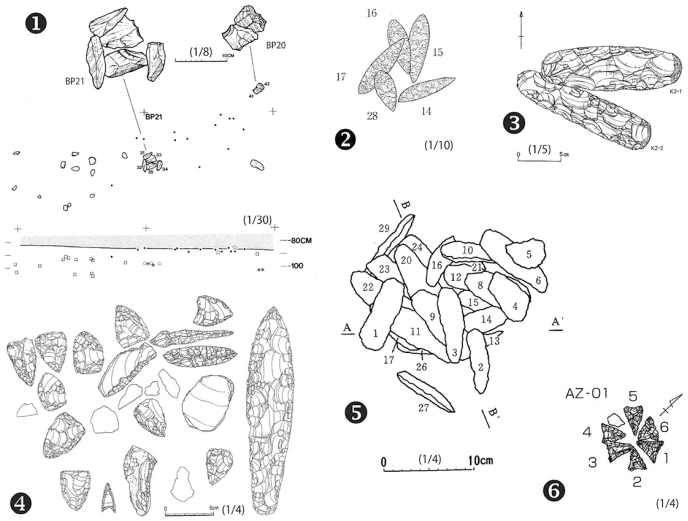


Fig. 7. Japanese Islands. Lithic caches.* 1 *Onbara 1, Palaeolithic, preforms of cores;* 2 *Mikoshiba, Incipient Jōmon, bifacial points;* 3 *Nanatsuguri, Incipient Jōmon, axes;* 4 *Ondashi, Early Jōmon, tools and blanks;* 5 *Tsukinoki, Middle Jōmon, axes;* 6 *Ahyu 6 Ku, Late Jōmon, arrowpoints.

11 Such instruments are known, for example, for some Clovis caches (Anzick, Richey-Roberts) in North America (*Clovis Caches 2014*).

ple, some researchers working with the materials of Pre-Pottery Neolithic B (PPNB) in the eastern Mediterranean distinguish 'deposits' (*dépôts*) composed of a series of homogenous items, 'reserve' (*réserve*) comprising a wider, heterogeneous set of selected preforms, and 'caches' as a whole package hidden for a specific (secret, ritual, ceremonial) reason (*Astruc, Ibáñez, and Gonzalez-Urquijo 2003.70*). According to another model with the subdivision into *functional* (stocks) and *symbolical* (caches) meanings, stock includes 'deposits', 'reserves' and 'hoards' (*Barzilai, Nigel Goring-Morris 2007.280*). The term 'cache', for many scholars, is connected to various forms of ritual or ceremonial activities. For example, caches of highly elaborated obsidian bifaces or prismatic blades in the Maya area (Mesoamerica) may be 'dedicatory caches' (prior the construction of any sacred building or temple), or 'intrusive caches' (placed into the existing structure). Both types of caches were prepared for special occasions and with final destination without return (*Kunen, Galindo, and Chase 2002*). Any of these approaches and models could be useful for the functional division of the far eastern lithic caches.

Third, it may be very interesting and productive to correlate the data on the far eastern region with the neighbouring territories, such as the Korean Peninsula, where the information of lithic caches is still waiting for the study (*Seong 2015*), and with the other regions of the world (Near East, Europe, *etc.*). Recent experience of the comparisons of the Clovis Paleoindian in North American caches, and Solutrean Volgu biface cache in France (*Kilby 2018*) fully demonstrates the promise of this approach, so the further study of the 'knap & keep' strategy awaits intriguing continuation.

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Archaeological traces of hunter-gatherer seasonal occupation in Western Coastal Estonia from the second half of the 6th millennium to the end of the 3rd millennium BC

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ABSTRACT – *Results of archaeological surveys of paleocoastlines in the Western Estonian Lowland are discussed with paleogeographic reconstructions. Mapped sites and stray finds can be dated to the period between the end of the Pre-Pottery Mesolithic and the end of the Neolithic (roughly 5300–2000 cal BC). Uniquely for Estonia and neighbouring countries in this time frame, the overwhelming majority of the sites are aceramic (and the rest feature very few pottery finds) and the find diversity is otherwise low, too. The findings are interpreted as traces of seasonal occupation and mobility, for the first time demonstrated in the Eastern Baltics on such a large scale.*

KEY WORDS – *hunter-gatherers; seasonal mobility; ephemeral sites; Narva Ware; Comb Ware*

Arheološki sledovi sezonskih poselitev lovcev in nabiralcev na območju zahodne priobalne Estonije od druge polovice 6. tisočletja do konca 3. tisočletja pr. n. št.

IZVLEČEK – *V članku predstavljamo rezultate arheoloških pregledov paleo-obale na območju Zahodnoestonske nižine in jih razlagamo s pomočjo paleogeografskih rekonstrukcij. Kartirana najdišča in naključne najdbe lahko datiramo v čas med koncem predkeramičnega mezolitika do konca neolitika (v grobem od 5300 do 2000 pr. n. št.). Velika večina najdišč je akeramičnih (ostala najdišča pa imajo zelo malo lončenine), pa tudi sama raznolikost najdb je majhna, kar je edinstvena značilnost za Estonijo in sosednje države v tem časovnem obdobju. Najdbe razlagamo kot sledove sezonske poselitve in mobilnosti, kar smo prvič pokazali za območje Vzhodnega Baltika v tako velikem obsegu.*

KLJUČNE BESEDE – *lovci-nabiralci; sezonska mobilnost; kratkotrajna najdišča; najdbe tipa Narva; glavničasta keramika*

Introduction

The current study presents new results of archaeological surveys in the Western Estonian Lowland (Estonia, Europe) at the eastern coast of the Baltic Sea (Fig. 1.A) conducted in 2015–2020. Although more than 400 Stone Age sites were previously known in Estonia (*Sikk* et al. *2020*), different parts of the country are studied to different extents (Fig. 1.B). The most understudied subregion is the Western Estonian Lowland that takes up most of the mainland coastline of Western Estonia between the Gulf of Finland and the Gulf of Pärnu, covering about 6000km^2 (about 13% of the area of Estonia).

In spite of the proximity of the much better studied Pärnu area to the south and the Western Estonian Archipelago to the west (Fig. 1.B) (*e.g., Kriiska 2001;*

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2003; Kriiska, Lõugas 2009), only four Stone Age settlement sites and one burial site (*Jalukse, Tõrv 2016.123*) were known before 2015 (*Kriiska, Mandel 1996; Kriiska* et al. *1998; Kriiska 2001.Fig. 3; 2001b.Fig. 4; 2004.172; Jussila, Kriiska 2004.13–15*), although the apparent need for surveying the subregion was recognized already in the 1930s (*Laid 1931.357–358*).

The aim of the present study is to map the Stone Age landscape use and its dynamics along the Baltic Sea paleocoastlines from the Litorina Sea Transgression Maximum (LTM) in about 5300 cal BC (corresponding to the Late Mesolithic in the Estonian archaeological periodization, Fig. 2) to the Limnea Sea development stage (final part of the Neolithic) in about 2000 BC (*Hang* et al. *2020; Kriiska* et al. *2020.17*). For that, two study areas were selected, covering more than half of the area of the West Estonian Lowland (Fig. 3).

Materials and Methods

As a prerequisite for the study, paleolandscape of the Western Estonian Lowlands was modelled basing on the LIDAR digital elevation model (DEM) and the Estonian Soil Map (*Estonian Land Board 2017. 2020*). The sea levels and locations of the coastline were reconstructed by the coast displacement curves for South-West Estonia (*Rosentau* et al. *2011*), Tallinn (Northern Estonia, *Muru* et al. *2017*) and Lake Veskijärv (northern study area, *Grudzinska* et al. *2013*), taking into account the post-glacial rebound (*Saarse* et al. *2003; 2006*). The paleosurfaces of the present-day raised bogs were reconstructed with the help of the Estonian Soil Map and the database of geological studies of Estonian peatlands (*Orru 2020*). No effort was taken to reconstruct past water levels of inland lakes as no paleolakes were included in the survey. All other topographic data is provided by the Estonian Land Board (*2021*).

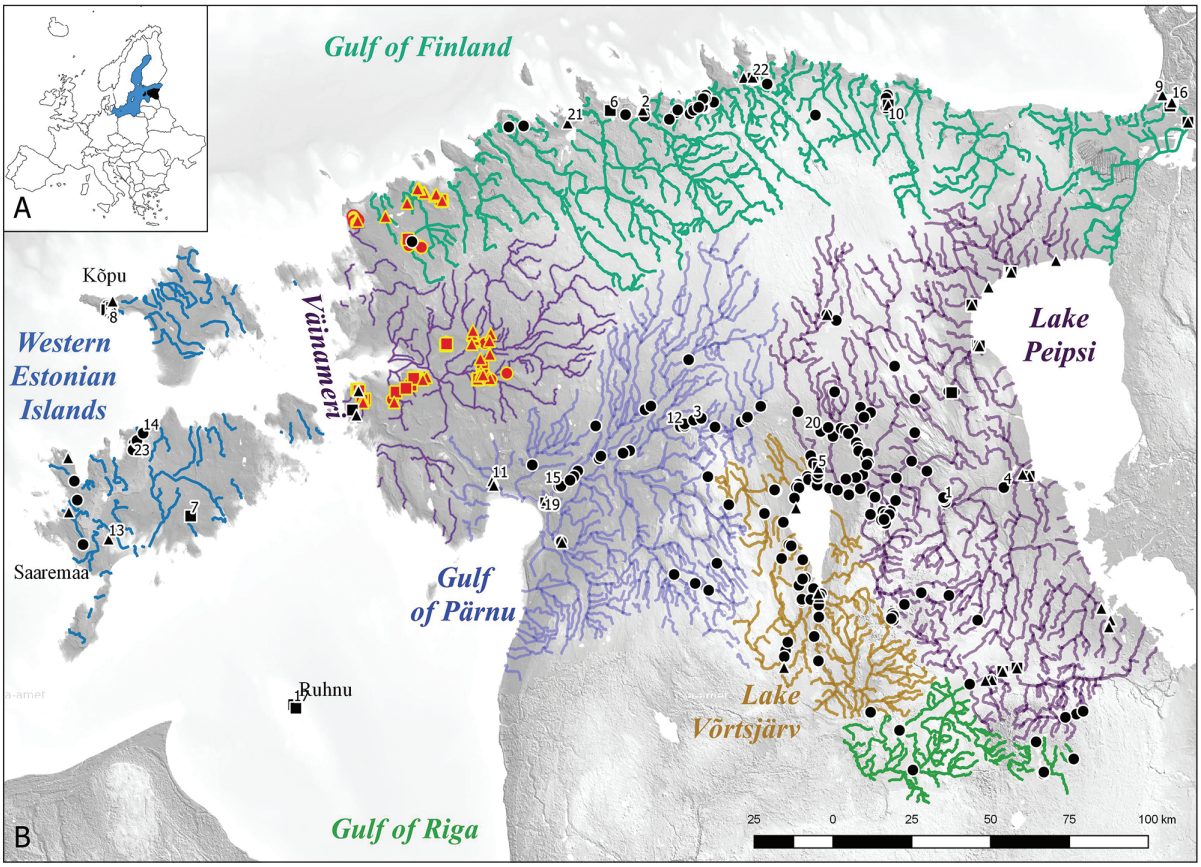


Fig. 1.* A *The location of Estonia (black) and the Baltic Sea (blue) in Europe.* B *Previously known (black) and newly discovered (red) Stone Age settlement sites projected onto the present-day Estonian grayscale elevation model together with water streams, divided by drainage basins by different colours.* Dots *Pre-Pottery Mesolithic,* rectangles *Narva stage,* triangles *Comb Ware stage. Numbers denote settlement sites mentioned in the article and not located on other figures:* 1 *Ihaste,* 2 *Jägala-Jõesuu sites,* 3 *Jälevere,* 4 *Kavastu,* 5 *Kivisaare,* 6 *Kroodi,* 7 *Kõnnu,* 8 *Kõpu sites,* 9 *Kudruküla,* 10 *Kunda Lammasmägi,* 11 *Lemmetsa sites,* 12 *Lepakose,* 13 *Naakamägi,* 14 *Pahapilli II,* 15 *Pulli,* 16 *Riigiküla I,* 17 *Ruhnu II,* 18 *Siimusaare,* 19 *Sindi-Lodja sites,* 20 *Umbusi,* 21 *Tallinn Vabaduse väljak,* 22 *Vihasoo III, and* 23 *Võhma sites.

Two main study areas (Fig. 3) were chosen to feature different landscape types (isthmuses, bays, river mouth lagoons, rivers, islands and islets at various distances from the mainland) characteristic to Coastal Western Estonia. The Litorina Sea paleocoastlines in the northern study area were fairly articulated, featuring two isthmuses embracing a wide bay, presently the Suursoo mire. Between the isthmuses, the paleocoastline of the bay is smooth, cut by several small streams. The biggest stream entering the bay is the River Vihterpalu, forming a lagoon at its mouth. This study area also includes the Elbiku paleoisland, separated from the mainland by some 15km of sea during the LTM. The southern study area is located south of the present-day Matsalu Bay. During the LTM, Matsalu Bay stretched about 25km further eastwards, being about 35km wide. Today, its eastern coast is well traceable as a wide arc of coastal formations between Üdruma and Avaste, cut by the River Kasari and its tributaries. Inside the bay, the present-day hills of Lihula, Lihutsi, Kloostri and Kasari formed an archipelago similar to the small islands in present-day Väinameri between the mainland and the island of Saaremaa. Some examined paleoislands (Massu, Salevere Salumägi) were situated outside of the bay in the open sea. In addition to these two main study areas, the shores of Kasari and Vigala rivers flowing to the southern study area were surveyed as far upstream as possible (about 17 and 44km from the paleocoast at Teenuse, respectively).

As no organics enabling radiocarbon dating were gathered from any of the sites, approximate dating is currently possible only by the coastline displacement model (*Jussila, Kriiska 2004*) and comparatively by archaeological finds. The elevation of a site was calculated as the mean elevation of its finds in masl without outliers (a Z-score smaller than –3 or larger than 3). For clusters of finds within the error margin of a single GPS point, only one point was used. For sites located at the paleocoast or in the coastal zone, the *terminus post quem* (TPQ) was calculated. The minimum elevation of the finds relative to the sea level was assumed to be zero (the TPQ means the earliest time when the site was above the contemporary sea level). The coordinates of the sites and TPQs are presented in the Table 1 (supplement at http://dx.doi.org/10.4312/dp.48.24).

In the further discussion, the sites will be divided into three zones by their proximity to the paleocoast:
- inland sites discovered while surveying the banks of the Kasari and Vigala rivers;
- coastal zone sites on the banks of rivers and brooks up to 10km from the paleocoast;
- coastal sites in the immediate vicinity of Littorina Sea coastal formations originating from the LTM or younger;
- island sites on paleoislands or islets.

The primary method of fieldwork was fieldwalking and gathering finds from the surface. Occasionally 30×30×60 cm test pits were made. At least three spatially close finds were grouped as a settlement site. Groups of finds were recorded as different sites

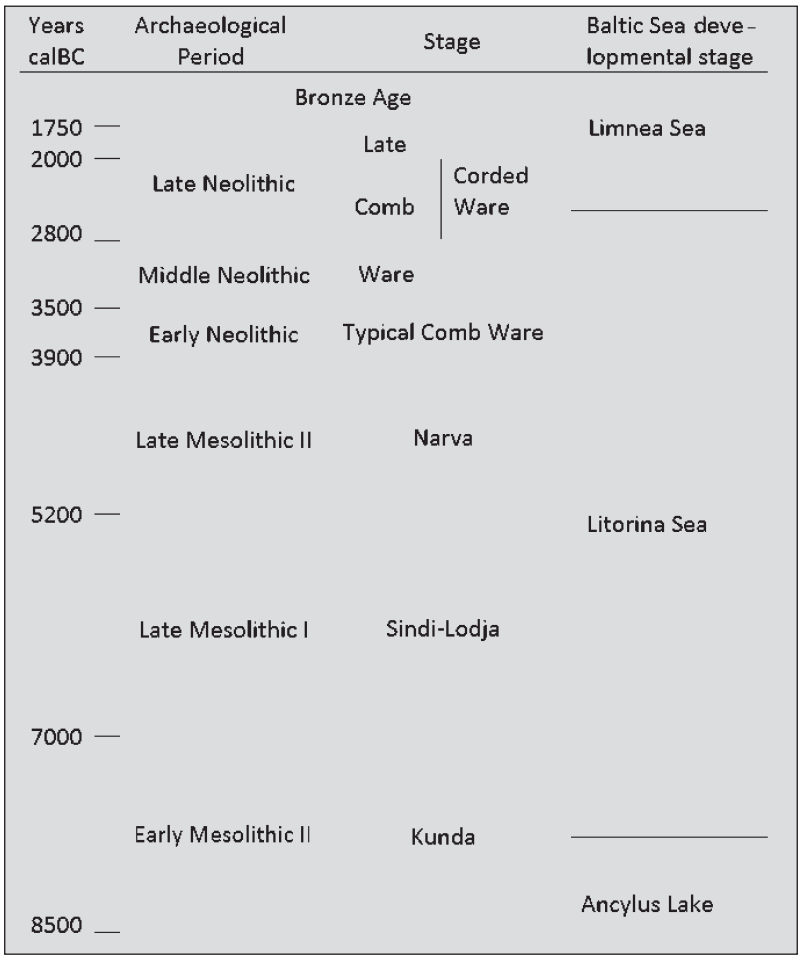


Fig. 2. Estonian Stone Age periodization together with Baltic Sea developmental stages (*Kriiska *et al.* 2020.17; Hang *et al.* 2020*).

if separated by a visual barrier (most often, afforestation), located at different elevations or spatially associated with coastal formations at different elevations. The division of closely located GPS findspots into sites thus often reflects the present land use and surface conditions. The locations of all findspots were recorded by handheld GPS with minimum precision ±8m.

Finds could have been collected only from areas with open ground: agricultural land, gardens, forest clearings and haulways. Therefore, the quantity of finds for each site does not indicate the intensity or nature of human activity during the time of deposition but the present-day finding conditions. The spatial orientation of the sites does not necessarily reflect the landscape use during the time of deposition either, as two adjacent sites might be separated by a strip of land with more difficult finding conditions. Similarly, the lack of finds from any particular area might be attributed to the lack of open ground.

The routes for fieldwalking traced Litorina Sea coastal formations, identifiable from the LIDAR elevation model and often visible on the ground. If possible, adjacent areas at different elevations were also checked for comparison. However, the goal of the fieldwork was to find as many sites as possible, not to survey a statistically representative sample of the surface. The overwhelming majority of finds are spatially associated with coastal formations, water streams or both. This might reflect a research bias towards areas with visible landforms, but the trend is in line with the current research on Stone Age settlement site location choice in Estonia (*Sikk* et al. *2020*).

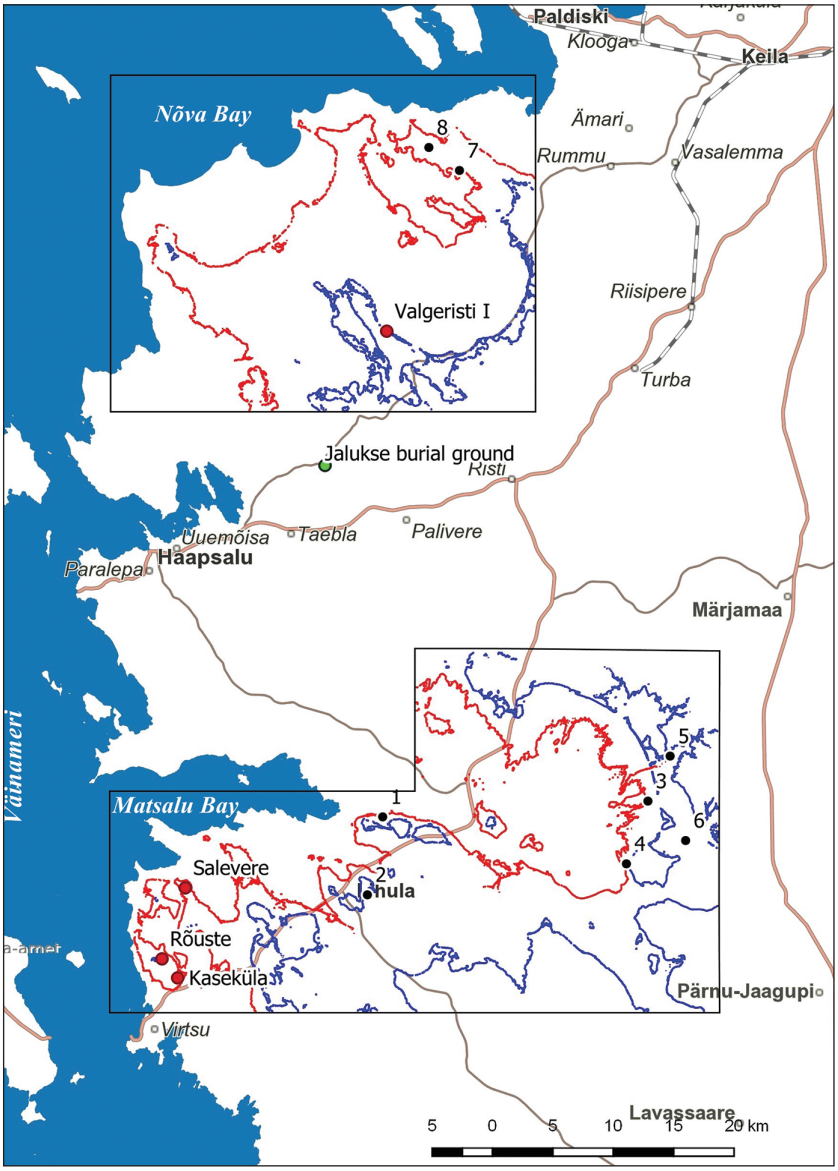


Fig. 3. Location of the study areas in the Western Estonia with paleocoastlines for 5300 cal BC (blue) and 4000 cal BC (red) projected on the present-day Estonian map with previously known settlement sites (red dots), burial ground (green dot) and stray finds (black dots:* 1 *Kloostri,* 2 *Lihula,* 3 *Oese,* 4 *Avaste,* 5 *Tiduvere,* 6 *Kesu I,* 7 *Harju-Risti,* 8 *Vilivalla).

Results

Finds

In total, 2185 Stone Age finds were gathered. In addition to 2131 finds from 99 sites, 54 stray finds were collected from 38 locations. The newly discovered sites amount to one fourth of all Estonian Stone Age sites published before the current study (Fig. 1; *Sikk* et al. *2020*). None of them have been published before except the locations of Kõmmaste V, Kesu II and Ojapere II-III sites (*O.c.*). As the number of finds gathered by fieldwalking depends heavily on surface conditions, it is not indicative of the intensity of the site use.

The vast majority of finds are lithic artefacts. There are only 27 sherds of Stone Age ceramics among the finds (2 of

Narva Ware, 15 of Comb Ware and 10 of Corded Ware vessels). 18 lithic finds exhibit signs of secondary processing. Among these are 8 flint and 2 quartz scrapers, 3 flint and 2 quartz retouched flakes and 3 flint arrowheads. 2 flint and 4 quartz flakes and 2 flint blades bear clear signs of use wear. The evidence of stone grinding is scarce: there are two adzes (from Ojaküla I and Teenuse II) and a fragment of grinding stone (from Küünimäe II).

The most common lithic material is quartz followed by Carboniferous, Silurian and Cretaceous flint and other lithic materials. As the number of finds is quite small for most of the sites, spatially close sites at close elevations with similar archaeological material were grouped for statistical overview of lithic material use (Tab. 1, supplement at http://dx.doi.org/10.4312/dp.48.24). Sites with a small number of finds and no adjacent sites were left out of the analysis.

Utilized landscape types

The number of inland sites (2) is surprisingly small, indicating low Stone Age human activity on the inland shores of water streams. The majority of the sites in the coastal zone (17) can be dated to the Neolithic Comb Ware stage by the finds, most of the rest having only a few finds registered. A notable exception is the Kesu II site, probably used during the Pre-Pottery Mesolithic, as indicated by a large share of blades. The group of coastal sites is the most numerous one (47), with TPQs ranging from the Pre-Pottery to Comb Ware stage. Thirty-three sites are located on the islands, islets or peninsulas formed after the LTM, indicating continuous use of islands starting at latest in the Narva stage.

Pre-Pottery Mesolithic and Narva stages

In the northern study area, numerous sites were located on the barrier separating the Vihterpalu River mouth lagoon from the Nõva Bay (the Valgeristi sites; Fig. 4) and along the western (inland) coast of the lagoon (the Küünimäe sites). The southern study area (Fig. 5) also features a river mouth lagoon at the lower reach of the River Velise (Tõnumaa and Ojapere sites).

A radically different landscape is represented by the cape sites. In the northern study area, a number of them are clustered in the Kõmmaste village, situated at the end of the peninsula, forming the eastern coast of the Nõva paleobay (Fig. 4). The strip of land at the cape was about 600m long and up to 150m wide between 5300 and 5000 cal BC, completely open to the sea. The Nurme I and the Üdruma sites in the southern study area are similarly situated near the tip of the peninsulas at the mouth of a bay (or in the case of Üdruma, possibly on a coastal islet soon to become such a peninsula).

Small paleoislands became utilized during the Narva stage at latest. This is best observable in the case of the eastern Massu paleoislet in the second study area, where the cluster of finds at the Massu I site covers the central part of the eastern islet in about 4000 cal BC or somewhat earlier (Fig. 6.A). The overwhelming majority of the Massu I finds consists of quartz with some Silurian flint present. The same is probably true about the Massu III site and the higher part of the Massu IV site on the western islet while at least some finds from the lower part of the Massu IV site were deposited during the Comb Ware stage at earliest. The Lihula I site might be even earlier, with TPQ around 5000 cal BC (Fig. 5).

While the Massu, Lihula and Kirbla islands were parts of a coastal archipelago a few kilometres away from the coast, the Elbiku paleoisland in the northern study area was situated about 15km from the coast during the Pre-Pottery and Narva stages (Fig. 4). If the Elbiku island finds of higher elevations (Elbiku VIII, IX, XI) were deposited at the coast, then human presence began in the Pre-Pottery Mesolithic. Most of the Elbiku sites can be associated with Narva stage coastlines.

The Comb Ware stage

Both Vihterpalu and Velise river mouth lagoons ceased to exist before the beginning of the Comb Ware stage (Figs. 7, 8), and newly formed lagoons in the northern study area have been investigated on minimal scale due to heavy afforestation. The use of the banks of the Velise river mouth at Ojapere continued after the end of the lagoon, where adjacent sites together take up about 13 hectares. A small number of Comb Ware sherds are present among the finds. In addition to Ojapere II–III sites, some Comb Ware sherds were also found from the Teenuse IX riverside inland site.

In the eastern part of the northern study area, the pattern of utilizing capes continued (Risti I, Risti III and Vihterpalu I sites and Hatu I and Vihterpalu II stray finds) during the first half of the Comb Ware stage.

The paleoislands in the southern study area gradually merged with the mainland, becoming peninsulas (Fig. 8). Stone Age sites are common along their

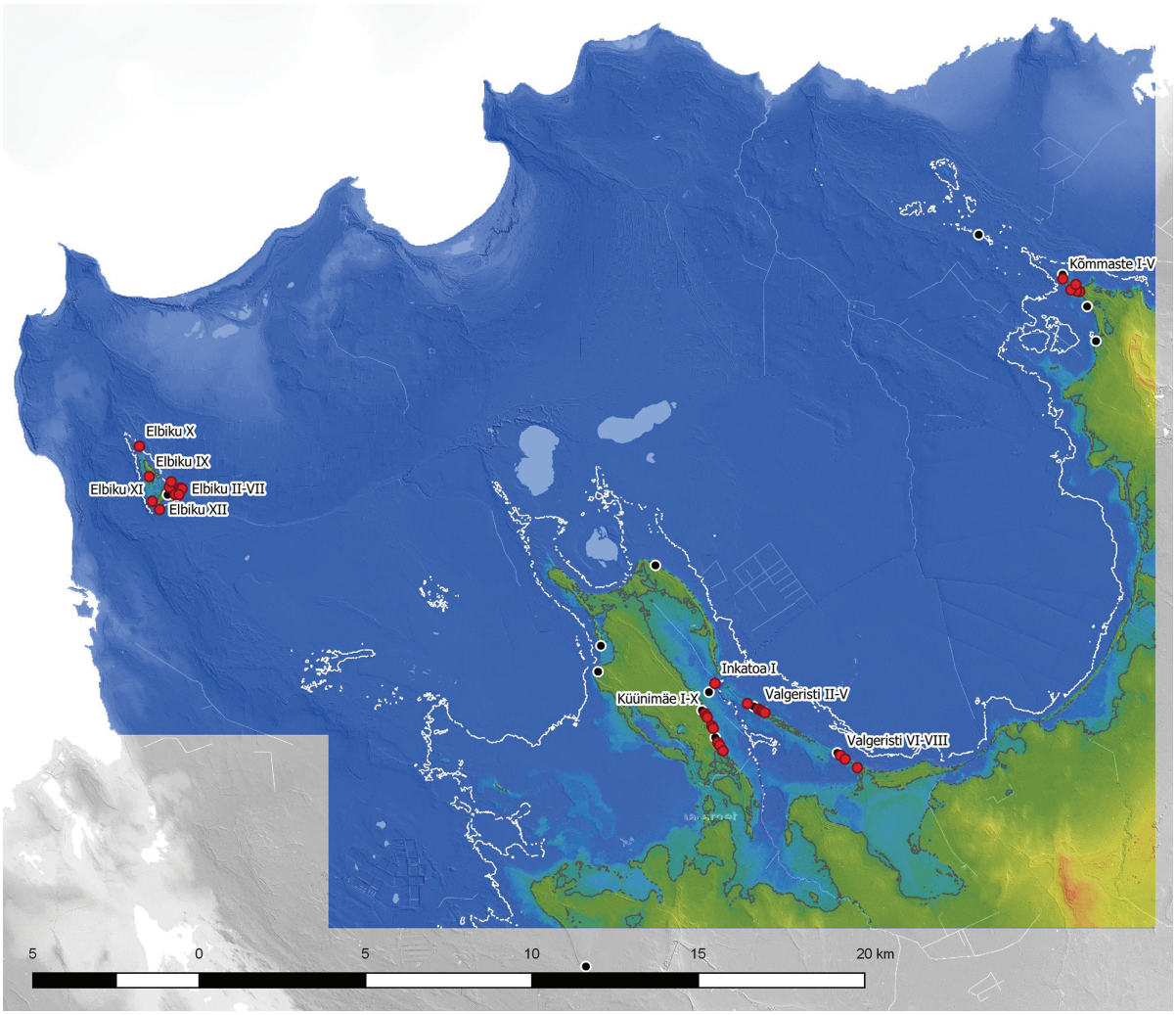


Fig. 4. Sites (red dots) and stray finds (black dots) discovered in the northern study area together with coastlines in 5300 cal BC (land denoted by green) and in 4000 cal BC (white).

coastlines at relevant elevations. In the Massu IV site, the Comb Ware stage landscape use is attested by a relatively large number of Carboniferous flint finds and a rhombic bifacial arrowhead (Fig. 6.B). However, only quartz bits were found from the Salevere I site, although the TPQ does not allow an earlier dating than the middle of the Comb Ware stage (the same is true about the coastal Änglema I site in the northern study area). The latest TPQ for the Elbiku paleoisland is 3850 cal BC (Elbiku XIII).

The lowest site of the Massu cluster is Massu V, the elevations of which (9.5–11m) correspond to the coastline of the peninsula in about 2600 cal BC, roughly contemporary with the previously known Kaseküla site (Fig. 3). East of the Massu V site, about 200m² of an Early Iron Age stone enclosure was excavated in 1973 (*Lang 2007.78–79.246; Tõnisson 2008.255*) but no Stone Age finds were recovered. The large majority of coastal zone sites by the tributaries to the River Kasari in the southern study area (Fig. 8) have a high percentage of Carboniferous flint combined with a very low percentage of flint blades. These two traits combined support dating to the Comb Ware stage even in the absence of pottery sherds.

Discussion

No excavations have been carried out at the newly discovered sites, and no finds datable by radiocarbon methods have been obtained from the surface. Besides coastal chronology TPQs, well-researched background information on lithic material use makes aceramic sites roughly datable by the proportions of different lithic materials and stylistic features of the artefacts.

First, during the 7th and 6th millennia BC, a change in stone usage occurred throughout coastal Estonia as Silurian flint was mainly replaced by quartz (*Kri-*

iska, Sikk 2014.51–52), the reasons for which are unclear. Second, the share of flint blades (including fragments and tools made from blades) is generally higher in the Estonian Pre-Pottery Mesolithic (*e.g.,* Pulli, Umbusi, Lepakose, Siimusaare, Ihaste, Sindi-Lodja II, Kavastu, Kivisaare and Jälevere sites, where it ranges from 10% to 40%; *Jaanits, Ilomets 1988.54; Kriiska* et al. *2003.36; Tvauri, Johanson 2006.42–43; Kriiska, Lõugas 2009.Fig. 26.5*), than in the Late Mesolithic Narva stage sites (*e.g.,* in the north-Estonian Vihasoo III and Kroodi sites in a range of 1–6%; *Kriiska 1997.9*). Third, while Carboniferous flint is present in several Mesolithic settlement sites (*e.g., Sander, Kriiska 2018.77–78; Kriiska, Khrustaleva 2020.41–42*), the inflow of that material appears to have decreased significantly before the LTM. It reappeared as a typical material used by people also using the Comb Ware pottery (*Moora* et al. *1935.45–46; Yanits 1959.334; Jaanits* et al. *1982.77; Kriiska 2015*). However, the share of quartz finds could exceed 90% of all lithic finds at some Comb Ware stage sites.

The indicators listed above work in combination (an early dating is justified if the share of blades among the flint finds and the share of flint among lithics are both high). In regard to the present study, the dynamics of the lithic material use and artefact typology described above (1) rule out the dating of the newly discovered coastal sites with a high share of quartz to a significantly earlier period than the LTM; (2) allow dating the coastal zone or inland riverside sites with a high share of Carboniferous flint and a low number of flint blades to the Comb Ware stage.

The most striking feature of the material found at the newly discovered sites regardless of dating is the low assemblage diversity, including almost total lack of pottery sherds and very few finds associable with stone grinding or wood chopping. Out of 99 Stone-Age sites, sherds of Narva or Comb Ware were present in only six (Narva Ware: Kõmmaste V (2), Comb Ware: Teenuse IX (2), Ojapere II (4), III (7), IV (1), V (1)) while the TPQ is later than the introduction of pottery for 64 sites. In addition to pottery sherds, one fragment of a grinding stone (Küünimäe II) and two adzes (Ojapere I, Teenuse II) were found. A previously known stray find of a stone axe could be associated with the Kesu I site.

The observation of relatively large Estonian mainland areas featuring only small sites with low assemblage diversity is novel to the present work. A number of aceramic sites of the Narva stage or sites with

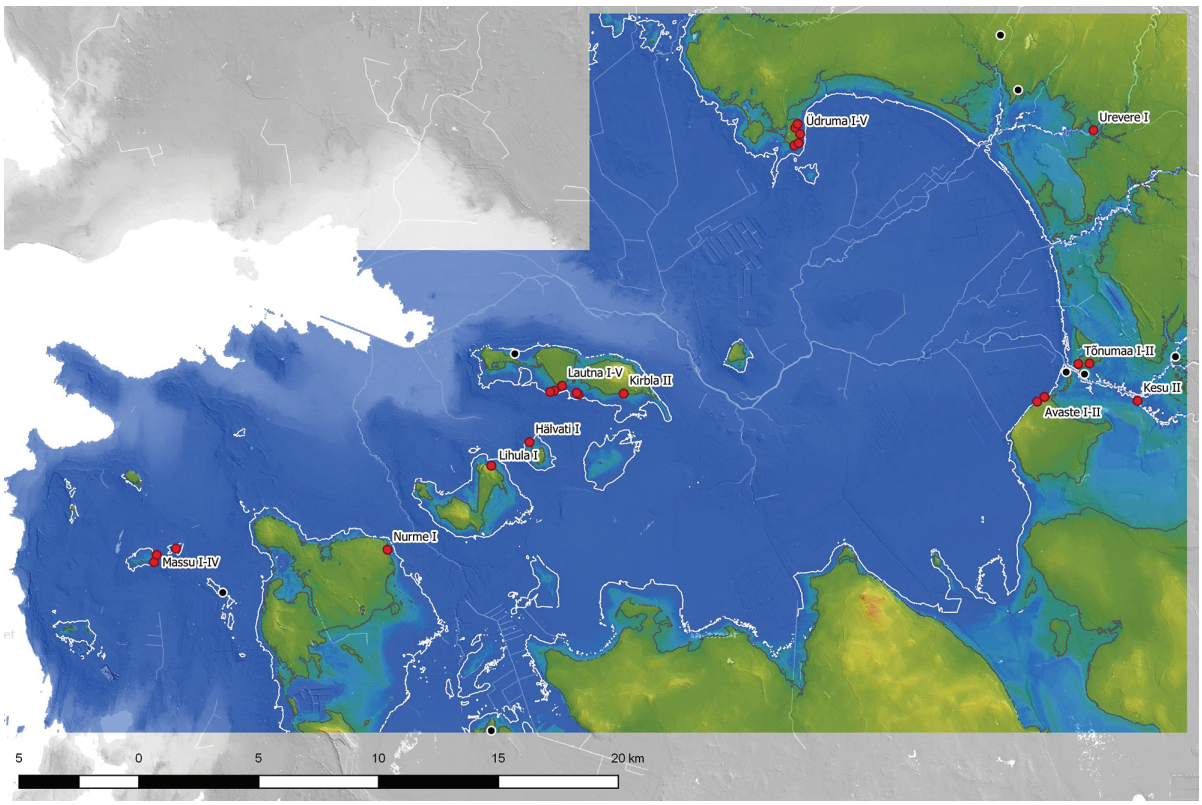


Fig. 5. Sites (red dots) and stray finds (black dots) discovered in the southern study area together with coastlines in 5300 cal BC (land denoted by green) and in 4000 cal BC (white).

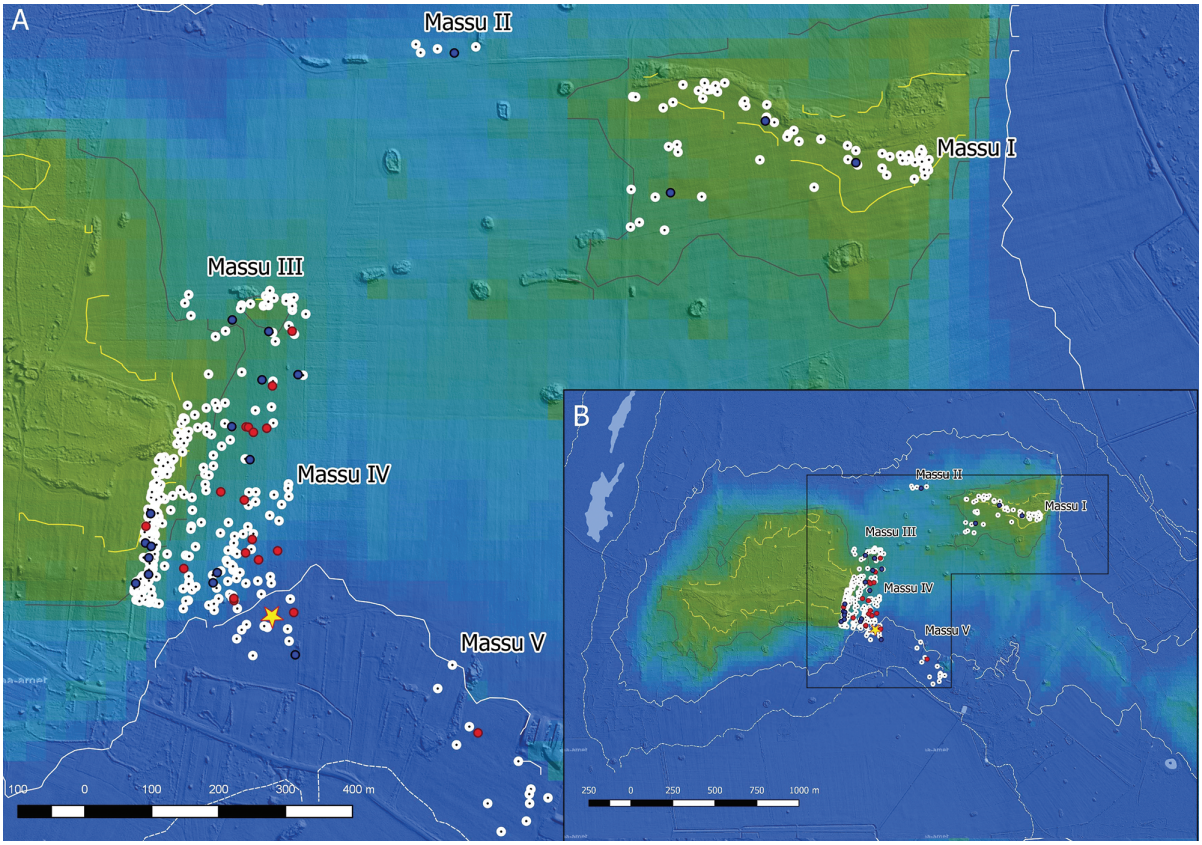


Fig. 6. The findspots of the Massu I-V sites together with paleocoastlines for 4500 cal BC (yellow), 4000 cal BC (end of the Narva stage, land denoted by green), 3000 cal BC (middle of the Comb Ware stage, white continuous line) and 2000 cal BC (final Neolithic, white dashed line) on the map of both Massu paleoislets (B) and the surroundings of the settlement sites (A). White dots: quartz, blue dots: Silurian flint, red dots: Carboniferous flint, yellow star: the rhombic bifacial arrowhead.

only a few Narva Ware sherds were previously known on the Western Estonian islands. Most of them are situated on the small Kõpu paleoisland (the highest part of the Kõpu peninsula of the present-day Hiiumaa island): Kõpu VII/VIII (*Lõugas* et al. *1996.205; Kriiska 1996a; 1996b; Jussila, Kriiska 2004.8*), Kõpu XIII, Kõpu XVI, Kõpu X (dating to the Comb Ware stage also possible – all *Jussila, Kriiska 2004*) and Kõpu XIV (*Rosentau* et al. *2020*). Of these, the Kõpu VII/VIII and Kõpu X sites have been excavated on a small scale. Pottery sherds are present among the finds gathered during the excavation of the late Narva stage Kõpu I site in a modest quantity (about 500 pottery sherds from more than 20 vessels). Lithic finds are about nine times more numerous, including a number of grinding stone fragments but only one wood chopping tool (*Lõugas* et al. *1996.204–206*). The younger radiocarbon datings of the Pre-Pottery Võhma I settlement site on the Saaremaa island (*Kriiska 2003.21*) do not rule out dating to the Narva stage. Very few pottery sherds have been recovered from the Narva stage layer of the Ruhnu II site on the Ruhnu island in the Gulf of Riga (*Kriiska 2000*). The aceramic Rõuste settlement site with Narva stage TPQ (*Kriiska 2001a. 8, 16; 2001b.Fig. 4; 2004.172; Jussila, Kriiska 2004. 13–15*) is located near the western coast of the present-day mainland (Fig. 3), at the highest part of the same coastal paleoisland where the Comb Ware Kaseküla settlement site is situated. Presently, no aceramic sites with Comb Ware stage TPQs are known on the Western Estonian islands, but that reflects the current research situation rather than trends in Neolithic landscape use.

Low assemblage diversity in general is often associated with the (seasonal) mobility of the site (*e.g., Kelly 2001*; case studies: *Cole 2012; Eschenbrenner* et al. *2017*). For instance, the presence of numerous wood-chopping tools (axes, adzes, chisels) and evidence of stone grinding or polishing could be considered as indicators of diverse activities at the site, as opposed to activities associated with resource gathering and minimal tool making (*Kriiska 2002a. 46–47*). However, a low number of any particular find type alone cannot be interpreted as an indica-

tor of the mobility of the site. For instance, among the numerous and diverse finds (including a large quantity of pottery sherds) of the exceptionally well-preserved Sārnate settlement site (Latvia) with permanent dwellings, only 15 wood chopping tools and 36 grinding or polishing stones are listed (*Vankina 1970.150–151, Tab. 3*).

For a community that has adopted pottery, the lack or low quantity of pottery sherds in a site assemblage could be somewhat intuitively associated with mobility, especially anticipated mobility (the amount of time members of a group expect to spend at the site, *Kent 1991*). However, as pottery vessels of the earliest (Narva) type were mainly used for processing aquatic food (*Oras* et al. *2017*), treating the presence of a large number of pottery sherds as a definitive indicator of sedentism would create a research bias towards considering settlement sites where aquatic resources were exploited as more sedentary, contradicting the seasonal nature of seal hunting or spawning runs of anadromous fish. The same point could either strengthen the case for the non-permanent nature of an aceramic site located near aquatic resources (especially on islands) or a suggestion that a site was used for some other reason if multiple types of resources were available (*e.g.,* the Narva and Comb Ware phases of Kunda Lammasmäe settlement site in the North Estonian coastal zone; *Sander, Kriiska 2018*). As seen above, evidence of stone grinding, wood-chopping and pottery use are all very scarce among the finds of the newly discovered sites.

Besides assemblage diversity, funerals (*Kriiska 2007*) and pit-houses (*Khrustaleva* et al. *2020 and references therein*) have been interpreted as markers of sedentariness. Further insights could be gained by spatial analysis and research into site structure (*Kent 1991*). Currently, only one presumably seasonal settlement site has been excavated on a sufficient scale and quality in Estonia (Tallinn Vabaduse väljak, *Muru* et al. *2017*).

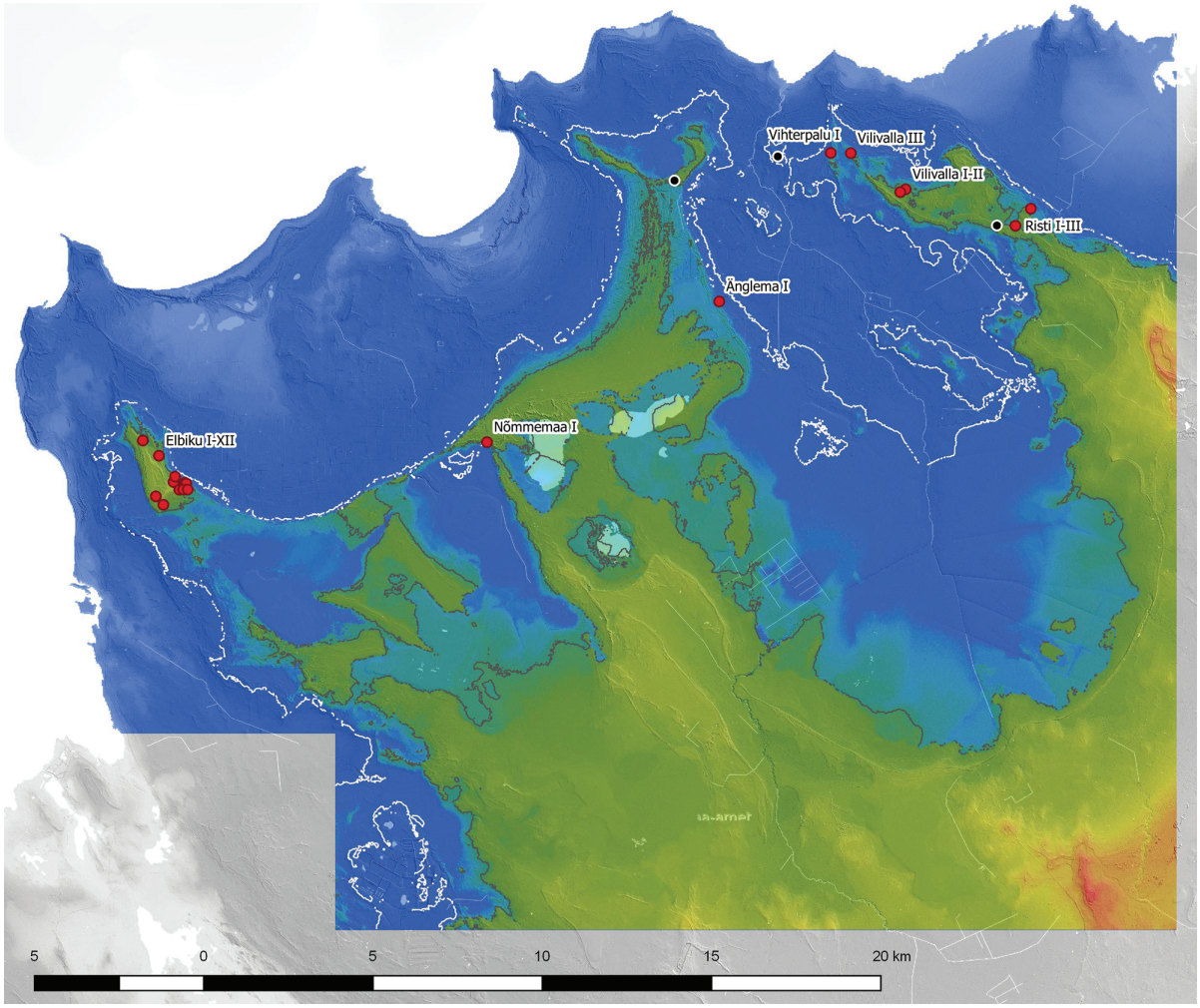


Fig. 7. Sites (red dots) and stray finds (black dots) discovered in the northern study area together with coastlines in 3500 cal BC (land denoted by green) and 2000 cal BC (white).

Other applicable criteria for determining the site seasonality or sedentariness of mainland sites are presently lacking. Intuitively, the low faunal taxonomic diversity of zooarchaeological material recovered from a site could also be considered a marker of seasonal occupation, even if the surrounding environment supported year-round occupation. Lewis R. Binford (*1980*) formulated a forager-collector continuum of settlement systems, distinguishing between two modes of mobility, where the foragers moved their settlements to the resources (residential mobility) and collectors moved the resources to their settlements (logistical mobility). The diversity of exploited resources at a site thus supports logistical mobility and vice versa (see also *Kelly 2013.77–104*). However, stable isotope analysis has demonstrated the prominent role of marine fish and mammals in the diet of Stone Age people buried on Saaremaa (Kõnnu, Kõljala, Naakamäe), consistent with the high share of marine mammal and fish bones in the zooarchaeological material (*Tõrv 2016.165–175, 197–204; Kriiska* et al. *2020.68*). In other words, the diet of the buried people seems to have been in line with low taxonomic diversity of the bone material gathered from the island sites.

Methods to assess the mobility of a site based on lithic reduction strategies (*e.g., Kelly 1991; Dibble* et al. *2005*) are not applicable for the study areas and time frame for two reasons: (1) quartz is abundantly available at least throughout coastal Estonia, and was already widely used before the LTM; (2) during the Comb Ware stage, Carboniferous flint imported over hundreds of kilometres was preferred to local Silurian flint. In addition to that, quartz was extensively used during the Comb Ware stage (apart from the early sites at least until 3700 cal BC, where Carboniferous flint is overwhelmingly dominant (*Kriiska* et al. *2020.126*)). The presence of a poorly workable but abundantly available raw material like quartz might lead to a shift towards its use instead of more efficient utilization of high quality but rarer raw materials by production of a larger number of formal tools (*Manninen, Knutsson 2013*). The large share of quartz among the lithic finds of the newly discovered settlement sites regardless of elevation (Tab. 1, supplement at http://dx.doi.org/10.4312/dp.48.24) might indicate mobility for earlier Comb Ware sites.

The seasonality of the Post-LTM landscape use in Estonia has been discussed mostly in the context of the Western Estonian islands (*e.g.,* Pre-Pottery Mesolithic Võhma I settlement site on the Saaremaa island (*Kriiska 1998*) and later Kõpu sites together with zooarchaeological studies (*Moora, Lõugas 1995;*

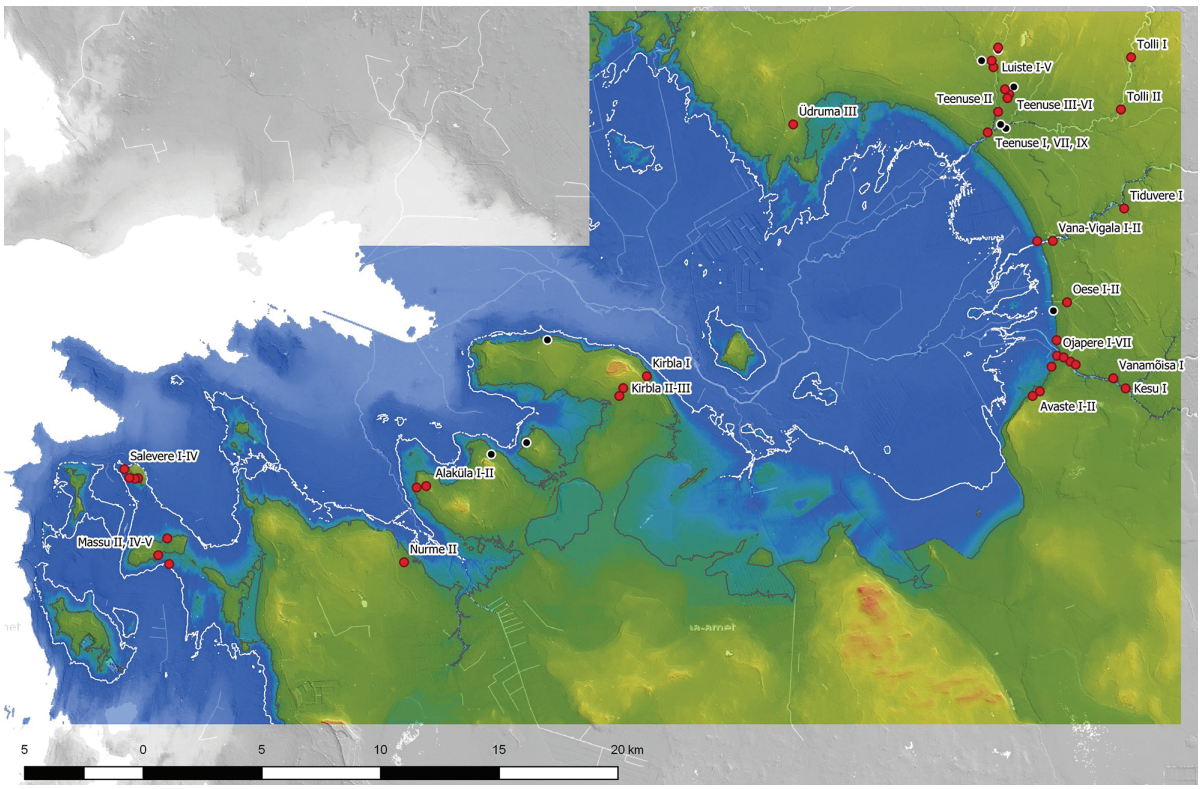


Fig. 8. Sites (red dots) and stray finds (black dots) discovered in the southern study area together with coastlines in 3500 cal BC (land denoted by green) and 2000 cal BC (white).

Lõugas et al. *1996; Kriiska* et al. *2017*)). In general, the existence of seasonally exploited island sites with comparably low assemblage diversity on the Western Estonian islands supports the idea of the seasonality of the newly discovered mainland sites. Until the present work, no presumably seasonal Narva or Comb Ware stage mainland sites besides the Tallinn Vabaduse väljak and Kunda Lammasmägi were known, and the small number of known seasonal sites has prevented further exploration of the topic. Timo Jussila and Aivar Kriiska (*2006*) briefly discuss the phenomenon of 'hunting camps' but do not suggest seasonal mobility, and seasonality has been only briefly mentioned in general treatises (*Jaanits* et al. *1982.48–49, 93; Kriiska* et al. *2020.61–64; 112–113*, but see *Moora* et al. *1935.52–53* discussing ethnographic parallels with the residential seasonal mobility of the indigenous Siberian peoples).

The anthropological and archaeological literature on seasonal mobility is abundant, covering most parts of the world, and much has been written about adaptations of pottery to hunter-gatherer lifestyle and mobility (*e.g., Arnold 1985; Simms, Bright 1997; Gibbs 2012; Hommel 2012; Santacreu 2014; Emmitt 2017; Heitz, Stapfer 2017*). Aceramic sites or sites with very few ceramic finds of people with established pottery traditions are a much less discussed phenomenon (but see *Pippin 1998; Eerkens 2003; 2008; Cole 2012* about the United States Great Basin area). This owes partly to the difficulties of distinguishing the aceramic and pre-ceramic sites, and partly to the general research bias towards large sites with diverse finds (for a discussion about the American Northeast featuring climate and landscapes quite similar to the Eastern Baltics but with an adverse effect of coastline change, see *Rieth 2008*). From this perspective, the study areas of the current work are noteworthy for their geological properties (that make even the small 'lithic scatter' sites datable by coastal chronology), well-researched background of lithic material use and artefact typology and their size (that makes the research into aceramic modes of landscape use finally inescapable). The first two points have been discussed above. In the following passages the third point will be addressed in some detail.

While a number of settlement sites contemporary with Narva or Comb Ware stages have been interpreted as permanent in neighbouring countries (*e.g., Vankina 1970; Núñez, Okkonen 2005; Berzins 2008*), archaeological traces of seasonal activities are less known by far. The dwellers of the Sārnate settlement site (Latvia) have been described as an extreme case of logistical mobility during Early and Late Sārnate Ware phases (*c.* 4365–3780 cal BC and *c.* 3630–2850 cal BC, respectively, *Berzins 2008. 383*). However, these logistic forays might have taken more than a day, necessitating field camps or ephemeral sites. Berzins (*ibid. 391–392*) discusses possible seasonal expeditions, noting that no field camp sites have been discovered so far. In Finland, Comb Ware period pit-houses are often considered a more sedentary settlement type than winter-only ones, with logistic forays similar to those postulated by Berzins (*Mökkönen 2011.35–38*). Small sites are known but seldom studied (but see *Carpelan* et al. *2008* for two examples of aceramic sites in Karelian Isthmus, Russia). The current study presents evidence not only about mostly aceramic single sites interpretable as 'field camps', but also about larger coastal areas featuring only such sites. The study areas are neighboured by three regions where more permanent settlement sites are known from the Comb Ware stage at latest: (1) the drainage basin of the Pärnu Bay south to the study areas, (2) the Northern Coastal Estonia and (3) the Western Estonia Archipelago.

Both study areas are situated north of the watershed separating the drainage basin of the Pärnu Bay from the drainage basin of the Väinameri (Fig. 1). It has been suggested (*Jaanits* et al. *1982.50–51; Jaanits 1992.43*) that already during the Pre-Pottery Mesolithic, the drainage basin of the Gulf of Pärnu together with the area around the Lake Võrtsjärv and possibly beyond formed a social territory linked together by a communication network based on waterways. As the surveys of the inland banks of the streams flowing to the southern study area revealed very few sites and finds, we suggest that (1) the newly discovered sites were mainly accessed from the sea; (2) the rivers of the drainage basin of Väinameri did not act as a comparable communication network and 'led to nowhere' in a social or cultural geographical sense, and (3) the population of areas where more permanent settlements are known was not dense enough to necessitate colonization of the drainage basin of Väinameri. The validity of the second point depends heavily on the results of future studies of the shores of Central Estonian (paleo)lakes.

The closest known sites to the study areas interpreted as (semi)sedentary settlements in the literature are Sindi-Lodja I and II (*Kriiska* et al. *2002; Rosen-*

tau et al. *2011.178–179*), Sindi-Lodja III (*Kriiska* et al. *2002; Kriiska, Lõugas 2009*) and Lemmetsa I–II (*Kriiska, Saluäär 2000b*), situated 35–45km from the southern study area by the Audru and Pärnu rivers. The current research supports the idea of (semi)sedentary settlements by the Pärnu River and its tributaries during the Comb Ware period at latest, but possibly even during the Pre-Pottery period while the information about the Narva stage is almost totally lacking.

The Sindi-Lodja I-II Pre-Pottery Mesolithic (about 7000–6700 cal BC) sites, situated by the Pärnu River some kilometres from the paleocoastline, have been interpreted as more sedentary settlements by the thickness of cultural layer and higher find density (*Kriiska, Tvauri 2002.32; Kriiska 2004.67–69; Kriiska* et al. *2020.57, 62, 65*) compared to the Early Mesolithic Pulli settlement site situated about 10km from the Ancylus Lake coastline by the same river (*Jaanits* et al. *1982.27–33; Veski* et al. *2005; Kriiska, Lõugas 2009; Kriiska* et al. *2020.51–54*). As the relevant population sizes are not known, the validity of this suggestion is unclear. The Sindi-Lodja III site by the Pärnu River (*Kriiska, Lõugas 2009; Rosentau* et al. *2011.180; Kriiska* et al. *2020.107*) has been radiocarbon dated to the beginning of the Comb Ware stage, but pottery sherds of earlier Narva type are also present. The site features intensive cultural layers with high find densities comparable to settlement sites with dwelling remains (the Narva and Comb Ware settlement site Riigiküla I, situated by the River Narva in the North-Eastern Estonia and Jägala Jõesuu V, *Khrustaleva* et al. *2020 and references therein*). The material found at the Lemmetsa I site by the River Audru from the later half of the Comb Ware stage is numerous and diverse, including more than 800 Comb Ware sherds and several wood chopping tools and grinding stones gathered by fieldwalking. The find density of the nearby Lemmetsa II site is lower, but the same find types are present (*Kriiska, Saluäär 2000*).

Leaving apart the sites clustered near the River Narva, Northern Coastal Estonia has become the least surveyed coastal region after the present work (Fig. 1), with only six Comb Ware stage sites known along more than 200km of northern coast, four of which have been excavated. While the Comb Ware settlements of Tallinn Vabaduse väljak and Kunda Lammasmägi clearly bear a seasonal character, the archaeological record of the settlement site of Jägala Jõesuu V between them features remnants of a Comb Ware period pit-house together with numerous and diverse finds (*Khrustaleva* et al. *2020*). Settlement patterns and pottery use along the Northern coast definitely deserve further research.

Finally, the largest paleoisland of the Western Estonian Archipelago in the central part of present-day Saaremaa (*Saarse* et al. *2009a; 2009b*) was at least seasonally used during the Pre-Pottery Mesolithic, and most probably permanently settled during the Narva stage by the example of the Kõnnu settlement site featuring an extensive cultural layer, funerals, diverse material finds and possibly pit-houses (*Jaanits 1979, Kriiska 1998.19; Kriiska 2001b and references therein; Kriiska 2002a; Kriiska* et al. *2020. 59–61*).

As for utilized landscape types, the newly discovered settlement sites on the coastal islands seem to postdate the first human activity in Saaremaa and Kõpu, suggesting a dual mode of maritime activities: earlier longer sealing trips (and consequent settlement) of faraway islands, and later continuous utilization of the coastal islands, starting during the Narva stage and continuing at least until the later part of the Comb Ware stage, as attested by the Kaseküla and Massu V sites (TPQ 2600–2500 cal BC). Although the notion of mainland cape sites utilized by the Stone Age people is novel to the present work, several late Pre-Pottery Mesolithic and Narva stage sites on Saaremaa island are situated at the open coast or on small peninsulas, surrounded by the sea from three sides (Pahapilli II, Võhma VII, Võhma I).

River mouth paleolagoons have been studied in the Narva-Luga area (*Rosentau* et al. *2013; Kriiska* et al. *2016; 2017; Ryabchuk* et al. *2019*) and in the Pärnu area (*Veski* et al. *2005; Rosentau* et al. *2011; Nirgi* et al. *2020*). The thin barrier peninsula and islands of the Narva River mouth lagoon were used by the Stone-Age people during the Narva and Comb Ware stages (*Rosentau* et al. *2013.Tab. 2, Fig. 7*), but no settlement sites have been discovered at the inland coast of the Narva lagoon. The Pärnu River mouth lagoon was contemporary with the Vihterpalu lagoon, having ceased to exist after the LTM and definitely before the Comb Ware, but no settlement sites are presently known from its coast.

Sites situated by the rivers or smaller streams both in the 10km coastal zone and farther inland form the most numerous subgroup of Estonian Stone Age sites in the Pre-Pottery Mesolithic, Narva and Comb Ware stages (*Jaanits* et al. *1982*, Tahvel I & III; *Sikk* et al. *2020*). The predominant location of the south-

ern study area riverside sites in the coastal zone suggests that they were accessed from the sea. As the (semi)sedentary sites in the Pärnu area are all located by big rivers, it is logical to assume that the seasonal utilization of the river mouth lagoons and riversides originated from an area where the possibilities to catch anadromous fish or hunt beaver were more limited: the Western Estonian Archipelago. If that was the case, then the phenomenon of the river mouth lagoon and coastal zone riverside seasonal settlement of the Western Estonia Lowland could be explained by two factors: (1) relatively sparse population of the Pärnu area (there was no need to colonize the Western Coast beyond the drainage basin of the Gulf of Pärnu), and (2) the colonization of Saaremaa at the end of the Mesolithic, resulting in an environmentally circumscribed population interested in exploiting additional mainland resources.

Unfortunately, this suggestion is very hard to prove by archaeological material. The only lithic indicator would be artefacts made of Baltic red quartz porphyry, a raw material local to Saaremaa and Hiiumaa (and a small part of the south-western coast of the mainland (the Kaseküla site), *Kriiska 2008.105*). These are rare even there, amounting to only a few per cent of all lithic finds (*Kriiska 2001b.Fig. 2*). Furthermore, the validity of the hypothesis depends heavily on future research into Stone Age landscape use in the Northern Coastal Estonia. If the landscape use in comparable study areas in North Estonia proves similar to the areas of the current study, the Stone Age seasonal mobility of most of Estonia could be considerably higher than previously thought.

Conclusion

Most of the newly discovered sites in the study areas can be dated to the end of the Pre-Pottery Mesolithic, Narva, Comb Ware and Corded Ware stages by coastal chronology, used lithic raw materials used and artefact typology. The diversity of the material found is fairly low, as pottery sherds and wood chopping or stone grinding tools are present only on rare occasions and as single specimens. This suggests seasonal use of the sites similar to the Narva stage sites on the Western Estonian islands, especially the Kõpu paleoisland. The notion of large areas featuring only seasonal sites during the Estonian Narva and Comb Ware stages is novel to the present work.

In addition to the previously known sites on the Western Estonian islands, the utilization of capes open to the sea can be observed on the mainland (novel to the present work). Besides capes, the paleolagoons at the past river mouths feature clusters of settlement sites similar to the Narva-Luga area in North-Eastern Estonia. At latest during the Narva stage, small coastal islands located up to 15km from the coast became extensively used. While the earlier utilization of the 10km coastal zone riversides is probable, the majority of the newly discovered riverside sites feature Carboniferous flint with very few blades, making it possible to date them to the Comb Ware stages even in the absence of pottery finds. The finds from banks of the tributaries of the River Kasari further away from the coast are very rare, suggesting that the coastal zone sites were accessed from the sea. This is radically different from the neighbouring drainage basin of the Pärnu Bay, where the Rivers Pärnu and Navesti formed a part of a communication network leading to the Lake Võrtsjärv region, featuring a large number of Stone Age settlement sites. This finding is in line with the very low number of known sites in Central Estonia north to the Lake Võrtsjärv region. As the River Kasari and its tributaries might have 'led to nowhere' in the social or cultural geographic senses.

The findings of the present work suggest the persistence of established landscape use patterns and the additive nature of spatial extension of subsistence strategies. This can be divided into three phases:

- at least seasonal utilization of Saaremaa and Kõpu already during the Pre-Pottery Mesolithic, concurrent with the mainland coastal sites of the study areas situated at capes or river mouths;
- the utilization of the coastal islands, probably starting during the Narva stage;
- the utilization of the mainland streams in the 10km coastal zone during the Comb Ware stage.

The utilization of capes and coastal islands started earliest and continued during the Comb Ware stages, as attested by the newly discovered Vihterpalu I (TPQ 3300 cal BC), the previously known Kaseküla and newly discovered Massu V sites (TPQ 2600–2500 cal BC), while the overwhelming majority of the sites by the rivers and brooks of the southern study area probably originate from the Comb Ware stage. This additive model of spatial expansion of human activities is novel to the present work.

The study areas are neighboured by regions where settlement sites with intensive cultural layers, larger find diversities, funerals or remains of pit-houses can be dated at latest to the Narva (Saaremaa island)

or the Comb Ware stages (the drainage basin of the Pärnu Gulf and Northern Coastal Estonia). One possibility to explain the findings of the present work is the hypothesis that the seasonal human activity originated from the Western Estonian Archipelago with an environmentally circumscribed population interested in exploiting additional mainland resources. The validity of this suggestion depends heavily on future studies of the landscape use of Northern Coastal Estonia: if study areas of similar size along the northern coast exhibit patterns similar to the study areas of the present work, then the seasonal mobility of most of Estonia rather than some particular region should be considered higher than previously thought.

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The Iron Gates Mesolithic in a regional context

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ABSTRACT – *The specific character of the Iron Gates Mesolithic material culture derives from the geomorphological and ecological features of the Iron Gates gorge in the Early Holocene. However, the Mesolithic of this geographic area can be entirely linked to the general flows of Mesolithic development in Europe as well as to the phenomena observed in the Adriatic-Ionian and Aegean zones. This demonstrates that the cultural, technological and economic changes which occurred during the Early Holocene were influenced by the same or similar factors as the entire area of the Balkan Peninsula. The absence of Mesolithic settlements outside the Iron Gates raises the question of whether the interior parts of the Central Balkans were inhabited during the Early Holocene. As hinted by the research in the Iron Gates and the Adriatic hinterland, Mesolithic settlements were probably located outside the denser forested areas (in the littoral and high-altitude zones) but this remains to be confirmed. Based on the assessment of the demographic potential of Mesolithic and Neolithic communities, four scenarios of Neolithisation of different parts of the Balkan Peninsula have been proposed.*

KEY WORDS – *Mesolithic; Balkans; Iron Gates; Neolithisation; population movements*

Mezolitik na območju Železnih vrat znotraj regionalnega konteksta

IZVLEČEK – *Posebnost mezolitske materialne kulture na območju Železnih vrat izhaja iz geomorfoloških in ekoloških značilnosti te soteske v zgodnjem holocenu. Lahko pa mezolitik na tem geografskem območju v celoti povezujemo s splošnimi tokovi mezolitskega razvoja v Evropi, kakor tudi s pojavi na območju Jadranskega in Jonskega ter Egejskega morja. To dokazuje, da so na kulturne, tehnološke in gospodarske spremembe v zgodnjem holocenu vplivali enaki ali podobni dejavniki na celotnem območju Balkanskega polotoka. Zaradi odsotnosti mezolitskih naselij izven območja Železnih vrat ostaja vprašanje, ali so bila območja v notranjosti osrednjega Balkana v zgodnjem holocenu sploh poseljena. Raziskave na območju Železnih vrat in v zaledju Jadranskega morja kažejo na to, da so bila mezolitska naselja verjetno izven gostejših gozdnih območij (v primorskem in visokogorskem pasu), kar pa bi bilo potrebno še dokončno potrditi. Na podlagi ocene demografskega potenciala mezolitskih in neolitskih skupnosti predlagamo štiri možne scenarije neolitizacije različnih delov Balkanskega polotoka.*

KLJUČNE BESEDE – *mezolitik; Balkan; Železna vrata; neolitizacija; selitve prebivalstva*

Introduction

In Serbia, the Mesolithic has so far been confirmed only in the area of the Iron Gates, where detailed surveys and archaeological excavations were undertaken during the 1960s and 1970s, due to the construction of hydroelectric power stations on the Danube. A large number of Mesolithic sites were thus discovered and explored in a very short period of time (Fig. 1). The remains of distinct architecture

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and graves were discovered at many locations, while the site of Lepenski Vir yielded stone sculptures (Fig. 2) which still represent a unique phenomenon within the Mesolithic (*Srejović 1969; Radovanović 1996*). These discoveries caused a strong interest in the Iron Gates Mesolithic, which continues today.

The research that followed was initially focused on determining the cultural-stratigraphic sequence and correlation of phenomena observed at different sites, while later research focused on anthropological and bioarchaeological studies, as well as archaeometric studies of samples and materials (*Cook* et al. *2002; Borić, Miracle 2004; Borić, Dimitrijević 2007; Borić* et al. *2018; Bonsall* et al. *2004; 2015a; 2015b; Nehlich* et al. *2010; Jovanović* et al. *2019*). After dating numerous samples from almost all of the known sites, the issue of the chronology of the late phase of the Iron Gates Mesolithic was largely resolved, while genetic and isotopic studies (*Borić, Price 2013; Mathieson* et al. *2017*) enabled a good insight into the nature of interactions Mesolithic and Neolithic populations.

However, despite the fact that recent years have brought significant progress in the research of the Iron Gates Mesolithic, there have been few attempts to examine this phenomenon in a regional context (*Radovanović 1996; Merkyte 2003; Mihailović 2007a*). The discrepancy in the intensity of the research conducted in the Iron Gates and the neighbouring areas only increased over time, which strengthened the initial impression that the Iron Gates Mesolithic represented an exceptional but rather solitary phenomenon.

To mitigate this impression, we considered the issues that we believe best reveal the connections of the Iron Gates with the surrounding areas. These questions refer to (a) the causes and consequences of the settlement of littoral areas in the Early Holocene, (b) the factors which led to the establishment of a linear settlement system and intensification in the procurement of aquatic resources in the Late Mesolithic, and (c) understanding of cultural transformations and interactions at the Mesolithic-Neolithic transition. Although these represent rather general issues, we believe that the Mesolithic of the Iron Gates cannot be approached without looking at the regional scale. We are also convinced that the nature of the Mesolithic-Neolithic transition in Southeast Europe cannot be understood until there is sufficient archaeological evidence on the distribution and size of the local Mesolithic population.

Geographical position and ecology of the Iron Gates

The Iron Gates (Đerdap) gorge represents the largest and longest gorge in Europe. It separates the northern from the southern part of the Carpathian-Balkan Massif, connecting the Pannonian Basin with the Wallachian Plain. In the past, however, the gorge was more of an obstacle than a communication route, especially when it comes to the right bank of the Danube. The narrow parts of the gorge were almost impassable before the flooding by the artificial Lake Đerdap, while communication with the mountainous hinterland, with rare exceptions (*e.g.*, the Cerna valley in Romania) was significantly limited. Due to this, the mobility of the communities that inhabited the Iron Gates was focused on the use of resources within the gorge itself, as evidenced by the low population of the gorge in earlier periods.

There are indications that the Iron Gates represented a refugium for flora and fauna, and, presumably, human populations, during the Last Glacial Maximum (*Mišić 1981*). The climate (which today belongs to the Danube variant of the continental pluviometric regime) is milder than in the neighbouring areas and is characterized by increased humid-

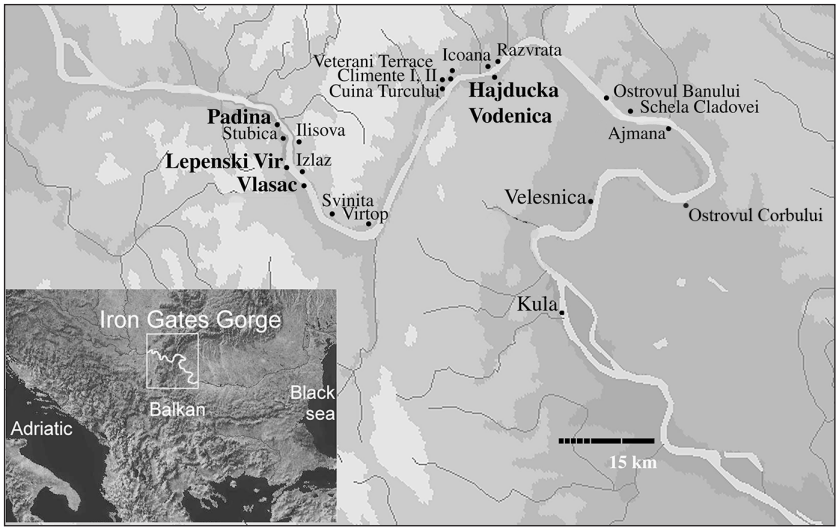


Fig. 1. Map of the Iron Gates with Mesolithic sites.

ity and smaller annual temperature deviations (*Radovanović 1996; Boroneanţ 2011*). A similar situation probably prevailed in earlier periods, although direct evidence of a human presence in the Iron Gates is lacking. In contrast, the Climente II, Cuina Turcului (layer I) and Hoţilor Caves in Romania yielded rich palaeontological material dated to the Late Glacial (Bølling-Allerød oscillation), allowing insights into the palaeoecology of the period (*Boroneanţ 2011; Bonsall* et al. *2016*). The material from these sites mostly consisted of warmth-loving fauna (deer, beaver, wild boar), but cold-loving species (*e.g., Pyrrhocorax graculus*) were also found. The layer II of Cuina Turcului, recently dated to the very beginning of the Holocene (*Bonsall* et al. *2015a*), also contains mixed fauna, which, along with the results of pollen analyses (*Pop* et al. *1970; Carciumaru 1985*), indicates that the Pleistocene-Holocene transition in the Iron Gates may not have been as abrupt as in the neighbouring areas.

The faunal remains found at the Iron Gates archaeological sites testify to the high ecological capacity of this region in the Early Holocene (*Radovanović 1996*). However, one of the defining ecological characteristics of the Early Holocene of the Iron Gates is a richness of fish stock, which included cyprinids (especially the European carp), catfish, pike, perch and salmonids (*Dinu 2010; Živaljević 2017*), but also anadromous species (beluga sturgeon) which swam upstream from the Black Sea into the Danube for spawning. There is little data on climate and ecological changes in the Early Holocene, but it is assumed that the sudden decrease in global temperatures at approx. 8200 cal BP (*Berger, Guilaine 2009*) may have caused the temporary abandonment of previously inhabited sites (*Bonsall* et al. *2002*).

Iron Gates Mesolithic

Early Mesolithic

The earliest evidence for the settlement of the Iron Gates gorge following the Last Glacial Maximum comes from sites located in present-day Romania. Numerous artefacts, fireplaces and graves, as well as engraved bone tools and perforated mollusc shells were documented at the Climente II Cave and the Cuina Turcului rock shelter (*Păunescu 1979; Boroneanţ 2000; Bonsall* et al. *2016*). The remains of fauna testify to the hunting of various animal species, including ibex, which was intensively hunted in the Cuina Turcului II phase (*Bolomey 1970; 1973*). Recent analyses show that fishing already played a significant role at that time. This is evidenced not



Fig. 2. The 'Progenitor' stone sculpture from the site of Lepenski Vir.

only by the fish bones recovered from Cuina Turcului (*Dinu 2010*) but also by the elevated nitrogen stable isotope ($\delta^{15}N$) values recorded for the human remains from Climente II (*Bonsall* et al. *2016*).

Other evidence of the early settlement of the banks of the Danube is rather scarce. The lower layers (I-II) of the Ostrovul Banului site, which yielded a characteristic Epipalaeolithic industry, were once thought to be of Early Mesolithic age, but are now dated to the end of the 8th millennium BC (*Boroneanţ 2011*). Similar material comes from the lower stratigraphic levels of the Veterani terrace, but these are not dated yet. On the other hand, dates for individual samples from the sites of Padina, Lepenski Vir and Vlasac showed that the territory of Danube's right bank was inhabited as early as the end of the 10th and the beginning of the 9th millennium cal BC (*Borić 2011; Bonsall* et al. *2015a*). The dates obtained for human bones confirmed that a specific funeral ritual (*i.e.* burials of individuals in lotus position) was practised in the Iron Gates at that time, but other samples could not be linked to the defined archaeological horizons or material found in them (*Borić 2011*). Therefore, it is currently not possible to understand the character of settlement and material culture in this period.

The situation observed at Padina is somewhat more favourable. Horizon A in sector II of Padina yielded stone and pebble platforms (work surfaces or house

bases) with numerous stone and bone artefacts, while a stone structure with graves was recorded in sector III (*Jovanović 2008*). Samples from both sectors were dated to the end of the 9th and the beginning of the 8th millennium cal BC. We believe there is little reason to doubt that the industry from sector II indeed corresponds to the obtained dates (*Borić 2011*), due to the fact the samples came from the vicinity of the zone where the highest concentration of artefacts have been recorded, and for which very few finds from later periods are recorded (*Radovanović 1981; Jovanović 2008*). However, it would certainly be desirable to date samples from the zone's surface as well.

Regardless of the small number of recorded sites, it seems there are enough elements to understand the settlement pattern of the late Upper Palaeolithic and Early Mesolithic, which has already been discussed (*Radovanović 1996; Bonsall 2008; Borić 2011*). Recent analyses have confirmed that the activity focus, even in the earliest (Bølling-Allerød) phase of settlement, was on the river and its immediate hinterland; in some phases (Cuina Turcului II) even ibex was intensively hunted (*Mihailović 2008*). In the final Palaeolithic, however, communities episodically inhabited the interior of the Iron Gates (*e.g.*, Hoţilor Cave), which was not the case in the Early Mesolithic. The question remains why no more settlements from this period have been discovered. Although there are different opinions regarding this question, most authors agree that the layers with Early Mesolithic remains at most sites were either washed away by erosion or disturbed by the activities of subsequent communities (*Radovanović 1996; Bonsall 2008; Mihailović 2008; Borić 2011; Boroneanţ 2011*).

The industry from the Climente II site was attributed to the so-called Clisurian (*Boroneanţ 2000; Bonsall* et al. *2016*), which is in no way different from the final Epigravettian known from the southwestern Balkans and the Apennine Peninsula. On the other hand, artefacts from the Early Holocene strata of Cuina Turcului and Padina were attributed to the Epipalaeolithic (*Radovanović 1981; 1996*), that is, to the Epigravettian of the Holocene. These industries display a technological decline which is manifested in the reduced presence of Epigravettian elements and the ever-increasing presence of tools made on flakes struck from irregular and bipolar cores (*Mihailović 2001*). This phenomenon, which can be entirely linked to the so-called expedient technology (*Binford 1979*), was initially explained by territorial and social isolation (*Radovanović 1981*), while later interpretations linked it to environmental factors, *i.e.* changes in mobility and resource procurement patterns (*Mihailović 2001*). Regardless of that, the cultural and social closure within this period is not disputed at all (*Mihailović 2007a*), and is actually evidenced by the fact that Early Mesolithic sites show very little evidence of the long-distance exchange of non-utilitarian objects (*Borić 2011*).

Late Mesolithic – early phase

The beginning of the Late Mesolithic in the Iron Gates around 7200 cal BC (*Bonsall 2008*) is marked by the appearance of a number of settlements with house structures, graves and numerous archaeological finds, mainly concentrated in the Lower Gorge (Icoana, Răzvrata, Hajdučka Vodenica) and downstream from the gorge (Schela Cladovei, Ostrovul Banului, Ostrovul Corbului, Kula), while the Upper Gorge records only two settlements – Vlasac and Lepenski Vir (*Radovanović 1996; Jovanović 2008; Bonsall 2008; Borić 2011*). The intensity and continuity in the settlement of the Iron Gates in this period were probably mainly influenced by environmental and perhaps demographic factors. Settlements were built on locations suitable for fishing (*Bartosiewicz* et al. *2008; Dinu 2010; Živaljević 2017*), and fish played an extremely important role in the nutrition of Mesolithic communities, as inferred by the results of archaeozoological and isotopic analyses (*Jovanović* et al. *2019*).

There have been few attempts to reconstruct the settlement system in this period (*Radovanović 1996*). The lack of sites in the hilly-mountainous hinterland, confirmed by recent field surveys (*Radovanović* et al. *2014*), indicates that the activities of human communities in this period were focused exclusively on riverbanks. However, it remains unclear for how long the communities stayed in particular locations, that is, whether they moved along the river coast depending on the seasonal availability of resources. The abundance of remains, graves and various indicators of seasonality suggests, however, that most of these sites were inhabited during different seasons and that there is reason to assume that a relatively sedentary lifestyle developed in the Iron Gates at that time (*Dimitrijević* et al. *2016*). This settlement model probably followed the achievement of a certain level of social and cultural complexity, as indicated by organized and systematic big-game fishing, indirect evidence of storage, evidence of dog domestication and the complexity of the funeral ritual.

The knapping technology displays a continuation of the trends from the previous period: the industry from Vlasac (*Kozłowski, Kozłowski 1982*) is very similar to the industry from Padina, the Epigravettian component is weakly expressed (except within the lower layers of Ostrovul Banului, if these strata were really deposited in the Late Mesolithic), while the industries from the sites in the Lower Gorge take on an almost entirely quartz character (*Radovanović 1996; Boroneanţ 2000; Mihailović 2001; 2008*). However, there are also some changes, primarily manifested in the emergence of bladelet technology (including micro-retouched bladelets of the 'Pontic' type) and microlithic trapezoid tools (*Kozłowski, Kozłowski 1982*). The bone tool industry also blooms during this phase (*Radovanović 1996*), and various tools made of horn are numerous at most sites. Massive pebble tools (mallets, 'sceptres', weights, *etc.*) which were probably used in fishing are also characteristic (*Srejović, Letica 1978; Antonović 2008*).

There is a revival of social contact, as evidenced not only by the changes in technology but also by the exchange of non-utilitarian objects such as *Cyclope neritea* marine gastropod shells, which might have originated from the Black Sea and are recorded at the sites of Vlasac and Ostrovul Banului (*Borić 2011*). Numerous similarities in the organisation of settlements, burials, sculptures, and habitation construction have been observed between the sites in the Iron Gates and those of the Pre-Pottery Neolithic (*Mihailović 2007a*), some of which are elaborated in detail (*Borić 2007*), demonstrating that the connections between the Balkans and Anatolia might be much older. Connections with the Aegean coast of Turkey are also indicated by the recent analysis of domesticated cereal starch grains entrapped in the dental calculus of human individuals buried at Vlasac and Lepenski Vir (*Cristiani* et al. *2016*). However, it is difficult to make any definite conclusions given the geographical distance between these two regions.

Late Mesolithic – late phase

After obtaining an entire series of AMS dates, it seems that most of the settlements in the Iron Gates became abandoned about 6200 cal BC. This abandonment is explained by the floods that occurred because of global climate deterioration (*Bonsall* et al. *2002*), but this is not confirmed yet. The period between 6200 and 5900 cal BC is represented by the trapezoidal buildings at Lepenski Vir I-II and Padina B, a few graves at Vlasac and the remains from Alibeg (Romania) for which there is currently only one absolute date available (*Boroneanţ 2011*). It was found that there is only a brief chronological overlap with the earliest Neolithic settlements downstream from the Iron Gates gorge (*Bonsall* et al. *2015b*), but it is also possible that older settlements do exist in this area due to the presence of pottery in the Lepenski Vir horizon I (*Garašanin, Radovanović 2001*) and the fact that several Neolithic sites older than 6000 cal BC have in fact been recorded in the region (*Whittle* et al. *2002*).

Understanding of the Late Mesolithic chronological relations did not resolve the dilemmas regarding the cultural attribution of Lepenski Vir. While most authors continue to treat Lepenski Vir as a Mesolithic settlement, some are still inclined to associate the site with the Neolithic (*Perić, Nikolić 2016*), while others avoid the issue by classifying it as a transformational/Early Neolithic (*Borić 2011*). Regardless of how we describe this period (transformation or contact phase, *etc.*), Lepenski Vir can undoubtedly be associated with the Mesolithic in almost all elements (settlement organisation, funerary ritual, economy, symbolism), while the Neolithic aspects appear only in the technological domain (*Mihailović 2004; Antonović 2008*). This phenomenon seems to be rightly attributed to the interactions between the local population and the neighbouring Neolithic communities (*Radovanović, Voytek 1997; Radovanović 2006*).

The function of the Lepenski Vir settlement is difficult to understand given the specific character of the remains and a small number of contemporaneous sites. The settlement at Lepenski Vir filled the entire cove, where large numbers of trapezoidal buildings, graves and stone sculptures were discovered (*Srejović 1969*). Exhaustive discussions regarding the organisation of settlement and the simultaneity and manner of habitat construction were conducted in the past, and more recently the discussion has shifted from the sphere of stratigraphic considerations and relative-chronological correlations to that of dating individual contexts (*Radovanović 1996; Garašanin, Radovanović 2001; Borić 2002; 2011; 2019; Perić, Nikolić 2016; Borić* et al. *2018*). These discussions gave rise to many original ideas about different aspects of the site of Lepenski Vir. Eventually, however, it turned out that partially published documentation, regardless of the number of obtained absolute dates (almost on a decade scale), does

not actually provide insights into the rhythm of construction activities and the appearance and duration of buildings from individual phases.

It is now clear, however, that Lepenski Vir was intensively inhabited for about 200 years (*Borić* et al. *2018*), that burial took place within the settlement (inside and between the houses) and that the sacral component (most convincingly evidenced by funeral rituals and stone sculptures) was very pronounced (*Srejović 1969; Radovanović 1996; Borić 2016*). In this context, the question arises as to what gave rise to such a specific form of religious expression at Lepenski Vir, which led some researchers to treat the site as a religious centre (*Roksandic 2012*) and the habitations within it as sanctuaries (*Srejović 1969*), regardless of the evidence that everyday activities were also conducted at the site (*Radovanović 1996; Dimitrijević 2008*). Reasons for this may lie in the general uncertainty caused, on the one hand, by the disturbance of ecological stability of the Danube and the floods at 6300 cal BC (*Bonsall* et al. *2002*), and on the other, by the endangerment of the identity of Iron Gates communities after the influx of the Neolithic population (*Radovanović, Voytek 1997*). Material remains show evidence of strict social control over the key elements of social and cultural identity during this period, including the construction of trapezoidal buildings, a clearly defined funeral ritual and religious symbolism.

Leaving aside the ideological aspects of Lepenski Vir not directly related to the topic of this study, we will only say that the research results also show that fishing (including big-game fishing) played a significant role in this phase as well (*Bartosiewicz* et al. *2008; Dinu 2010; Živaljević 2017*), and that there is no evidence of domesticated plants and animals in the diet prior to the beginning of the 6th millennium BC (*Borić, Dimitrijević 2007; Jovanović* et al. *2021*). However, a different situation has been observed in the field of toolmaking technology: classic Neolithic blades, including those made of the so-called Balkan flint (*Mihailović 2004*) were found along with bipolar pieces and tools on flakes; in addition to massive stone tools, tools with the Neolithic-type cutting edges were also found (*Antonović 2008*); typical Neolithic spatulas were recorded along with characteristic tools made of bone and horn (*Radovanović 1996*). All this underlines that there was a significant degree of interaction between the Mesolithic and Neolithic populations, which is also evidenced by the presence of individuals of non-local origin in the Iron Gates in the period before 6200–6000 cal BC (*Borić, Price 2013; Mathieson* et al. *2017*).

Regional context

Postglacial adaptation

Recent research into the Palaeolithic of the Central Balkans has shown that hunting and gathering communities episodically inhabited gorges and canyons before, during, and after the Last Glacial Maximum (Fig. 3), sometimes due to specialised activities (*Gamble 1997; Borić, Cristiani 2016; Hauck* et al. *2016*). Their exploitation continued during the Late Glacial, when the settlement system was probably residential in character, as evidenced by numerous sites in the Adriatic-Ionian region and its immediate hinterland (*Mihailović 2007b*). All this shows that the settlement of the Iron Gates gorge at the end of the Late Glacial and beginning of the Holocene was not related to the exploitation of water resources, but rather that it has roots in the previous period.

However, the question arises as to why there are no confirmed Mesolithic sites in the interior of the Balkans (apart from those in the Iron Gates). It was assumed that this was due to poor research, but even after intensive field surveys and numerous archaeological excavations (only rarely thematic in character; *Radovanović* et al. *2014*), Mesolithic finds were recorded only at one site: Bukovac Cave near Despotovac. The remains of fauna (including fish bones) were found in the partially preserved layer dated to the Early Holocene (*Živaljević* et al. *2018*). Therefore, it should come as no surprise that some authors have concluded that the Balkan Peninsula was very sparsely populated in the Early Holocene and that Mesolithic communities probably erected ephemeral camps which left little trace in the archaeological record (*Perlès 2003; Runnels 2003; Pilaar Birch, Vander Linden 2017*).

Different interpretations have also emerged, among which the one of Maria Gurova and Clive Bonsall (*Gurova, Bonsall 2014*) stands out. These authors pointed to the fact that dense forest vegetation (up to a height of 700m) developed in the Balkans at the beginning of the Holocene, which complicated the resource supply and communication, thus leading to an increased settlement of coastal areas. According to the same study, the Balkans did not provide favourable conditions for human settlement because the Peninsula included only a few large and navigable rivers and lakes (*Gurova, Bonsall 2014*). However, we do not completely agree with this in-

terpretation. The hydrographic network of the Balkans was very developed at that time, so the aggregation of human populations in the river valleys (Danube, Sava, Velika Morava; Fig. 4), cannot be excluded. As indicated by the position of the oldest settlements in the Iron Gates (*Srejović 1969; Jovanović 2008*), probably only a narrow coastal belt was inhabited, and this had to be preceded by vegetation clearing. The remains of these settlements are today probably submerged, eroded, or covered with a thick alluvium layer – as Clarke (*1976*) pointed out – so it is not realistic to expect that they should have been noticed in the archaeological record by now (*Perlès 2003*). To discover these sites, it would be necessary to undertake thematic field surveys that would include the lowest terraces and profiles of riverbanks. This kind of research, however, has not been conducted so far.

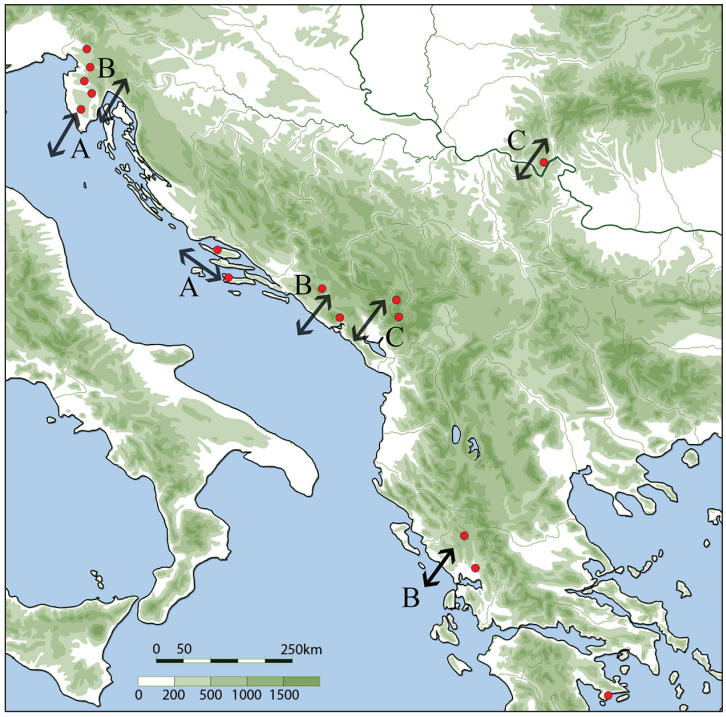


***Fig. 3. Possible routes of residential movements during the Final Palaeolithic in the Balkans:* A *between the coast and the palaeo-Adriatic plain;* B *between the coast and the mountainous interior;* C *between the river valleys and the mountainous zone. The distribution of sites follows* Mihailović 2009.**

Previous research has undoubtedly shown that hunting of predominantly forest fauna played a significant role during this period, but the use of alternative terrestrial resources (especially molluscs) has been recorded at almost all the sites (*Lubell 2004*). Evidence of fishing has been confirmed in the Iron Gates (*Dinu 2010; Živaljević 2017*), the cave Zala in the Dalmatian hinterland (*Karavanić* et al. *2015*), as well as on the Greek islands (*Sampson 2014*), but not in Franchthi Cave (*Perlès 1999; Stiner, Munro 2011*), or on the Adriatic islands (the Vela Spila, Kopačina and Vlakno Caves) which were connected to the mainland at that time (*Miracle 2007; Pilaar Birch, Vander Linden 2017*).

Reduced mobility and changes in the procurement of resources seem to have left a mark in the technological domain as well. Many industries attributed to the Holocene Epigravettian show a tendency towards a technological decline, reflected in the gradual decrease of Epigravettian elements, deterioration of the quality of raw materials used for knapping and in an increased presence of flakes and formal tools on flakes. Initially, this phenomenon could be observed only at Franchthi Cave (*Perlès 1990*) and at the sites in the Iron Gates (*Radovanović 1981*). Later, however, it was found that the phenomenon was widespread (*Mihailović 2001*), and can be traced to all the Early Holocene sites in the Balkans: in the central Adriatic, Montenegro, Greece and even in Slovenia (*Kavur 2006; Vukosavljević* et al. *2011; 2014*). Certain regional differences were also observed between the industries found at these sites, which are mainly manifested as different degrees of representation of Epigravettian and Sauveterrian elements, and the presence/absence of microblade technology (*Komšo 2006; Mihailović 2009; Kaczanowska, Kozłowski 2014*).

The question remains to what extent cultural regionalisation in the Early Holocene was influenced by social closure, which could have occurred due to geographical isolation (*Radovanović 1981*) or reduced mobility, *i.e.* difficult communications (*Mihailović 2007a*). Although, for now, there is little evidence of contact between more distant communities in the interval from the beginning of the Holocene to the middle of the 8th millennium, we still believe that the technological decline of the Early Holocene industries in the Balkans was more likely related to changes in the settlement and resource supply patterns than to cultural and social isolation.

Social complexity and contacts

Even though the Iron Gates Mesolithic still cannot be linked to any particular model of social comple-

xity (*Price, Brown 1985*), there are undoubtedly many elements that point to both organisational complexity and complexity that arose to preserve social stability and implementation of activities related to the procurement of resources (*Binford 2001*). The question as to how much social complexity can be related to sedentarisation (which by itself represents a rather debatable concept) remains unresolved (*Kelly 1992; Whitecross 2016*). In this context, however, it must be pointed out that intensive fishing (especially of large fish) implies a longer duration of settlements. In such circumstances, the number of community members might have risen, as indicated by the numerous graves within settlements, at least in the Iron Gates region. Rather than looking at these cultural phenomena from an evolutionary standpoint, we are inclined to observe them from an ecological perspective, having in mind the ecological stability during the Boreal, which enabled intensive and continuous fishing, not only in the Iron Gates but in the marine coastal zone as well.

The Late Mesolithic in most parts of Europe was marked by technological innovations (the pressure knapping technique, appearance of trapezoids) and new techniques of resource procurement, the causes and expansion directions of which cannot be precisely characterized (*Kozłowski 2009; Binder* et al. *2012*). Unlike Sauveterrian, which has not been recorded south of Istria (*Komšo 2009*), Castelnovian of the Adriatic coast spread all the way to the southern Adriatic, while Greece records industries which (in addition to Epigravettian and Sauveterrian elements) display bladelet technology and a specific microlithic repertoire – a unique feature of the region (*Kaczanowska, Kozłowski 2014*). On the other hand, micro-retouched bladelets were recorded in the Iron Gates Mesolithic, but many other elements characteristic of the Black Sea region (*e.g.*, bullet cores) were not (*Kozłowski, Kozłowski 1982; Kozłowski 2009*).

Along with the spread of technological innovations, the exchange network for non-utilitarian objects was being revived, as evidenced by numerous finds both in the Iron Gates and the Adriatic zone (*Borić, Cristiani 2019*). Within the latter, Vrbička Cave in Montenegro documents worked cyprinid teeth which originated from the Danube (*Borić, Cristiani 2016; Borić* et al. *2019*). Intensive (maritime) communication has also been confirmed in the Aegean (*Sampson 2014*), so we should not rule out the possibility that the Eastern Mediterranean communication zone at one point included the Balkans, as suggested (but still not confirmed) by data from the Iron Gates Mesolithic.

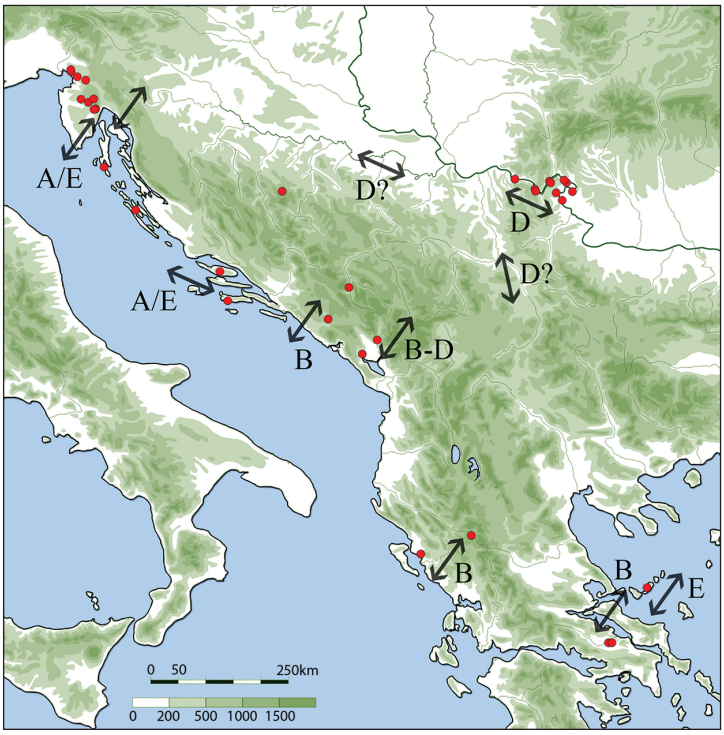


***Fig. 4. Possible routes of residential movements during the Mesolithic in the Balkans:* A *between the coast and the palaeo-Adriatic plain;* B *between the coast and the mountainous interior;* C *between the river valleys and the mountainous zone;* D *along rivers and lakes;* E *along maritime routes. The distribution of archaeological sites follows* Pilaar Birch, Vander Linden 2017.**

The Mesolithic-Neolithic transition

As inferred by the available absolute dates, a sudden expansion of the Neolithic from Anatolia occurred around 6500 cal BC (*Brami, Zanotti 2015*). On the stretch from the Aegean to the southern part of the Pannonian Basin alone, the Neolithic progressed more than 1000km in 200–250 years (*Weninger* et al. *2014; Fort 2015*). When it became clear that the rate of expansion could not be explained by classical models of progression, whether it be colonisation (*Ammerman, Cavalli-Sforza 1971; Van Andel, Runnels 1995*) or agricultural frontier mobility (*Zvelebil 1986*) models, it became obvious that the initial expansion must have been caused by some major event, as was previously assumed (*Cauvin 2000*). More recently, climate and environmental changes – not only those of the so-called 'Hudson Bay' 8.2

ka cal BP cooling event (*Berger, Guilaine 2009*) but also those of the entire Rapid Climate Change (RCC) interval, which lasted from *c.* 6600 to *c.* 6000 cal BC (*Weninger* et al. *2014*) – are considered to represent the main causes for the rapid expansion of the Neolithic. It is quite possible, however, that the pace and directions of expansion could have been greatly influenced by demographic, economic, and social factors (*Orton* et al. *2016; Vander Linden 2011*).

So far, the problem of Neolithisation of the interior of the Balkan Peninsula has been mainly studied from the aspect of colonisation, within the framework of traditional models (*Jovanović 1968; Garašanin 1979*), while the possibility that local communities participated in the process has been discussed only in regard to the Iron Gates (*Srejović 1969; Radovanović, Voytek 1997; Radovanović 2006; Borić 2011*), with rare exceptions (*Whittle* et al. *2002*). In this context, the recent attempt by Marko Porčić *et al.* (*2016*) to use the summed calibrated radiocarbon probability distributions (SCPD) to gain a broader view of the demographic situation in the Balkans in the Early Neolithic must be mentioned. According to their study, there was a significant population growth after *c.* 6200 cal BC, which is in accordance with the Neolithic Demographic Transition (DMT) model formulated by Jean-Pierre Bocquet-Appel (*2008*). Without going into the main objections to the application of this model (*Weninger* et al. *2014*), we would only point out that it cannot be successfully applied to the process of Neolithisation in the Balkans due to uneven archaeological pressure (*French, Collins 2015*), *i.e.* due to scarce evidence for the presence of Mesolithic populations in the southern part of the Pannonian Basin and the interior of the Balkans (*Živaljević* et al. *2018; 2021*).

Several Mesolithic sites have been recorded in the Adriatic zone. In contrast to the Iron Gates, there is a significantly higher number of Early rather than Late Mesolithic sites in this area (*Komšo 2009*). According to previous interpretations, the scarcity of Late Mesolithic sites and discontinuity in settlement relative to the Neolithic could be explained by changes in the settlement pattern (*i.e.* cessation of life in caves and building of open-air settlements) rather than a demographic crisis (*Forenbaher, Miracle 2006*). Continuity in settlement, as detected at the southern Adriatic sites, could indicate the gradual adoption of elements of the 'Neolithic package' in accordance with Marek Zvelebil's predictions (*Zvelebil 1986; Zvelebil, Lillie 2002*). According to Stašo Forenbaher and Preston Miracle (*2006*), the initial colonisation was probably a maritime one, when research expeditions of the Neolithic communities inhabited the coastal zone; Neolithisation of the local communities in the hinterlands only occurred later, after the Neolithic peoples established their first coastal enclaves.

The central parts of the Balkans were probably populated from the direction of the Morava valley (Pomoravlje), and perhaps from the direction of the Danube, as indicated by the absolute dates obtained for the initial Neolithic of this area (*Whittle* et al. *2002; Weninger* et al. *2014*). Judging by the numbers of sites and finds, but also by the estimated rates of progress, the first wave of colonisation possibly had greater demographic potential, but this is difficult to demonstrate as absolute dates are lacking for most sites. Therefore, several scenarios should be kept in mind when considering the Mesolithic-Neolithic transition in the Central Balkans (Fig. 5):

(a) If the population density of the Balkan Mesolithic groups was low and that of the first wave of Neolithic groups was high, there is no doubt that rapid assimilation of local communities could have occurred. This could be especially true for the valleys of large rivers (Velika Morava, Danube) which are suitable for agriculture (*van Andel, Runnels 1995*).

Mesolithic population size	Large	Early phase • infiltration of Neolithic groups; acculturation according to the 'availability model' • Iron Gates, possibly coastal areas	Middle and late phase • territorial competition; possible conflicts; withdrawal of hunter-gatherers; return in the late phase due to attraction factors • Iron Gates, possibly Velika and Zapadna Morava River valleys
	Small	Early phase • acculturation according to the 'availability model' • coastal areas	Late phase • consolidation/assimilation • Danube (Podunavlje) region and marine coastal zone
		Small	Large
		Neolithic population size	

Fig. 5. Possible forms of interactions between Mesolithic and Neolithic communities.

However, if the Mesolithic groups in those areas had higher population densities (as discussed previously) there was certainly a territorial competition, which could have resulted in a short-term withdrawal of Mesolithic peoples to the hilly hinterlands (Fig. 6). If that was in fact the case, the acculturation occurred later, via the so-called push-and-pull factors (*Radovanović 2006*).

(b) If the demographic capacity of Neolithic groups was small and progress was slow or successive, the tempo of Neolithisation could have largely depended on the size and geographical distribution of local communities (*Guilaine 2000; Zvelebil, Lillie 2000*). In the case that the local population was larger, the acculturation process could have lasted longer and included all stages of the so-called availability model. If, however, both populations were small, the attraction factors could have had a decisive influence, in line with the 'psycho-cultural' consequences of contact between the Mesolithic and Neolithic groups (*Cauvin 2000*). These factors could have been especially important after the formation of the first Neolithic settlements.

For now, it seems that the conditions for a rapid advance of Neolithic populations existed primarily in the Morava (Pomoravlje) and Danube (Podunavlje) valleys, regardless of the population density of the Mesolithic groups living in those regions. The withdrawal of local populations is indicated by the situation observed in the upper part of the Iron Gates gorge, where there was a concentration of Mesolithic sites dated to 6300–5900 cal BC; we cannot exclude the possibility that similar processes took place in the Adriatic coastal zone, as data for Crvena Stijena, Odmut, and Vrbička Caves (*Kozłowski* et al. *1994; Mihailović 2009; Borić* et al. *2019*) suggest an Early Holocene recolonisation of the mountainous hinterland of the Dinaric Alps. Yet, for now, there is no conclusive evidence of a greater presence of Neolithic groups in both regions at such an early period.

The second scenario (where there was low-intensity colonisation) is indicated by the presence of pottery and other Neolithic artefacts at Lepenski Vir and various (for now few) testimonies of cultural interactions at the Mesolithic-Neolithic transition both in the Iron Gates and the Adriatic zone. Within the Iron Gates, all three stages of acculturation of local communities (*Zvelebil 1986*) are well represented: availability (Vlasac), substitution (Lepenski Vir, Padina B), and consolidation (Velesnica, Padina and other sites). Similar phenomena have been recorded in the Adriatic coastal zone as well (*Zvelebil, Lillie 2002*), but there are issues regarding the stratigraphic integrity of the layers containing Mesolithic and Neolithic artefacts or domesticated animal remains (*Mihailović 2009*).

Even if acculturation did in fact take place, the question arises as to how it could have been so rapid and why it did not leave more traces in the archaeological record. The only possible explanation is that the emergence of Neolithic populations led to the fragmentation of Mesolithic groups, which could have survived only in the geographically isolated area of the Iron Gates, where there were optimal conditions for their survival and where strong social

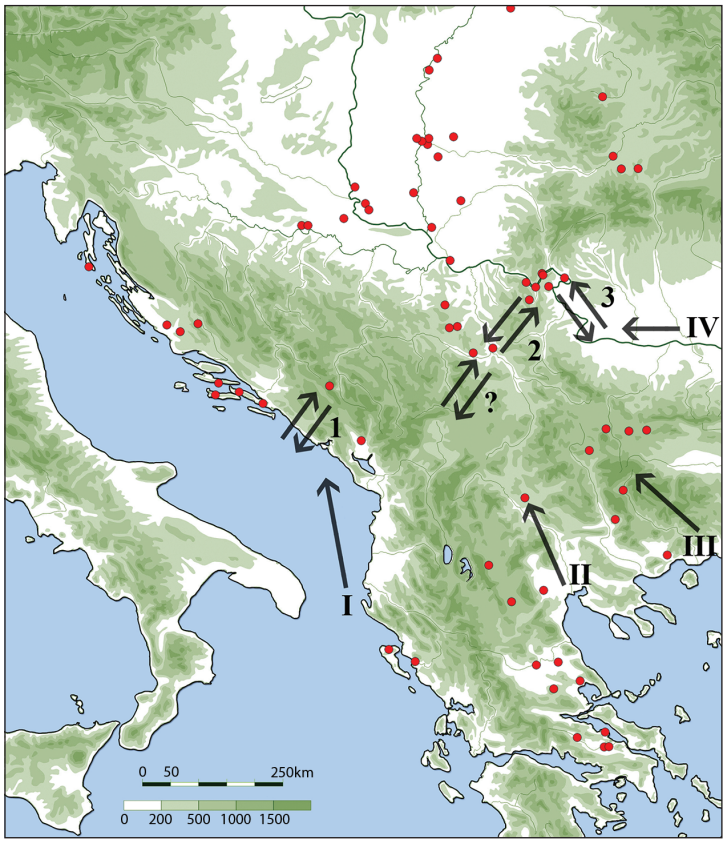


Fig. 6. The possible directions of the advance of the Neolithic (I-IV) and the zones of interaction between the Mesolithic and Neolithic communities. Within the zones of interaction push factors could have been active during the early phase of Neolithisation and pull factors could have been active during the late phase. The distribution of archaeological sites follows Pilaar Birch, Vander Linden (2017).

and ideological integration took place earlier. However, the final transformation and full integration into the Neolithic cultural *koiné* could have taken place only with the acceptance of Neolithic values, which may have occurred because of population outflow (due to the action of pull factors). Ultimately, only future research can show which of these scenarios is the most appropriate to explain Neolithisation of the different parts of the Balkans.

Conclusion

The Iron Gates sequence holds the most complete Balkan record of climatic, ecological and cultural changes of the Late Glacial to the Early Neolithic interval, and is unique in the Balkans in terms of evidence of Mesolithic adaptation and (partial) chronological overlap with the onset of the Neolithic. The peculiarity of the Iron Gates Mesolithic largely derives from the geomorphological and ecological specifics of the area. The Iron Gates is the only gorge in Europe in which a linear settlement system could have been developed and where, among other things, it was possible to catch large anadromous fish. Therefore, it should come as no surprise that the Danube River played a significant role not only in terms of the economy, but also in the ideological sphere, including funerary rituals.

However, the phenomena within the Iron Gates Mesolithic only reflect the changes that also took place in many other parts of Europe (and the Balkans itself) at the beginning of the Holocene, which underlines the inseparable connection of climatic and ecological factors, settlement models and patterns in techno-economic behaviour. The settlement of gorges did not start suddenly but has its roots in the earlier periods; in the Early Holocene, it was undoubtedly related to fishing, regardless of the importance of fish in the survival of human communities (*Radovanović 1996*). It is not realistic to assume that this settlement pattern was limited to the Iron Gates and that large parts of the Balkan Peninsula and the southern part of the Pannonian Basin were uninhabited at the time. We believe that the settlements were probably concentrated on the edges of the river and lake basins and former wetlands, and thus are likely to remain 'hidden' (*Živaljević* et al. *2021*) until detailed field surveys of lake and river terraces are undertaken.

Changes in the procurement of resources are also indicated by changes in technology, which definitely takes on an expedient character during this period and where there are actually very few differences between the Iron Gates industries and those of the marine coastal zone. Although the association between expedient technology and reduced mobility/sedentary lifestyle is hard to establish (*Vaquero, Romagnoli 2018*), the data from the Balkans, and above all from the Iron Gates, is perhaps best at demonstrating this (*Mihailović 2001*).

Research in the Iron Gates confirmed that social factors and demographic trends significantly influenced cultural changes during the Late Mesolithic. Evidence for the renewal of social networks dates back to the end of the 8th millennium cal BC and reaches its peak after the middle of the 7th millennium cal BC (*Mihailović 2007a; Borić 2011*). It is still unclear to what extent the ideological integration in the Iron Gates became influenced by the general insecurity caused by the 8.2 ka cal BP cooling event and to what extent by the possible presence of Neolithic communities in the area (*Bonsall* et al. *2002; Radovanović 2006*). The distribution and chronology of sites from this period indicate that the emergence of the Neolithic in the Balkans was accompanied by the withdrawal of local communities and the fragmentation of the territory they inhabited. The Iron Gates shows evidence that a brief period of interaction with the newcomers was followed by complete assimilation of the local groups into the Neolithic population – although the procurement of aquatic resources continued to play a significant role (*Cramp* et al. *2019*). However, it became obvious that the Mesolithic-Neolithic transition did not follow the same pattern everywhere, which necessitates the need for archaeological testing of different models of Neolithisation in each of the individual regions.

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The development of early pottery in the forest zone of the Middle Volga region (Eastern Europe)

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ABSTRACT – *The article is devoted to the Neolithisation in the forest zone of the Middle Volga River basin. The different conceptions of the process are considered. The archaeological materials from different sites located on this territory and neighbouring regions have been compared. The question was raised regarding animal domestication and its attributes in the forest zone of the Volga region in the Neolithic period. The hypothesis that pottery spread in the forest zone of the Middle Volga region under the influence of cultures from a forest-steppe zone of the Volga region was examined, and the chronological frame of this process was determined. However, the process has been essentially one of migration and was not autochthonous. The mobile lifestyle of early Neolithic hunters played a major part in their movements and did not connect with a productive economy (*i.e. *domestication). An indicator of these changes is pottery style. For the forest zone of the Middle Volga region, the earliest Neolithic vessels are characterized by rare ornamental patterns that appeared earlier than other types.*

KEY WORDS – *Neolithic; Middle Volga region; earliest pottery; pottery technology; domestication; chronology*

Razvoj najstarejše lončenine na območju gozdne cone ob srednjem toku reke Volge (Vzhodna Evropa)

IZVLEČEK – *V članku predstavljamo neolitizacijo gozdne cone na območju srednjega toka reke Volge. Pri tem smo upoštevali različne zasnove tega procesa. Arheološki material smo primerjali tako na ravni različnih najdišč na tem območju kot v primerjavi s sosednjimi regijami. Predstavljamo tudi vprašanje domestikacije živali in njenih lastnosti na območju gozdne cone ob Volgi v času neolitika. Raziskali smo tudi hipotezo, da se je lončenina razširila v gozdni coni na območju srednjega toka reke Volge pod vplivom različnih kultur iz območja gozdne stepe ob Volgi, in določili kronološki okvir tega procesa. Proces lahko predvsem vežemo na migracije, ne na avtohton razvoj. Mobilnost lovcev v starejšem neolitiku je imela pomembno vlogo pri njihovem gibanju in ni bila povezana s produktivnim gospodarstvom (tj. domestikacijo). Eden od kazalnikov teh sprememb je slog lončenine. Za najstarejše neolitske posode na območju gozdne cone ob srednjem toku reke Volge so značilni redki okrasi, ki so se pojavili pred drugimi tipi posod.*

KLJUČNE BESEDE – *neolitik; območje srednjega toka reke Volge; najstarejša lončenina; tehnologija lončenine; domestikacija; kronologija*

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Introduction

The region examined in this study is situated in the basin of the Volga River. There are several main archaeological sites along the Volga. In the southern part of the Lower Volga there is an expansive steppe area, with the Samara River acting as the natural border between the steppe and the forest-steppe zone in the Volga region. Meanwhile, the Lower Kama River is the border of the forest-steppe zone to the north. The forest zone extends to the west in the Middle Volga basin (Mariyskii region) up to the mouth of the Oka River (Fig. 1).

In recent years archaeologists have shown interest in the study of the development of Neolithisation in the forest zone of the Upper Volga (*Kostyleva 2003; Dolbunova* et al. *2017; Tzvetkova 2019*) and the Kama River regions (*Vybornov 2008; Lychagina 2020*). Here we should note different interpretations of the term 'Neolithic'. Domestication is the main criteria of the 'Neolithic package' in the southern territories (*Cilingiroglu 2005; Budja 2013*), while some scholars consider other criteria for the forest zone of Eastern Europe: the appearance of ceramic manufacture, new technologies of stone treatment (polishing, drilling, *etc.*), and a sedentary lifestyle (*Oshibkina 1996*). More recently a new conception of the Neolithisation was proposed for the northern regions (*Nordkvist, Kriiska 2015; Piezonka 2015*). Some researchers see the appearance of pottery as the main indicator of the transition to the Neolithic, and have proposed the concept of a 'ceramic revolution' (*Mazurkevich 2006*). Other specialists point to the emergence of some stone tool features as critical new technologies (*Leonova 2019*). Archaeological investigations focusing on the forest zone of the Middle (Mariyskii) Volga region have a significant role in addressing such questions (*Nikitin 2011; Vybornov 2017*). Notably, the bones of domesticated animals have been found on several sites in this region. In the other words, the southern component of the 'Neolithic package' can be found in the focal studying region. The authors of the current article have their own views on this issue, as explored below.

Conceptions of Neolithisation process in the Volga region

According to Valeriy V. Nikitin (*1996; 2011*) the Neolithisation in the forest zone of the Middle Volga region happened as a result of the interaction of the local Mesolithic groups with inhabitants coming from the southern parts of the Lower Volga region. The migrants brought with them the skills of pottery making and elements of animal domestication. If the first component of the Neolithic formation on the base of local tradition (the Mesolithic without pottery) on this territory has been accepted without questions, the second component (animal domestication) is still under discussion (*Vybornov 2017*). In this article two critical aspects will be considered in this context. The first is about the region of cultural traditions that impacted the emergence of ceramic production in the Mariyskii Volga region. The second

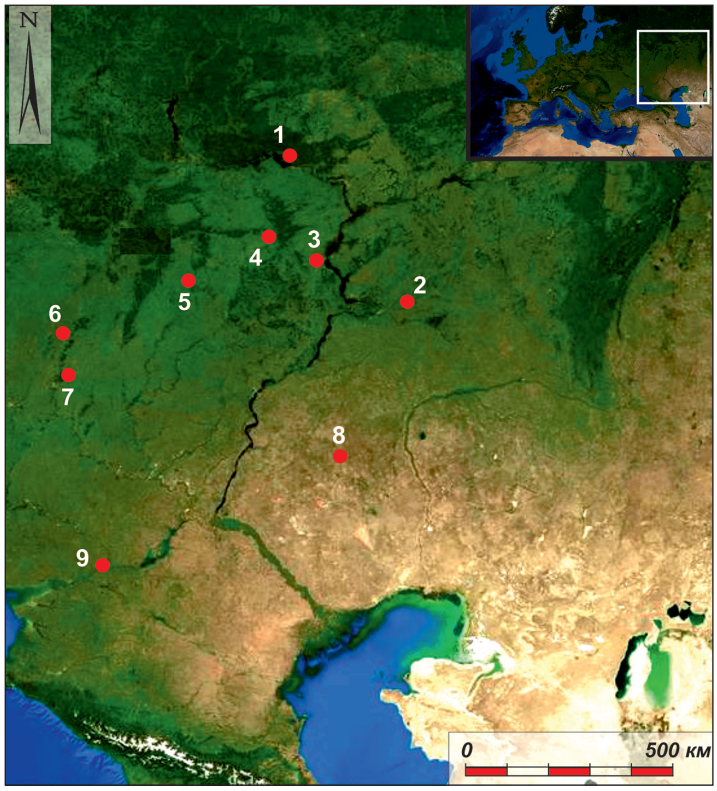


Fig. 1. The map of sites of the Volga-Don basin.* 1 *Dubovskaya III, VIII, Otarskaya VI, Sutirskaya V, Sokol'ny VII, XII sites (forest zone of the Middle Povolzhye);* 2 *Chekalino IV, Nizhnya Orljanka II, Ilinka, Kalmikovka I, Lebjazhinka IV sites;* 3 *Elshanka XI site;* 4 *Vjunovo Ozero II site;* 5 *Oziminki II site (Elshanskaya culture);* 6 *Vasilievskii Kordon 3, 5, 7, Dobroe 4, 7, 8, Karamishevo 5, 9, 19 sites (Karamishevskaya culture);* 7 *Universitetskaya I, III, Yamnoe, Ivnitsa sites (Srednedonskaya culture);* 8 *Varfolomeevka, Algay, Oroshaemoe sites (Orlovskaya culture);* 9 *Rakushechny Yar site.

is which of the groups of Neolithic pottery in this region is most ancient.

There are various points of view on the first question. The first is the Don variant, with historiographic tradition having an effect on this perspective. For example, Alfred K. Khalikov (*1969*) suggested that all innovations in the northern regions were connected with the southern ones, where more intense cultural development had been common. Here we can note that the southern Dnieper-Don region was better studied in comparison to the Lower Volga basin in the middle of 1990s, and a comparative analysis of ceramics from the sites of the forest zone of the Middle Volga and Middle Don regions was the basis of the Don hypotheses.

The early Neolithic pottery from the Middle Volga region is characterized by straight-walled vessels with flat bottoms. There are two groups of vessels. The first group consists of vessels with rare ornamental patterns, horizontal pit rows under the corolla, while on the inner sides of the wall, there are bulges (Fig. 2). The second group of pottery is characterized by having ornamentation only on the upper and bottom parts of the vessels. This decoration was done using the technique of a retreating stick in a triangular or oval shape, with the impressions which were done by pin action. The compositions are quite simple, with inclined rows and zigzags (Fig. 3). It needs to be noted that Nikitin did not allocate the first ceramic group to a specific type, and saw both groups as part of the same cultural and chronological complex. There are some common features of this ceramic group with pottery from the Middle Don region (*Sinjuk 2004*). This is the vessels with straight walls, the line of pits under the corolla and the impression technique used for the ornamentation. However, there are also some differences. Vessels from the Middle Don region do not have flat bottoms, nor any group of vessels with rare ornamental patterns. The inner surfaces of the ceramics show traces of crosshatching made using a toothed instrument. The ornamentation covers the whole surface of the vessels. One of the main ornamental characteristics is impressions in the form of the brackets and twin brackets, as well as in a triangle shape. The ornamental compositions are represented by geometric schemes (Fig. 4). Overall, the differences in the pottery typologies of these ceramic groups are greater than the similarities. The issue of the development of animal domestication at this time period remains very controversial. With regard to agriculture, it should be noted that its emergence in the Volga-Don basin has been registered as occurring no earlier than in the Early Iron Age. Sites with a single homogenous cultural layer from the Neolithic period have not yet been found to contain the bones of domesticated animals in this region. Moreover, the lack of radiocarbon dates on the sites of both regions has complicated the search for an answer to this question. On the other hand, no archaeological evidence has been found of people moving from south to north between the Middle Don basin and the Mariyskii Volga region in the Early Neolithic. All of this means we cannot yet consider the Neolithisation of the forest zone of the Middle Volga region in terms of the migration of separate social groups that possessed the skills of both pottery technology and a productive economy (animal domestication) from the territory of the Middle Don region.

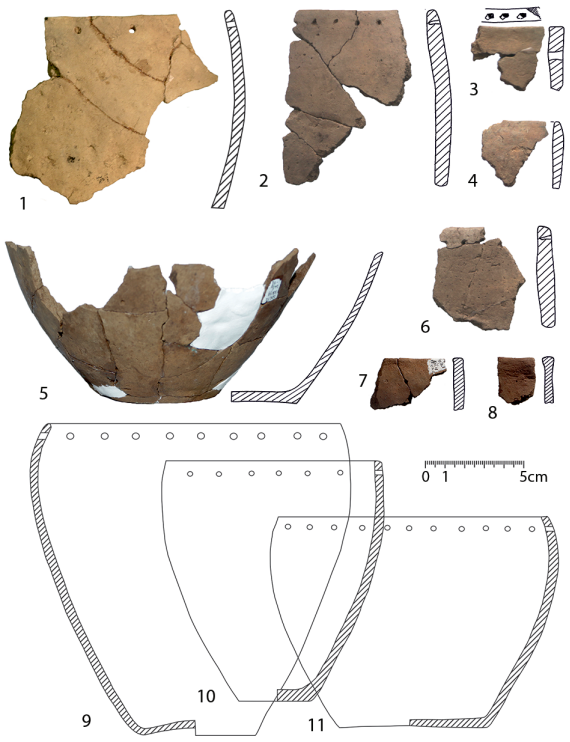


Fig. 2. The forest zone of the Middle Povolzhye. The rare ornamented pottery.* 1 *Otarskoe VI site;* 2–6 *Sokol'ny XII site;* 7–8 *Sokol'ny VII sites;* 9–11 *Dubovskoe III site.

Another region which could play a more important role in the Neolithisation of the northern areas is the forest-steppe Volga region. Around 30 years ago archaeologists found some technological similarities between artefacts from the Samara-Sok basin and the Mariyskii Volga region. On that basis, the specialists considered the Mariyskii region as a northern border of the Srednevolzhskaya cultural spread (*Va-*



Fig. 3. The forest zone of the Middle Volga region. The pinned ornamented pottery.* 1–6 *Sokol'ny XII site;* 7–9 *Sokol'ny VII sites.

siliev, Vybornov 1988). Moreover, scholars also suggested that animal domestication had been developed on the Neolithic sites of the forest-steppe of the Volga-Ural region (*Morgunova 1995*). However, all these results were based solely on the criteria of artefact typology, as in this period the technical-technological analysis of ceramics was not applied, and there were no radiocarbon dates for the Neolithic sites of these regions.

Later, more scientific data for Neolithic sites in the forest-steppe zone of the Volga region was obtained. Based on radiocarbon dates and the criteria of the typology of artefacts, the two stages of the Early Neolithic cultures were divided into the Elshanskaya and Srednevolzhskaya cultures, and a time frame was also set for these cultural traditions. Despite this, questions remained about the productive economy in these societies (*Vybornov 2008*).

New materials and methods, results and discussion

In 2011, the technological and technical analysis of Neolithic ceramics from the sites of the focal region began to be applied (*Vybornov, Vasilieva 2013*). This analysis gave the possibility to determine some technological characteristics of Neolithic pottery for different regions. Numerous radiocarbon dates were obtained for archaeological sites of the Lower and Middle Volga and the Don River basins (*Vybornov* et al. *2013*). These dates were obtained on different types of organic materials, such as charcoal, bones and charred food crusts on ceramics by means of both the traditional and AMS methods (*Vybornov* et al. *2017*). In some cases when the organic material was absent the radiocarbon dates were obtained on the organics from pottery, and details of this technique were published elsewhere (*Kulkova 2014*). It should be noted that the dates from charcoal and bones coincide well with those from the organics from the ceramics of the Neolithic cultures of the Volga-Kama region (*Vybornov* et al. *2018a*).

Over the last ten years, the database on the Neolithic sites of the Middle and Upper Don region has expanded (*Smolyaninov 2020*). However, the characteristics of the archaeological complexes did not change significantly. Some complexes of pottery with rare ornamental patterns and flat bottoms were categorized (Fig. 6), but no evidence about the spread of these complexes in the northern area on the boarder of the forest zone in the Middle Volga region was obtained. There are some differences in ceramic technology between the sites of the Middle and Upper Don and the Mariyskii Volga regions (*Vasilieva 2017*), although no traces of animal domestication at these sites have been found.

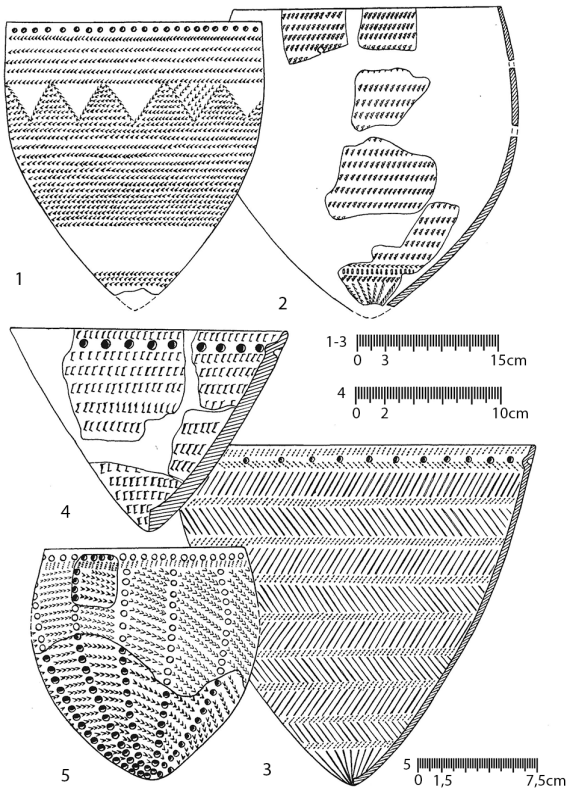


Fig. 4. The Srednedonskaya culture:* 1, 2, 5 *Universitetskaya III site;* 3 *Dronikha site;* 4 *Monastirskaya site I.

In the light of recent investigations the idea proposed by Nikitin has been slightly changed. The southern vector of the Neolithisation remains, but it shifts from the Don River basin to the Low Volga region (*Nikitin 2011*). This can be explained by the results of investigations on the Early Neolithic sites where the flat bottom vessels decorated using a pin action technique was found. The characteristics of the artefacts from the Lower Volga region were developed on the materials from the Varfolomeevskaya site (*Yudin 2004*), and the bones of domesticated animals were also found at this site (*Yudin 2004*). Archaeologists have identified the Orlovskaya culture as a particular culture, noting that the cultural impulse from the Low Volga impacted the formation of the Neolithic cultures of the northern regions, including the Mariyskii Volga region (*Yudin 2004*). The comparison of the pottery of the Orlovskaya culture with that found on the sites of the forest zone of the Middle Volga region should be carried out from the point of view of their technological characteristics. The ceramic paste of wares from the Varfolomeevskaya site of the Lower Volga region consists of silt or poor sandy, silty clay, with an admixture of shells of freshwater molluscs and lake plants (*Vasilieva, Vybornov 2016*).

At this time some authors proposed that Early Neolithic pottery emerged in the forest zone of the Volga region as a result of cultural migration from the Lower Don region, and the Rakushechny Yar culture in particular (*Viskalin 2015; Stavitsky 2015*). The Neolithic pottery from the Lower Don region, unlike the pottery of the forest zone, is represented by large vessels. The vessels are characterized by profile shapes and thick walls and bottoms. The corolla has a flat cut. The inner and external surfaces are ornamented by hatching with a the tool like a comb. However, there are no ceramics with rare ornamental patterns.

The vessels ornamented by triangular impressions have horizontal rows of pit depressions under the corolla. But the patterns of decoration and the related compositions are different from that seen on the pottery from the Srednevolzhskaya culture in the forest zone of the Volga region (Fig. 7) (*Mazurkevich* et al. *2015*), and there are also technological differences. According to Irina N. Vasilieva (*2018a*), the Rakushechny Yar pottery was made without the shells of freshwater molluscs and had special firing conditions. The issue of domesticated animals in the Early Neolithic society of the Lower Don region remains open and under discussion (*Gorelik 2019*).

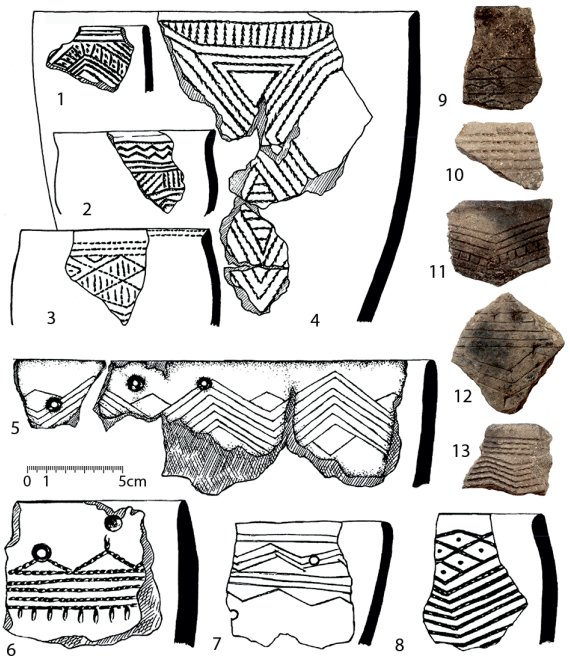


Fig. 5. The Orlovskaya culture. The Varfolomeevka site.

Therefore, the Lower Don region could not be a centre of the cultural impulse of the spread of ceramics to the forest zone of the Middle Volga region.

From 2014 to 2020, two new sites of the Orlovskaya culture were studied in the Volga steppe region: Algay and Oroshaemoe (*Yudin* et al. *2016; Vybornov* et al. *2020*). This raised the possibility of obtaining new information that has been supported by analytic results about the pottery technology of the Orlovskaya culture. The research confirmed earlier findings of the technological features of the Orlovskaya ceramics (*Vasilieva 2018; Vybornov* et al. *2018a*). The same recipe of ceramic paste can be traced from the Lower Volga, but before the Samara river of the natural border of steppe and forest-steppe zones, to the sites to the north. Another recipe of ceramic paste for Neolithic pottery was determined in the forest zone of the Middle Volga region. Typically, the ceramics with rare ornamental patterns were made of silty clay without shell admixtures, but tempered by grog. The technology of pottery decorated by a pin action (impressions) did not differ from that seen with the pottery of the first technological group (*Vasilieva, Vybornov 2015*). In particular, given the fact that the technology of ancient ceramics is conservative, some principal differences between pottery technology from sites of the Lower Volga and the Middle Volga can be determined. Concrete examples of cardinal changes in pottery technology under the influence of migrated people from

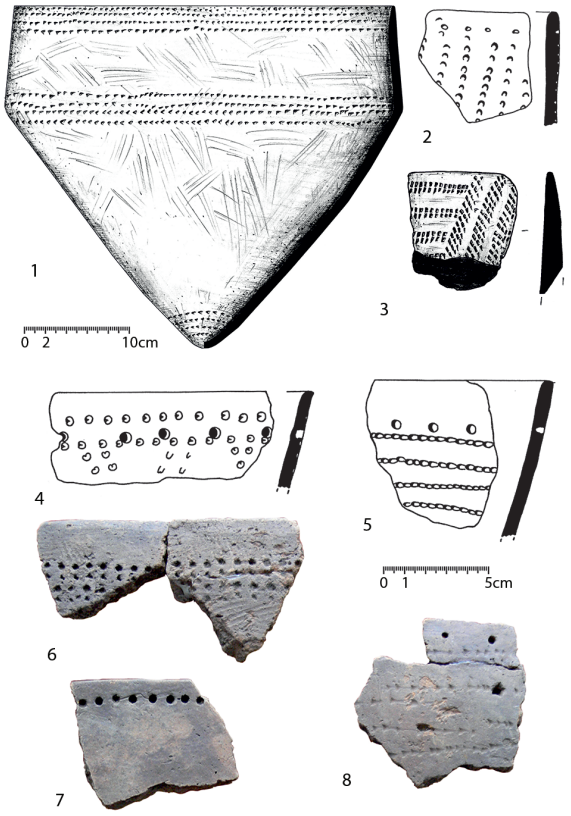


Fig. 6. The Karamishevskaya culture:* 1, 2 *Ivnitsa site;* 3 *Kurino 1 site;* 4–5 *Karamishevo 9 site;* 6,8 *Karamishevo 5 site;* 7 *Vasilievskii Kordon 5.

other regions in the Neolithic period are unknown, and this is contrary to suggestions about the Orlovskaya cultural basis and its part in the formation of ceramic traditions in the Volga forest region. There are also strong discrepancies in the ceramic typologies of these groups. In the pottery assemblage of the Orlovskaya culture, the group of vessels with rare ornamental patterns is missing. This ceramic group is typical of the forest zone. The flat bottom vessels are found in both cultures, but there are some differences in the corolla forms and their cuts. The decoration by a pin action is characteristic for pottery of both the Lower and Middle Volga regions. Pottery from the Lower Volga basin has different geometric compositions (Fig. 5), unlike pottery from the Middle Volga region. If we are considering the issue of migration it is difficult to suggest that this process is expressed just in one cultural component, like pottery. But it is also difficult to find any similarities in the stone tools. With regard to geometric microliths such types as segments and trapeziums are common for the Orlovskaya culture (*Vybornov* et al. *2020*). The northern border for the spread of such artefacts is not far from the border of steppe and forest-steppe zones. Therefore, the comparative analysis of stone tools did not confirm the assumption about the influence of the Lower Volga cultural impulse on the forest cultures. Moreover, the speculation about the appearance of animal domestication in the late stage of the Orlovskaya culture was not confirmed (*Yudin 1995*). There also are some chronological contradictions. The last stage of the Neolithic in the Lower Volga region is dated to 4500 cal BC, whereas the materials with bones of domesticated animals belonging to the earlier Neolithic stage in the forest zone have dates about 5700 cal BC. It was notable that the materials from the Varfolomeevskaya site contained only sheep bones, whereas the bones of sheep as well as horses and cattle were found at the sites of the Mariyskii region (*Nikitin 1996*). As Nikitin suggested, the southern vector of domestication can be confirmed by the presence of oval drilled holes in the Neolithic vessels from the Northern Cis-Caspian and the Lower Volga regions, which can be evidence for the production of milk (*Nikitin 2011*). Later research on the Vorfolomeevskaya site concluded that the presence of sheep domestication remains an open question. Further rigorous investigations of a large collection of palaeozoological materials were carried out for the Algay and Oroshaemoe sites. It is important to note that these archaeological sites have sterile layers between Neolithic and Eneolithic horizons,

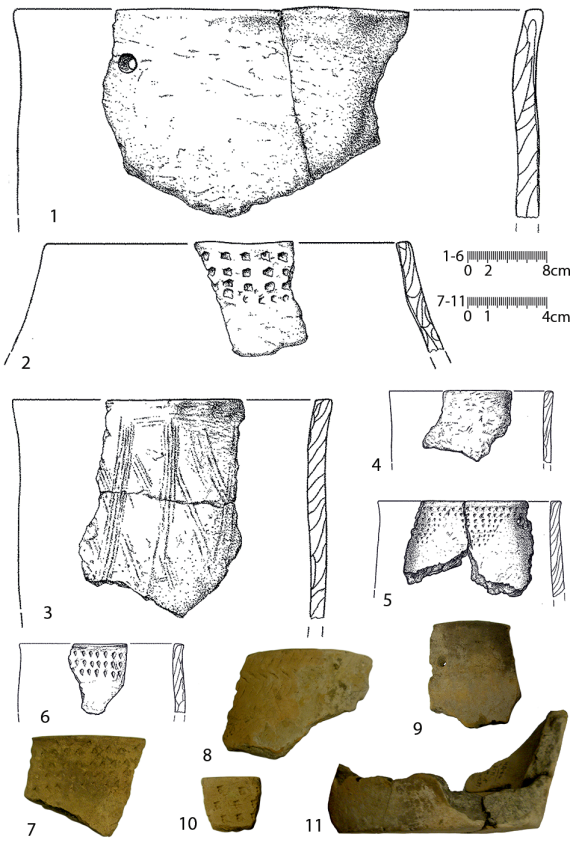


Fig. 7. The Rakushechny Yar site.

which prevented the mixing of artefacts and bones of different periods. The analysis of bones showed a lack of these from domesticated animals on these sites (*Vybornov* et al. *2015; 2016; 2019*), and the oval drilled holes in the vessels are not evidence of their use for milk production (a strainer), as lipid analysis does not support the production of dairy products in this pottery (*Vybornov* et al. *2018b*). Based on this, animal domestication could not spread to the neighbouring regions from sites of the Orlovskaya culture.

A new stage in research into this issue started with the renovation of field excavations of the Early Neolithic sites both in the forest-steppe and forest Volga regions (*Vybornov* et al. *2004; Andreev* et al. *2020; 2020a*). New data such as a series of radiocarbon dates for Neolithic sites of both regions was obtained (*Vybornov* et al. *2017; 2018; Andreev* et al. *2020*), and the technical and technological analysis of pottery of the Elshanskaya and the Srednevolzhskaya cultural traditions was carried out (*Vasilieva, Vybornov 2016; 2016a*). However, no evidence of animal domestication and agriculture was found. The pottery of the second stage of the Elshanskaya culture is characterized by straight walls or a turned down

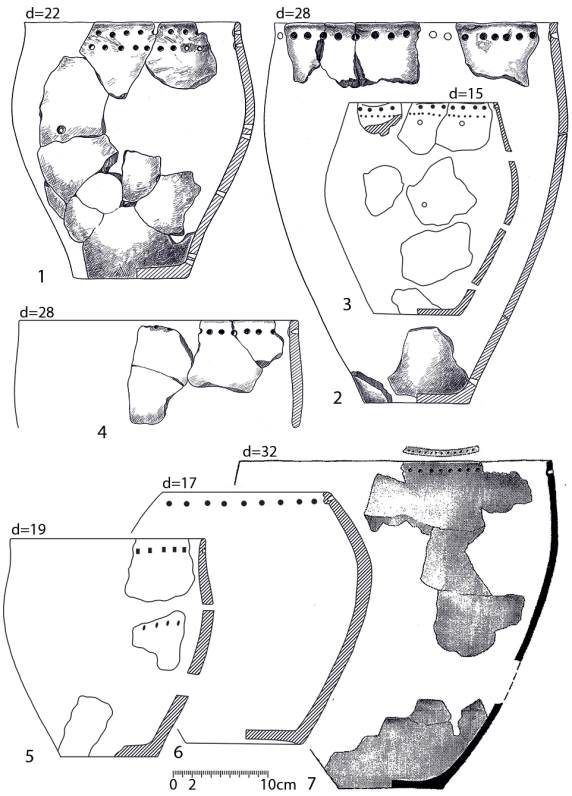


Fig. 8. The Elshanskaya culture (the second phase – the Lugovskoi type).* 1 *Bolshaya Rakovka II site;* 2 *Krasniy Gorodok site;* 3 *Lebjazhinka IV site;* 4 *Elshanka XI site;* 5 *Ilinka site;* 6 *Lugovoe III.

corolla and flat bottoms. There is a row of horizontal pit depressions under the corolla from which the convexities on the external vessel surfaces were exposed. There are also vessels with rare ornamental patterns (Fig. 8). An analogy of this pottery was determined on the sites of the forest zone of the Middle Volga region (Fig. 2). Unlike the ceramic from sites of the Volga basin, the Mariyskii type of pottery has perforating holes under the corolla. The technical and technological analysis of the pottery of the second stage of the Elshanskaya culture shows that the paste was composed from silty and sandy clay without any admixture of shells of freshwater molluscs but with the use of organic solution and tiny grog inclusions that were applied for their manufacture (*Vasilieva, Vybornov 2016a*).

The pottery from the sites of the forest zone of the Middle Volga region was made of silty clay with sand inclusions (60%), as well as with an organic solution and some admixture of grog (*Vasilieva, Vybornov 2015*). In 2019, 13 sherds from pottery with rare ornamental patterns from the Sokol'naya site XII were analysed. The ceramic pastes consist of thin silty clay tempered by grog and fired clay and organic solution in 60% of the samples, while 40% of the samples were tempered by grog and organic solution. Therefore, not only the pottery typology but also the technological features of these ceramics are evidence of the significant proximity of vessels with rare ornamental patterns from sites of the forest-steppe and forest zones of the Middle Volga region. Between the sites of these regions there are connecting points like the Lugovoe III and Elshanskaya X sites in the Sviyaga river basin, where the same type of pottery was found. Using a series of radiocarbon dates, the chronology of this ceramic cultural tradition was determined in the range from 5800 to 5500 cal BC (*Andreev* et al. *2019*). The most ancient archaeological complexes in the forest zone of the Middle Volga region have dates from 6000 to 5700 cal BC (*Vybornov* et al. *2018c*). There is some likelihood that the dates in the range from 6000 and 5900 cal BC obtained on organics from pottery and charred food crusts could be the result of the reservoir effect. Therefore, the most valid dates are in the range from 5800 to 5700 cal BC. According to newly obtained dates, the upper chronological limit for this ceramic type is assessed before 5500 cal BC (Tab. 1). It needs to be noted that the pottery with rare ornamental patterns is dated to an earlier period in comparison with the ceramics ornamented using a pin action technique (*Andreev* et al. *2020*). In fact, the age of this ceramic type on the sites of

the forest and forest-steppe zones is the same. In accordance with the conclusions of specialists and technologists (*Tsetlin 2007*), this ceramic type could not be developed without the direct transfer of the skills of pottery making. Therefore, we can suggest the infiltration of separate groups of people from the forest-steppe zone to the forest zone of the Middle Volga region that influenced the appearance of pottery making among the local people. This process cannot be explained by a sudden rise of the population on sites of the Later Elshanskaya culture due to the development of domestication. An assumption about the appearance of domestication among the Neolithic societies of the Volga-Ural interfluvial was based on the analysis of sites with archaeological complexes of different ages (*Morgunova 2004*). On the homogeneous sites of the same age only wild animal bones like tur, saiga, tarpan, elk, and red deer were identified (*Mamonov 2000*), without any evidence of agriculture. The moving of separate groups of Elshanian culture carriers connects with the mobile lifestyles of ancient hunters.

No.	Site	Index	Age (BP)	Calibrated age (2σ, calBC)	Material
1.	Dubovskaya	IIISPb_1290	7000±150	6113–5631	pottery
2.	Dubovskaya	IIISPb_2816	6930±120	6026–5626	pottery
3.	Dubovskaya	IIIUa-44724	6892±40	5890–5700	charred crust
4.	Otarskaya VI	Le-5998	6700±40	5628–5488	charcoal
5.	Sokol'naya XII	ISPb_3189	6583±120	5720–5317	pottery
6.	Dubovskaya	IIISPb_2817	6467±110	5621–5225	pottery
7.	Dubovskaya	IIISPb_2818	6340±120	5526–5011	pottery

Tab. 1. Radiocarbon dates from the Neolithic sites of the forest zone in the Middle Volga region: the pottery with rare ornamental patterns (1–5); the pottery decorated in pin acting technique (impressions) (6–7).

The investigations of the Neolithic sites in the forest zone of the Middle Volga region in 2018 to 2020 allowed us to obtain additional important results with regard to these issues. Several sherds which differed from vessels with rare ornamental patterns made using a pin action (impressions) were found on the Sutirskaya V site. One of the vessels has thin walls without ornamentation and a profiled shape. The second one has a horizontal in-depth groove under the corolla. Some other sherds were ornamented by dashes in the form of an oblique lattice (*Vybornov* et al. *2004*) (Fig. 9). These features were discovered on the pottery from other sites of the Early Neolithic of the Mariyskii Volga region (*Nikitin 2011.Figs. 24.1, 30.5, 62.2, 99.11, 129.10, 148.2, 157.1, 220.8*). All these features are inherent in the pottery of the Elshanskaya culture (*Andreev, Vybornov 2017*). In the excavation of the Sokol'naya XII site in 2019, a thick-walled profiled vessel with a flat bottom was found. It was ornamented by dashes in form of an oblique lattice (Fig. 10). Typologically it is earlier than the group of pottery with rare ornamental patterns. This is evidence of the penetration of separate groups of people to the forest-steppe zone of the Mariyskii Volga region earlier than the time of the second stage of the Elshanskaya culture. These groups of people became the first propagators of the skills of ancient ceramic technologies among the local people. Unfortunately, the cultural layers of the Neolithic sites in the forest Middle Volga region lay in sandy deposits, and bones could not be preserved in these conditions. This is one of the causes of the lack of any burials for the Neolithic period, and thus there is no paleogenetic data. No burials from the Early Neolithic have been found in the neighbouring regions either.

The question about the presence of domesticated animal bones on the three sites of the earlier Neolithic

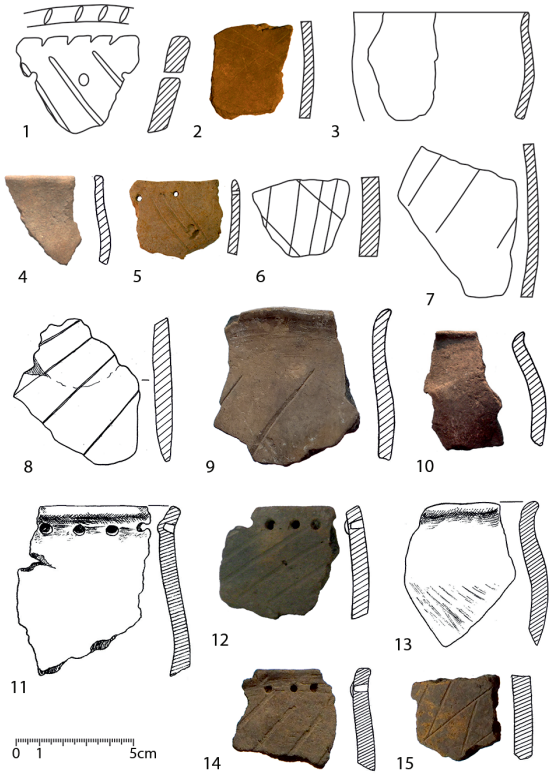


Fig. 9. The pottery of the forest Povolzhye (1–7) and the steppe-forest Povolzhye (8–15).* 1–3 *Sutirskaya V site;* 4 *Sokol'ny XII site;* 5 *Dubovskoe VIII site;* 6 *Otarskoe VI site;* 7 *Dubovskoe III site;* 8 *Chekalino IV site;* 9 *Nizhnya Orljanka II site;* 10 *Kalmikovka I site;* 11 *Vjunovo Ozero II site;* 12 *Ilinka site;* 13–15 *Lebjazhinka IV site.

period in the forest zone of the Middle Volga region needs to be solved. The data presented in this article does not support the presence of domesticated animals on the sites of the steppe and forest-steppe zones in the Volga and Don regions. The forest zone of the Middle Volga region is outside the common context of the Early Neolithic communities. Moreover, in this region the bones of domesticated animals have not been found on the Later Neolithic sites or in the layers of transition to the Eneolithic period. based on the palaeozoological evidence, making clear diagnostic distinctions between the bones of wild and domesticated animals for the period of 5800–5500 cal BC is almost impossible. In some cases, the bones of cattle can be identified as those of aurochs, while those of a domesticated horse can be identified as those of a tarpan, and those of sheep as a saiga, so it is possible some mistakes are made. For these bones AMS dating should be done to check if their age is about 5800–5500 cal BC, or they are more ancient.

The lack of animal domestication in the Early Neolithic of the Mariyskii Volga region, as well as in the forest-steppe zone of the Volga region, was no impediment to the development of pottery technology. Moreover, similarities can be noted in complexes of the earlier stage of the Upper Volga culture (*Dolbunova* et al. *2017*) and Kargapolsky ceramic type (*Kashina 2020*).

Conclusion

Based on the evidence set out above, the appearance of ancient ceramics in the forest zone of the Middle Volga region was not connected with the cultural traditions of the Lower Volga region, or those of the Lower, Middle, and Upper Don basin. The most likely region from where ceramics appeared is the forest-steppe Middle Volga region. In the period of 5900–5700 cal BC sites of second stage of the Elshanskaya culture were spread in this region. According to the typological, technical and technological characteristics of the pottery, these ceramics have analogies to the ancient pottery from the Mariyskii Volga region and are characterized by the same age. The archaeological sites with the same pottery type were found on the transitional territory between forest-steppe and forest zones. These finds support the suggestion about the trajectory of people moving from the forest-steppe toward the north. The infiltration of separate groups of people of the Elshanskaya culture into the forest zone of the Middle Volga region is not related to an increase in population. There is

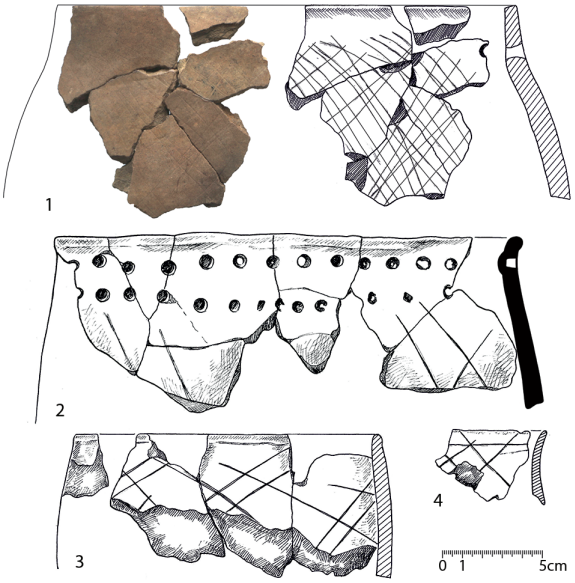


Fig. 10. The pottery ornamented by dashed lines (grid motive).* 1 *Sokol'ny XII site;* 2 *Nizhnya Orljanka II site;* 3 *Ilinka site;* 4 *Ozimenki site.

a lack of evidence of animal domestication in the forest-steppe zone as well as in the forest zone of the Middle Volga region. As such, the pottery making in the northern regions appeared not as an autochthonous process, but as a result of migrations. It can be considered not a southern impulse (from South-Western Asia), but as evidence of an eastern (Central Asian) trend in the development of pottery technology. This was connected not with the development of animal domestication, but with the mobile lifestyle of Early Neolithic hunters.

The question about the further Neolithisation of these regions, the distribution and proportion of vessels with rare ornamental patterns and vessels decorated using the technique of a pin action (impressions), the appearance of a polishing technique and double-sided retouched arrowheads with a triangular shape on the sites, remain of interest for future investigations.

ACKNOWLEDGEMENTS

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From a concentration of finds to Stone Age architecture: the Lommi III pit-house in Northwestern Russia

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ABSTRACT – *High-quality documentation that was made during fieldwork at archaeological sites can provide new information for old excavations, even decades later. The revision of the archival data of the Stone Age settlement site Lommi III, located in the border zone of Russia and Estonia and excavated by Richard Indreko in 1940, allowed us to identify the remains of a Comb Ware culture (4th millennium cal BC) pit-house based on the concentration of artefacts marked in the field drawings. The rectangular shape and size of the concentration (*c. *7.1x4.4m, depth 0.7–0.75m) corresponds to the architectural form common in the European forest zone and has numerous analogies at the settlement sites of that time in Finland, Karelia (Russia) and Estonia. The composition and diversity of the finds and their distribution indicate the (semi-)sedentary way of life of inhabitants of the pit-house. The radiocarbon age obtained from the organic crust on pottery fragments collected in the pit-house corresponds to the first half of 4th millennium cal BC.*

KEY WORDS – *Luga River basin; Stone Age; Comb Ware culture; concentration of finds; pit-house; architecture*

Od koncentracije najdb do kamenodobne arhitekture: vkopana hiša na najdišču Lommi III v severozahodni Rusiji

IZVLEČEK – *Kakovostna terenska dokumentacija arheoloških najdišč lahko prinese nove podatke o starih izkopavanjih, tudi desetletja kasneje. Z revizijo arhivskih podatkov o kamenodobnem najdišču Lommi III, ki se nahaja na meji med Rusijo in Estonijo in ga je izkopaval Richard Indreko leta 1940, smo lahko prepoznali ostanke vkopane hiše z najdbami kulture z glavničasto keramiko (4. tisočletje pr. n. št.), in sicer na podlagi koncentracij najdb, ki so bile dokumentirane na terenskih skicah. Pravokotna oblika in velikost te koncentracije (ok. 7,1x4,4 m, globina 0,7–0,75 m) se sklada z arhitekturno obliko, ki je pogosta na evropskem gozdnem območju in ima številne primerjave s sočasnimi naselbinami na Finskem, v Kareliji (Rusiji) in Estoniji. Sestava in raznolikost najdb ter njihova razprostranjenost kažejo na to, da ima ta vkopana hiša značilnosti (delno) stalne poselitve. Vkopano hišo smo s pomočjo organskih ostankov na keramičnih odlomkih radiokarbonsko datirali v prvo polovico 4. tisočletja pr. n. št.*

KLJUČNE BESEDE – *porečje Luge; kamena doba; kultura glavničaste keramike; koncentracija najdb; vkopana hiša; arhitektura*

Introduction

While pictorial sources (sculptural images, engravings and drawings) are available to study dwellings mainly from the Chalcolithic period, and written sources from the earliest civilizations of the Old World (*e.g., Passek 1938; Nechaeva 1975; Frayne 1998; Tallet 2017*), the research base for Stone Age dwellings is almost entirely limited to archaeological remains of buildings or traces of such structures.

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There are very few exceptions for Palaeolithic period from different parts of the World (*Pidoplichko 1969.Fig. 58; Marshack 1979.290; Svoboda 1997. Fig. 8; Olenkovskiy 2000.376; García-Diez, Vaquero 2015*). However, not a single image of the dwellings of the Stone Age hunter-gatherer societies of the European forest zone is known.

Folk dwellings, as can be seen from ethnographic data (*Popov 1961; Hole, Heizer 1973.112*), can be very diverse depending on natural conditions, historical period, lifestyle of the residents and building traditions. At the same time, although building remains from archaeological contexts are relatively numerous, the data are mostly limited in the architectural sense and the level of detail. We subscribe here to the idea that from an archaeological point of view a dwelling is a set of archaeological materials with certain boundaries and a way of accumulation; quite often a dwelling can only be identified as an artificially allocated or transformed natural space that can accommodate at least one person, in short, often just the floor of the dwelling can be found (*Boriskovskiy 1958.4; Grigorjev 1974.12; Rogachev, Anikovich 1984.189; Grøn 2003.686–688; Leonova 2004.66*).

The main architectural remains, destroyed and decayed structural elements are usually not preserved in the sandy soils of the Stone Age sites in the European forest zone without special conditions (such as wetlands or other kinds of anaerobic soils, burning of wooden elements or clay daub, *etc.*). Sometimes only post holes, stones or ash and charcoal spots can indicate the location and existence of an ancient dwelling (*Loze 1979.55–60; 1988; Zhulnikov 2003.20; Leonova 2004; Khrustaleva 2017*). Often, however, only concentrations of artefacts or, vice versa, empty zones can indicate the presence of settlement features (*Pesonen 2002.11; Zhulnikov 2003.19; Gelhausen* et al. *2009; Larsson, Sjöström 2013.506–508; Kriiska* et al. *2016; Rostedt, Kriiska 2019.18*). The high quality of the excavations and the documentation required for such an analysis are usually only achieved through modern excavations. However, archival data may also provide new discoveries for some studies conducted decades ago.

The results of the revision of the archival data of the Stone Age settlement site Lommi III, located in Ingria (Leningrad Region, northwestern Russia) and excavated by Richard Indreko in 1940 (at that time this territory was part of Estonia), can also be called a discovery. When working with the materials from this site, attention was drawn to a rather expressive concentration of artefacts marked on field drawings, both on the horizontal plan and on the stratigraphic section of one of the excavation areas. The size and shape of this concentration suggested a structure that had divided space and limited the distribution of cultural remains. All this indicated the presence of a pit-house that Indreko had discovered without even realising it. After excavating in the area that is at the heart of our paper, he wrote in his field report: "*To see how widespread the finds are, and also partly in search of a dwelling, 5 small test pits were dug in different places on the right bank of the Notika River...*" (*Indreko 1940.6*). As the quote suggests, Indreko went to look for a dwelling elsewhere, but the quality of his field documentation, which is very high for its era, allows for a new analysis using modern knowledge and methods.

This discovery determined the purpose of our work – to analyse the materials of the settlement site and substantiate the presence of the dwelling remains, and, if possible, establish its function and construction details. The methodological basis of the study includes spatial and comparative-typological analysis and analysis of the proportions of raw materials used, as well as radiocarbon (AMS) dating of burnt animal bones and organic crust on pottery fragments. In addition to an overview of the general context of contemporaneous settlement sites, this work also prompted us to delve into the theoretical discourse on the history and methods of studying Stone Age pit-houses in a larger territory and broader chronology.

Lommi III settlement site

Lommi Stone Age settlement sites (named after a now lost village) are located on the banks of the small River Notika, a left tributary of the Luga River in Ingria, near the Gulf of Finland of the Baltic Sea. The area is a coastal lowland bounded in the south and east by the Cambrian and Ordovician bedrocks (Baltic Klint) and located on the border of Estonia and Russia (Fig. 1.1). Two major rivers, Narva and Luga, flow through the lowlands and numerous different coastal landforms of Middle and Late Holocene are preserved in the area (*Rosentau* et al. *2013*). Nearly a hundred archaeological sites, mostly Stone Age settlements (Fig. 1. 2), have been discovered in the basins of the two rivers during a century of research (*Kriiska 1996a; Kriiska* et al. *2016b; Gerasimov* et al. *2019*).

The story of the discovery of the Stone Age settlement sites in Lommi began in the winter of 1939 with a careful border guard who found potsherds and flint artefacts from the gravel transported to build a road near the cordon. He interviewed the transporters, stopped the gravel quarrying and sent the finds to the head of the border guards, who in turn took them to the Narva Museum (*Soom 1939; Indreko 1940*). In October of the same year, the director of the Narva Museum visited the place together with the border guard and collected Stone Age artefacts from both banks of the Notika River (*Soom 1939*). Finds and documentation of field observations were sent to the Institute of Archaeology of the University of Tartu (*Soom 1939; Indreko 1940*). After that, Richard Indreko of the University of Tartu conducted an inspection and excavations at the site from 1 to 19 July 1940. In addition to the leader, six other people took part in the expedition. The field report (*Indreko 1940*), which has not been completed and does not contain any photos, shows the ensuing war (Fig. 2). This naturally affected all archaeological work in Europe as a whole, and for Indreko personally ended with emigration from Estonia (*Johanson, Tõrv 2013*). He published the results of the excavations only after the Second World War (*Indreko 1948; 1964*).

Indreko provided general information and a map of the locations of the discovered sites. Two of them were situated on the left bank of the Notika River, in the territory of the former farms of Männimetsa/Passi (Lommi I) and Saare/E. Hämäläinen (Lommi II). The Lommi III site was located on the right bank of the Notika, opposite Lommi II. The modern riverbed was formed later and partially destroyed the settlements, as indicated by the Stone Age finds (including potsherds) from the Notika River (*Indreko 1940.3*). Full-scale excavations were conducted at Lommi III (Fig. 1.3). The find assemblage of more than 150 excavated square meters included potsherds, flint artefacts, whetstones, stone and amber ornaments and clay figurines (the finds are stored in the Archaeological Research Collection of the University of Tallinn, Estonia; collection number AI 3867). Indreko associated all the excavated materials with the Comb Ware culture, and suggested that the cultural layer had developed 'simultaneously' (*Indreko 1940.6; 1948.299*); currently the Comb Ware culture in Estonia is divided into two parts, the Typical and Late Comb Ware culture, dating 3900–3500 cal BC and 3500–1750 cal BC respectively (*Kriiska* et al. *2020.Fig. 1*).

Later, only minor fieldwork was done in Lommi. In 1952, Nina Gurina from the Institute of Archaeology (Leningrad, USSR) surveyed the area and made two test trenches measuring 2x2m on the left bank of the Notika River (*Gurina 1961*). This was the territory of the Lommi I or II site, as became apparent after the recent detailed revision of her fieldwork plans and written site descriptions. However, Gurina

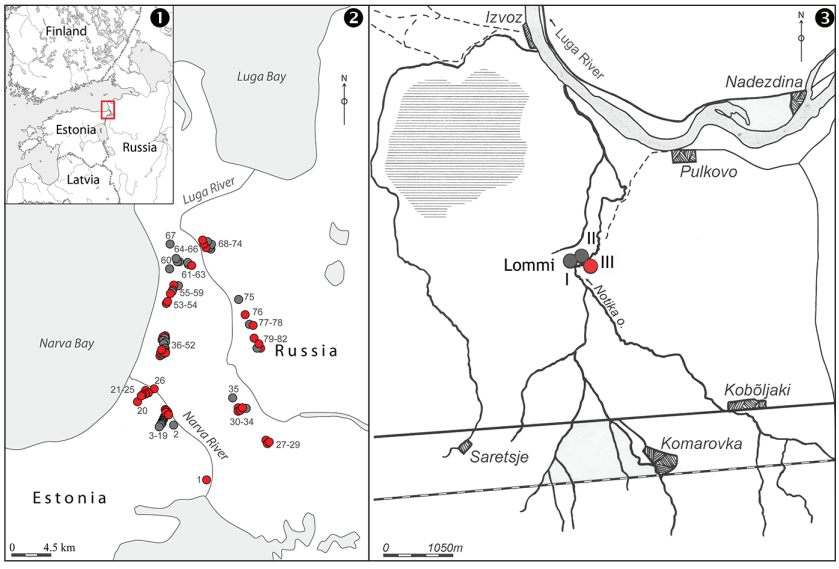


Fig. 1. Location of the research area:* 1 *Narva-Luga interfluve (red rectangle) on the map of the Eastern Baltic;* 2 *Stone Age sites known in the Narva-Luga interfluve (after* Kriiska et al. 2016; Gerasimov 2019*; amended by the authors), red dots mark the settlement sites of the Comb Ware culture:* 1 *Narva Joaorg;* 2 *Vasa;* 3–19 *Riigiküla I–XVII;* 20 *Viljapea;* 21–25 *Narva-Jõesuu I–IV;* 26 *Venkul (Väiküla);* 27–29 *Lommi I–III;* 30–34 *Izvoz 2–6;* 35 *Keykino;* 36–52 *Rosson 1–16;* 53–54 *Väike-Ropsu 6–7;* 55–59 *Väike-Ropsu 1–5;* 60 *Kuzemkino 3;* 61–63 *Kuzemkino 5–7;* 64–66 *Kuzemkino 1, 2, and 4;* 67 *Strupovo;* 68–74 *Galik 3, 4, and 6–10;* 75 *Kurovitsy 7;* 76 *Kurovitsy 1;* 77–78 *Kurovitsy 4 and 8;* 79–82 *Kurovitsy 2, 3, 5, and 6.* 3 *location of Lommi settlement sites (after: Map AI 4-1-51-1-1= Narvataguse khk. Lommi kl. kammkeraamilise kult. asulakoha ümbruskonna plaan. Kaevamised R. Indreko 1940. a. 1–19.VII. AI 4-1-51-1-1. Drawing in the Archaeological Research Collection of the University of Tallinn, Estonia), red dot – Lommi III.

seems to have assumed that this was site III, as she included it in the general context of artefacts found by Indreko in Lommi III. Gurina also described the stratigraphy of the site, but it is not clear from her text which finds were directly made in the test trenches (at least part of the finds is kept in the Kingisepp Museum of History and Local Lore, Russia). She dated the settlement site to the 'advanced Neolithic' (*Gurina 1961.412*).

The Lommi I settlement site was again localised in 2011 by Dmitry Gerasimov (Peter the Great Museum of Anthropology and Ethnography, the Kunstkamera; St. Petersburg, Russia) and Aivar Kriiska. Archaeological finds (Comb Ware sherds and a few bone fragments) were collected from the surface of a small sandy hillock (*Gerasimov 2019. 183*). A fragment of Estonian Corded Ware (2800–2000 cal BC; *Kriiska* et al. *2020.Fig. 1*) was also discovered, indicating that the same places by the Notika River were used at the end of the Stone Age as well.



12. VII. 40

4500-aastane asula Narva taga.

[redacted] Lommi külas satuti rikkalikule kiviaegsele leiukohale. [redacted]

[redacted]

TEADUSLIK KAEVAMISTÖÖ Lommi küla metsas. [redacted]

Narwa lähedal [redacted] Lommi küla maa peal Notika oja juures on juba mõnda aega käimas [redacted] arheoloogilised kaewamised, mis on annud rikkalikke tulemusi. Siin on satutud kiviaegsete inimeste elualsemele, kust on kaewamisel päewawalgele tulnud mitusada eset, mis walgustawad nn. kammkeraamilist ajajärku.

koos kuue ülikõpilasega kohale teostama kawakindlat teadusliku kaewamist. Uurijate poolt on kindlaks tehtud, et

selles kohas, kust talumehed kaewajd kruusa, oli kiwiaja elamu tulease korrapäraselt kiwidest laotud koldega,

mida tõendab paks tahma- ja tuhakiht selles kohas. Kahjuks on aga liiwawedajad selle koha ära lõhkunud.

Sellel alal, kus praegu on käimas kaewamised, on tulnud ka ette lahtiseid tuleasemeid ühes kui teises kohas. Nende kohtade ümber koonduwad ka leiud. Peaasjalikult on seni leitud hulk sawinõude killde, mis kuuluwad nn. kammkeraamilisse kultuuri. Pealeselle tuleb järjest päewawalgele wäga palju tulekiwikilde, mis osalt wõibolla on pudenenud teiste esemete wäljatöötamisel. Ka leidub palju mitmesuguseid kõwitsaid, millega tehti wanasti wäga mitmesuguseid töid, näit. kraabiti nahka, silutl puuriistu, töötati wälja tarbeesemeteks luu- ja sarwmaterjali. Wäärtuslikuma osa leiust moodustawad

pajulehe-kujulised, peenelt wälja-töötatud tulekiwist nooleotsad, mida on seni leitud ohtrasti.

Sellised nooleotsad on kammkeraamilisele kultuurile wäga tüüpilised. Siis on weel leitud üks kiwist ripats ja poolik ehterõngas, samuti kiwist. Suuremaid asju pole seni lagedale tulnud, wälja arwatud üks kiwikirwe tükk. Seni on registreeritud 178 leiunumbrit, kuid tegelikult on ühe numbri alla koondatud kuni sada üksikleidu.

Kammkeraamiline kultuur on tüüpiline Põhja-Euroopas. See kuulub jahipidajatele ning ajaliselt kolmandasse aastatuhandesse enne Kristust, sawinõude ornamentide järgi otsustades umbes selle aastatuhande keskpaiku. Seega on siin tegemist

inimeste elualsemega, mille wanus ümmarguselt 4500 aastat.

Kõik tundemärgid näitawad, et siin on elatud pikemaajaliselt, mistõttu jäänuseid on säilinud üsna paksu kihina, maapinnast alates kuni 60 jm. jügawuseni. Omal ajal oli siin wäga soodus elamiskoht ümbruskonna soodest kõrgematel ja kuiwematel liiwaluidetel. Pealegi pole kahtlust, et Notika oja oli hallis minewikus palju suurem weekogu kui praegu.

[redacted] märkis jutuajamisel meie lehe esindajaga, et kammkeraamilise kultuuri kohta on meil seni olnud wähe selgitawaid leide, mistõttu käesolew leiukoht annab selles suhtes head materjali. Kawas on weel lähemas ümbruskonnas ette wõtta proowikaewamisi,

et leida weel mõnda teist elamu asukohta.

Teispool Lommi küla teed on weel üks endine kruusawõtukoht, kust sageli on päewawalgele tulnud mitmesuguseid esemeid. Seal on aga kogu see maa-ala niiwõrd segi kaewatud, et süsteemitsindla teaduslikku kaewamise teostamiseks pole wõimalusi.

Fig. 2. The only surviving photo from the excavations of Lommi was published in Estonian newspapers on July 12, 1940 (4500-aastane asula Narva taga. Maa Hääl: maarahva ajaleht, 80, 12 juuli 1940). On September 29, 1950 (as indicated by a stamp faintly visible in place of text cut out from a newspaper article, kept in the Archaeological Research Collection of the University of Tallinn, Estonia), history was corrected with the 'Soviet method' – part of the text was completely cut out, and the name of Richard Indreko, together with the words 'near the border' and 'border guard' were painted over with black ink, because after the war this border area of the Republic of Estonia was annexed to the Russian Soviet Federative Socialist Republic, and because Indreko had become "an enemy of the people" due to his escape to the 'West'.

To summarize, only Indreko conducted a full-scale excavation at the Lommi III settlement site during one season. He opened two large areas east of the gravel pit from which the artefacts collected by the border guard came, and also dug five test pits and a trench with a total area of probably only a few square meters (*Indreko 1940*). Unfortunately, some parts of the documentation were lost during World War II, including the general plan of the excavations. Plans are only available for two large excavation areas, but their spatial relationship to each other is unclear. The larger excavation area was 128m^2, and the second area of 24m^2 was apparently located to the west of it. The excavation and documentation methods were very precise, but since sieving was not practiced in those days some of the small items were obviously overlooked. Most of the artefacts were collected individually, in some cases small groups were recovered from a single location. Each of them got its own number and was drawn on horizontal and vertical plans; thus, all finds have a documented three-dimensional position.

This paper focuses only on the large excavation area, and especially its northern part, where the concen-

tration of finds that initially caught our attention is located (Fig. 3). We analysed the artefacts drawn on the plans (401 numbers, 1538 items; more than 95% of all finds from this area), but without other documentation it is impossible to localize the rest. All of these artefacts were found *in situ*, with the exception of the gravel pit edge in the northeastern part of the area.

At the time of Indreko's fieldwork, a thin layer of moss covered the entire study area. Beneath it a sandy cultural layer, intersected by lenses of dark sand of varying thickness. The upper part of the layer also contained lenses of ash along with occasional charcoal pieces (thickness *c.* 0.1–0.3m). The base layer consisted of white-greenish sand. The upper part of the cultural layer was mixed to a depth of about 0.1m and, in addition to the Stone Age finds, also contained nails, bullets and cartridge cases. Finds from the cultural layer were made up to a depth of 1.15m from the surface at that time. According to the lithological layers drawn on the horizontal plans, the main artefact concentration, visually estimated, is mainly associated with the dark sand and ash layers, the boundaries of which cannot be clearly outlined on the horizontal level (Fig. 4.1). In the stratigraphic section, however, the inter-layered dark sands and ash spots quite clearly stand out against the background of other layers (Fig. 4.2). Still, it is difficult to determine what these 'ash' layers actually mean in Indreko's documentation: was it a description of a colour (gray as ash) or did it mean inclusions of charcoal pieces? We suppose that it meant the presence of charcoal, since there are quite a few pieces of it present in the find collection. However, it cannot be unambiguously confirmed whether they are related to Stone Age activities at the site.

Methods

The methodological basis of the study includes spatial and comparative-typological analysis and analysis of the proportions of raw materials used, as well as radiocarbon (AMS) dating of burnt animal bones and organic crust on pottery fragments. Plans of the horizontal and vertical distribution of lithological layers, finds and archaeological features drawn on paper were digitized using the AutoCAD 2013 Autodesk Software. The coordinates (x, y, z) of all artefacts were determined according to their position on the drawings and recorded together with their description in a table. This enabled further easy manipulation of this data in three-dimensional space using the computer programs AutoCAD 2013 Autodesk Software and Surfer 11 Golden Software. Spatial analysis (see *Binford 1972; Hodder, Orton 1979; Blankholm 1991; Lancelotti* et al. *2017*) was the main method for substantiating the presence of dwelling remains at the site and determining its outlines.

All finds were classified and their raw material, type, size (stone artefacts) and weight (flint items) recorded. The composition of the admixture added to the moulding clay mass was determined visually for potsherds. To investigate the homogeneity of the cultural layer and determine the relationship of features at the settlement site, the links between stone finds made from the same raw material were traced.

To establish the age of the settlement site, radiocarbon dates were obtained from burnt animal bones and organic crusts on pottery fragments. The samples were dated by the acceleration mass spectrometry (AMS) technique at the Kiel Leibniz-Laboratory for Radiometric Dating and Isotope Research (KIA), the Beta Analytic Testing Laboratory (Beta) and the Poznań Radiocarbon Laboratory (Poz). The obtained dates were calibrated using the OxCal 4.4.2 program (*Bronk Ramsey 2020*) with the IntCal 20 atmospheric curve (*Reimer* et al. *2020*).

Results

Most finds from the large excavation area (Fig. 5) are pottery sherds (1331 pcs), flint tools, blanks and production waste (150 pcs) and sandstone whetstones (34 pcs); the absence of micro debris noted in the course of the analysis is likely the result of the lack of sieving during excavations. Pottery is represented by sherds of Typical Comb Ware, both with mineral and organic admixture, two fragments can be associated with Narva Ware (typo-chronological date in Estonia and Ingria 5200–3900 cal BC; *Kriiska* et al. *2017.77*).

The main concentration of finds includes 1236 artefacts (80% of all finds from this excavation area; Table 1). It is located in the northern part of the excavation, rectangular in shape and *c.* 7.1x4.4m in size. The finds reach a depth of 0.7–0.75m from the ground surface of that time, with most artefacts found at a depth of 0.2m to 0.7m. In the northeastern corner of this concentration, more than 680 finds have been recorded under one number (AI 3867:51). As can be seen on the plan (Fig. 3.1), this part was disturbed by a later (gravel?) pit and it can be assumed that this number includes all the finds collected from this pit during excavations.

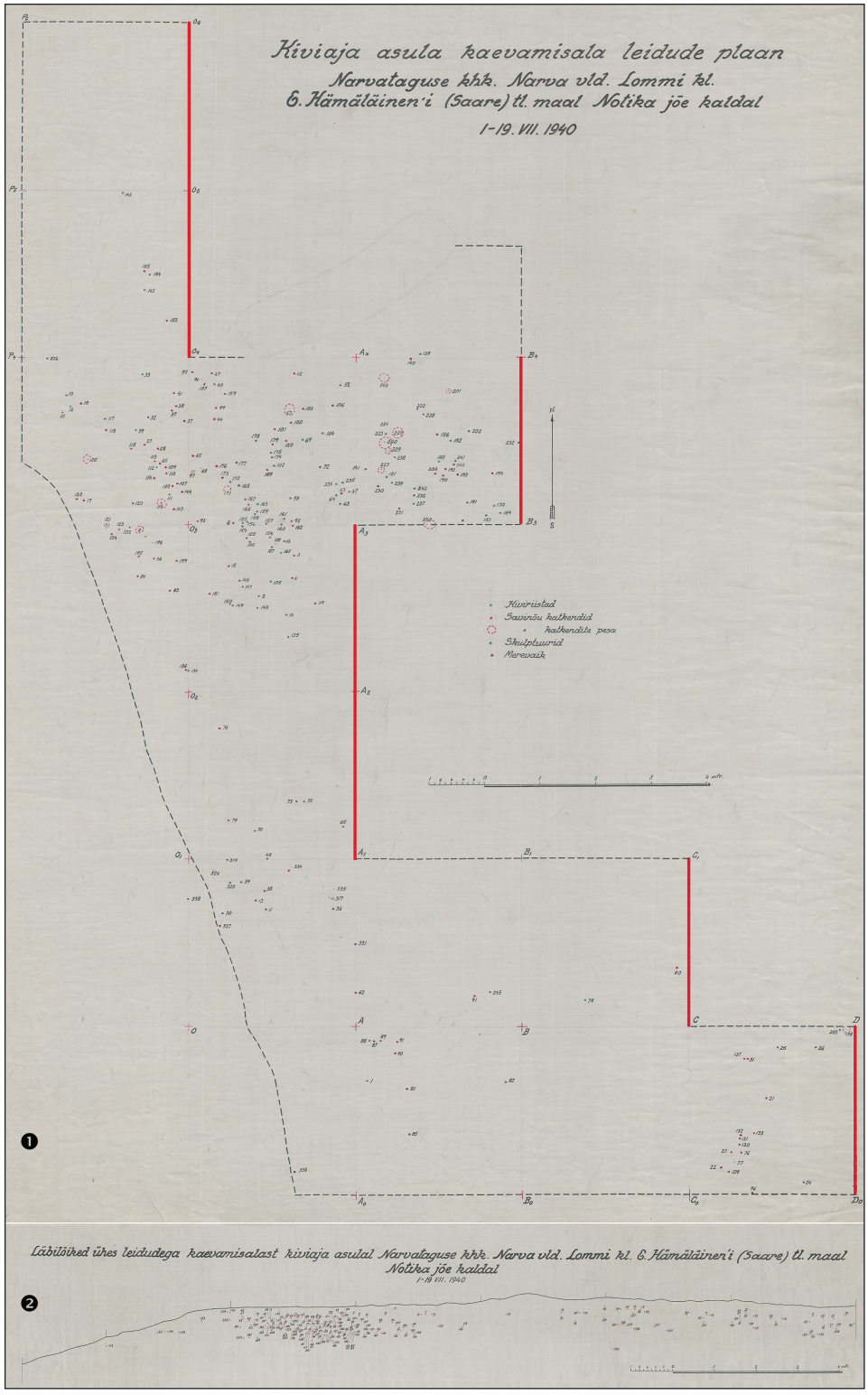


Fig. 3. Lommi III, the large excavation area. All artefact finds measured during excavations drawn on the plans.* 1 *Horizontal projection, the red lines show the positions of vertical sections; a gray oval drawn in pencil in the northern part of the excavation area marks a probable gravel pit (Plan of finds AI 4-1-51-1-11 = Kiviaja asula kaevamisala leidude plaan. Narvataguse khk. Narva vld. Lommi kl. E. Hämäläinen'i (Saare) tl. maal Notika jõe kaldal 1–19.VII.1940. AI 4-1-51-1-11. Drawing in the archaeological Research Collection of the University of Tallinn, Estonia).* 2 *Vertical section (Composite profile AI 4-1-51-1-4 = Läbilõige ühes leidudega kaevamisalast kiviaja asulal Narvataguse khk. Narva vld. Lommi kl. E. Hämäläinen'i (Saare) tl. maal Notika jõe kaldal 1–19.VII.1940. AI 4-1-51-1-4. Drawing in the Archaeological Research Collection of the University of Tallinn, Estonia).

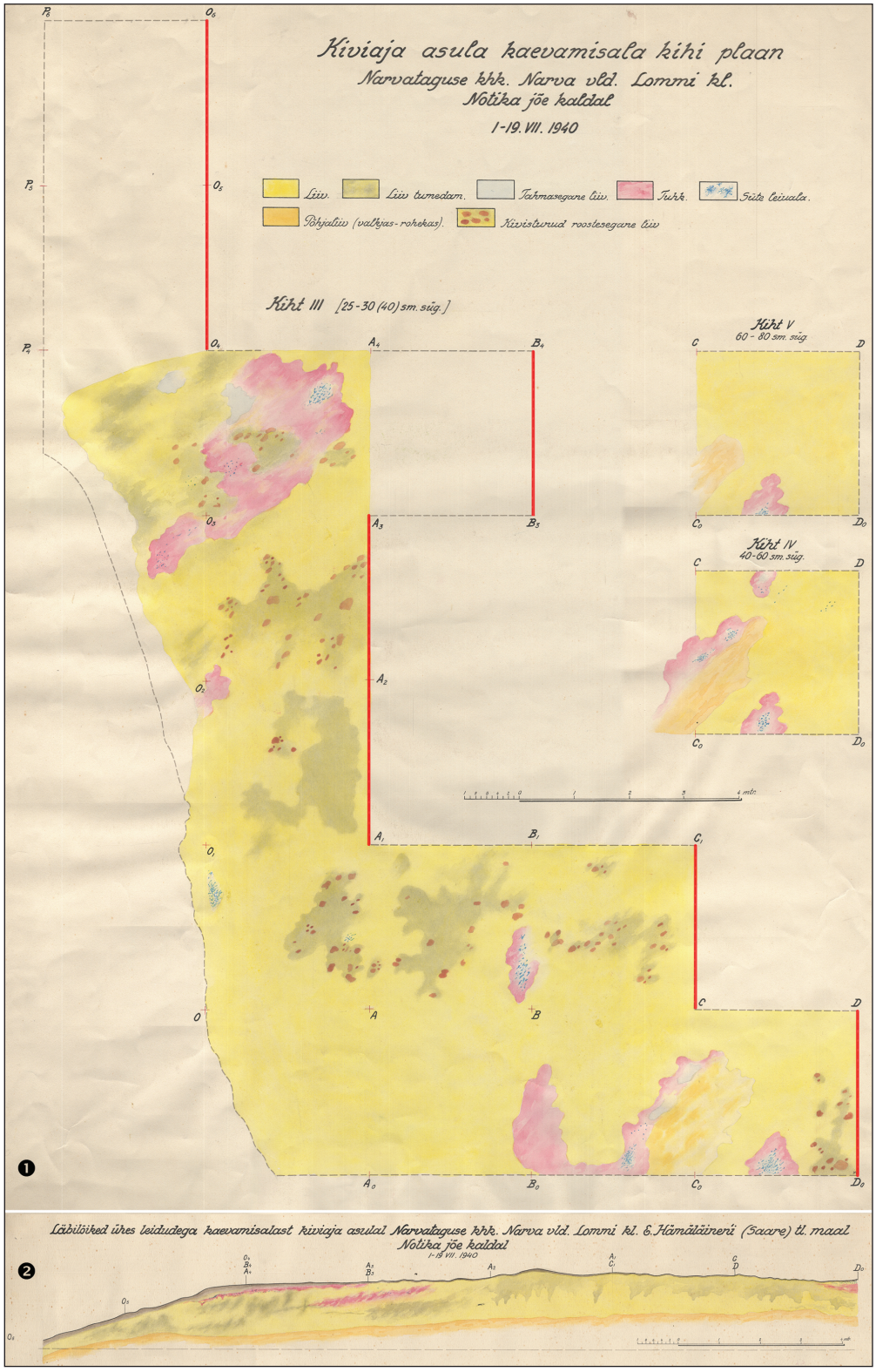


Fig. 4. Lommi III, the large excavation area. Lithological layers drawn on the plans.* 1 *Horizontal projection, level of the third layer (0.25–0.3m) (Layer III AI 4-1-51-1-8 = Kiviaja asula kaevamisala kihi plaan. narvataguse khk. Narva vld. Lommi kl. Notika jõe kaldal 1–19.VII.1940. Kiht III (25–30 (40) sm. süg.). AI 4-1-51-1-8. Drawing in the Archaeological Research Collection of the University of Tallinn, Estonia), the red lines show the positions of vertical sections.* 2 *Vertical projection (Composite profile AI 4-1-51-1-5 = Läbilõige ühes leidudega kaevamisalast kiviaja asulal Narvataguse khk. Narva vld. Lommi kl. E. Hämäläinen'i (Saare) tl. maal Notika jõe kaldal 1–19.VII.1940. AI 4-1-51-1-5. Drawing in the Archaeological Research Collection of the University of Tallinn, Estonia).

Among the artefacts from the main concentration are 1118 potsherds. Of these, 63% are Typical Comb Ware with mineral admixture (Fig. 6.1 and 3) and 36% Typical Comb Ware with organic admixture (Fig. 6.2), less than 1% can be classified as Narva Ware. In addition to pottery, one small clay lump with a pit ('figurine') was found (Fig. 6.4). The Typical Comb Ware vessels have round or pointed bottoms, are weakly profiled and often large (according to the measurable fragments found in the settlement, the volume could reach 43 litres; *Kriiska 1995.Tab. 4*). They are made of iron-rich clays (*Kriiska 1996b. 377*) and crushed rock debris of the granite-gneiss group (the main minerals are quartz, feldspar and biotite) and, in individual cases, grog (probably crushed pottery), are present as mineral admixtures (*Kriiska 1996; 2008.198*). Organic admixture is represented by burnt-away pieces of crushed plant.

Artefact category	Number, pcs	% (pcs) of finds of the same category in the large excavation area
Pottery:	**1118**	**84**
Mineral-tempered Typical Comb Ware	709	91
Organic-tempered Typical Comb Ware	407	74
Narva Ware	2	100
Flint:	**80**	**53**
Flakes	39	48
Blades	5	36
Cores	2	67
Tools:	34	64
Scrapers	*11*	*46*
Retouched flakes (or fragments)	*11*	*85*
Bifacial arrowheads	*3*	*50*
Blanks of arrowhead	*3*	*100*
Retouched blades (or fragments)	*3*	*100*
Points	*2*	*100*
Bifacial tool	*1*	*100*
Other stone items:	**34**	**67**
Whetstones	24	71
Fragments of polished tools	3	
Fragments of stone tools	5	
Stones without processing	2	
Other finds:	**3**	
Slate pendant	1	
Clay lump	1	
Amber bead	1	
Burnt bone	**1**	**100**
TOTAL	**1236**	**80**

Tab. 1. Find material from the main concentration of artefacts (i.e. filling of the supposed pit-house).

Most of the potsherds have some decoration indicating that often the entire surface of the vessels was ornamented. Decoration elements include comb stamp impressions, pits and notches, which are combined in different motifs and often located in horizontal zones (*Kriiska 1995.83, 91*).

Most of the 80 artefacts of Carboniferous flint found from the main concentration were of material with a distinctive purple and pink tint. The total weight of these finds is 239.5g, 44.5% of the weight of all flint from the excavation. The assemblage includes one double-platform core for blades and flakes (Fig. 6.6) and one fragment of a blade core that was retouched into a scraper (Fig. 6.5), but flakes, blades and various tools, such as bifacial arrowheads (Fig. 6.7) and blanks of arrowheads (Fig. 6.8), scrapers (Fig. 6.9), points, and retouched flakes and blades were also found (Tab. 1). Items made of other types of stone, mainly sandstones and slates, are represented by whetstones of different shapes and sizes and with intensive traces of abrasion (Fig. 6.10,11), fragments of polished tools (Fig. 6.12), fragments of undefined tools, as well as stones with no traces of processing. In addition, a flat slate pendant (Fig. 6. 14), an amber bead (Fig. 6.13) and only one fragment of burnt animal bone were found in this concentration.

The concentration of artefacts, its shape and size obviously indicate the remains of a settlement structure (building). The composition and diversity of the finds are similar to the assemblages commonly encountered in dwellings of the Comb Ware and contemporary cultures from the neighbouring territories (*Foss 1940.35; Karjalainen 2002; Miettinen 2002.142–144; Zhulnikov 2003.Tab. 9*). Judging by the concentration of artefacts, the depth of the pit, its regular geometric shape and vertical walls, the feature can therefore only be interpreted as the remains of a pit-house (Fig. 7). Its horizontal and vertical boundaries are most clearly marked with whetstones (Fig. 7), but the distribution of artefacts and different artefact types does not allow determining the internal structure of the pit-house or revealing any specific activity areas. Despite the alternation of zones with a high density of finds and zones without finds, there is no specific pattern in the distribution of artefacts within this concentration; rather, they are distributed over it relatively unevenly. The finds at the bottom level were mainly sherds of Typical Comb Ware with mineral admixture, flint and some other stone flakes, as well as the amber bead (Fig. 7). Higher up, all other artefact categories

were found together, including Typical Comb Ware with various admixtures.

Tracing links between artefacts based on their raw material was not carried out systematically for Lommi III, and only items and materials that could more or less easily be identified by the naked eye when classifying finds were studied. They include various flint raw materials of a specific colour combination or containing visually identifiable inclusions and fragments of sandstone slabs, differing in their structure and thickness. No pottery was studied, with the exception of fragments of one 'mini-pot', which strongly stood out from the other material due to its

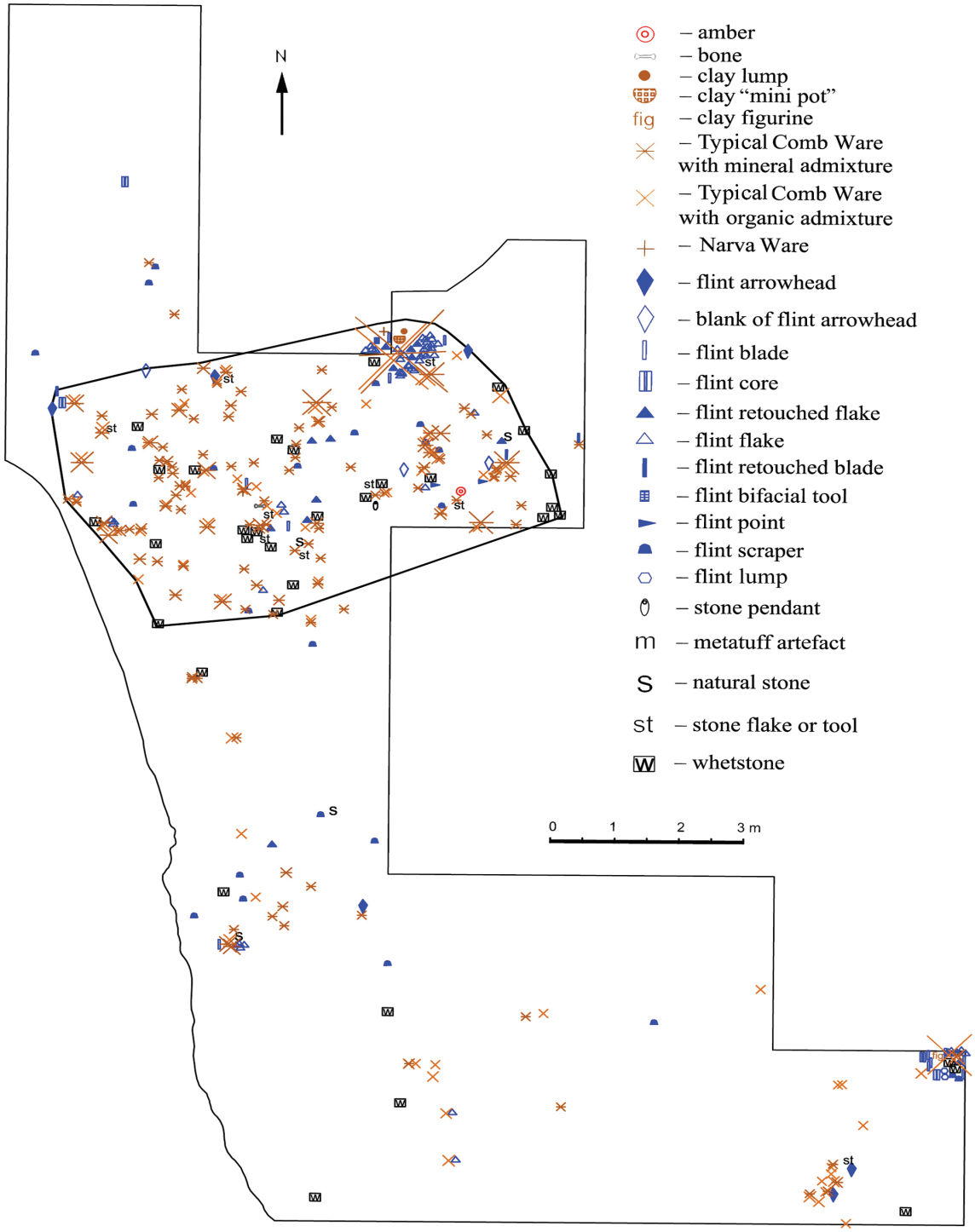


Fig. 5. Lommi III, the large excavation area. Horizontal distribution of artefacts, the black solid line shows the limits of the main concentration. The size of the symbols depends on the number of artefacts recorded with the same number.

size and ornamentation. As a result, a few link chains were distinguished: three of them for flint artefacts (consisting of four, five and eight items), one for sandstone whetstones (consisting of four fragments) and one for pottery (two fragments). Only two whetstone fragments could be refitted into one item, and these were found close to each other in the southeastern corner of the pit-house. Raw material links between artefacts found inside the concentration, in- and outside of it and in other excavation areas can be traced. In vertical projection all items from each chain of links lay mostly in similar elevations. However, it cannot be proven that the whole excavated part of the settlement site would have been occupied only once and at the same time (for discussion on the same topic, see *Kravtsov, Zhilin 1995.138; Grøn 1998.12*).

Outside the pit-house remains, finds are spread irregularly and only small accumulations can be distinguished. Some of these find concentrations could also be settlement features, such as pits or fireplaces, but their nature can no longer be confirmed due to a lack of documentation.

To solve the chronology of the site, radiocarbon dates were obtained from two burnt bones found in different parts of the second (smaller) excavation area and from crust on two Typical Comb Ware pottery fragments with mineral admixture found in the pit-house. Unfortunately, most of the numerous pieces of charcoal and burnt bones included in the assemblage are from unclear contexts or too small for analysis (for example, the single fragment of bone originating in the pit-house). The first date obtained from a burnt animal bone (large mammal, AI 3867: 436) gave an age 4784–4552 cal BC (5820±30 BP, Beta-309096, first published by *Rosentau* et al. *2013. Tab. 2*; all dates are given with 95.4% probability), and the second one (ringed seal, AI 3867:285) 4454–4352 cal BC (5578±26 BP, KIA-55278, from apatite). The crusts on two Typical Comb Ware fragments gave ages 3946–3642 cal BC and 3948–3661 cal BC (4970±70 BP, Poz-133669, and 5020±40 BP, Poz-133186).

Discussion

As it was documented in several cases in Estonia and Finland (*e.g., Pesonen 2004.90; Kriiska, Nordqvist 2012.30; Khrustaleva et al. 2020.14*), both admixtures mineral and the organic were used in the production of Typical and Late Comb Ware. Based on this knowledge and on the similarity of ornamentation, there is no reason to see different pottery types according to the admixture at the Lommi III settlement site (*c.* 64% of mineral-tempered sherds and 36% of organic-tempered sherds). Along with the Riigiküla II site materials (3765–3532 cal BC, *Kriiska* et al. *2016.76*) in the lower reach of the Narva River, it rather indicates that the coexistence of two types of admixture began relatively fast during the early stage of Typical Comb Ware. One of the main lithic raw materials of the Comb Ware culture was flint. It predominated in Estonia and was also present in Finland, sometimes in significant amounts, at the sites with Typical Comb Ware, while at the Late Comb Ware site its amount significantly decreased (*Kriiska, Rappu 2008.18–19; Mökkönen, Nordqvist 2016; Mökkönen* et al. *2017.182; Kriiska* et al. *2020.124*). The closest natural sources of flint for the Lommi sites are in eastern Estonia (Silurian flint), in the southeastern part of the Novgorod Region in Russia (Valday Hills area; Carboniferous flint) and in

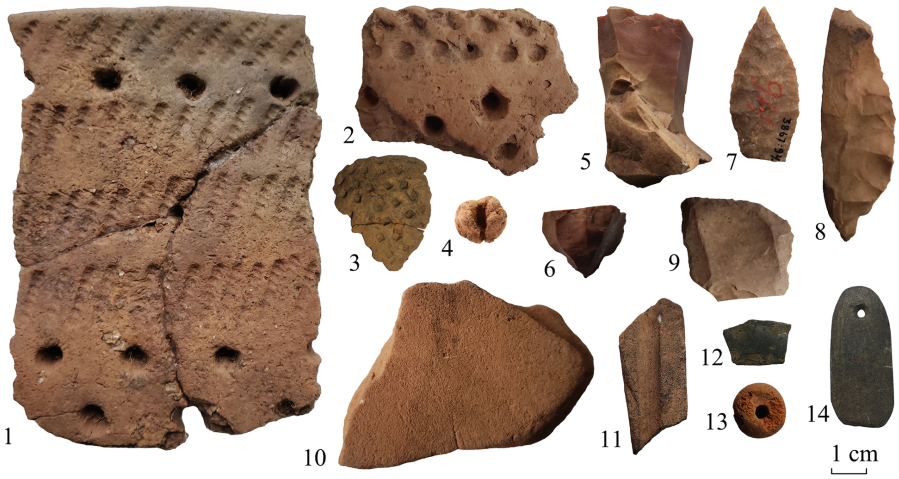


Fig. 6. Lommi III, examples of artefacts from the main concentration:* 1 *Comb Ware fragment with mineral admixture (AI 3867:28);* 2 *Comb Ware fragment with organic admixture (AI 3867:140);* 3 *fragment of a 'mini-pot' (AI 3867: 51);* 4 *clay lump with a pit ('figurine'; AI 3867: 51);* 5–6 *flint cores (AI 3867:143, 12);* 7 *bifacial flint arrowhead (AI 3867: 94);* 8 *broken blank of a bifacial flint arrowhead (AI 3867:33);* 9 *flint scraper (AI 3867:104);* 10–11 *sandstone whetstones (AI 3867:105, 148);* 12 *fragment of a polished tool of metatuff (AI 3867:115);* 13 *amber bead (AI 3867:242);* 14 *slate pendant (AI 3867:43).

southern Lithuania and Belarus (Cretaceous flint) (*Galibin, Timofeev 1993; Baltrūnas* et al. *2006; Kriiska* et al. *2018.37*). In Lommi III, flint makes up more than 70% of all the lithics, and the specific Carboniferous variant with a characteristic purple and pink tint from the Valday Hills prevails. At the other sites, the composition of different flints varies, but often predominately Carboniferous and to a lesser degree Silurian and Cretaceous flint are present. Carboniferous flint from Estonian and Ingrian sites varies in colour and quality, reflecting the different sources of raw material used at different sites. However, we cannot assume that there were permanent contacts between the inhabitants of the Comb Ware culture settlements in our area and some specific 'suppliers' of any particular type of natural flint, because a one-time arrival of raw materials to the site is also a real possibility. For example, at the large excavation area of Lommi III, 150 flint items with a total weight of only 550g were discovered. Usually micro debris make up a large percentage of flint finds, nevertheless, even if we multiply the current quantity several times, the weight of the flint raw material remains within the limits that could be brought to the site during one episode.

The earliest radiocarbon dates obtained from bones correlate with the time of Narva culture (*Kriiska* et al. *2017*) and probably point to the first habitation phase of the Lommi III settlement site, which is also indicated by the few fragments of Narva Ware (*Kriiska 1995.60*). These two pieces of Narva Ware revealed in the large excavation area, both in the pit-house, indicate that the Typical Comb Ware dwelling was dug through a layer containing some earlier artefacts. Moreover, their small number does not call into question the assignment of the remaining material to the context of the Comb Ware culture. Radiocarbon dates obtained from organic crust on the Comb Ware sherds with mineral admixture together gave an age of 3948–3642 cal BC. Lipid analysis (going to be published elsewhere) of both dated

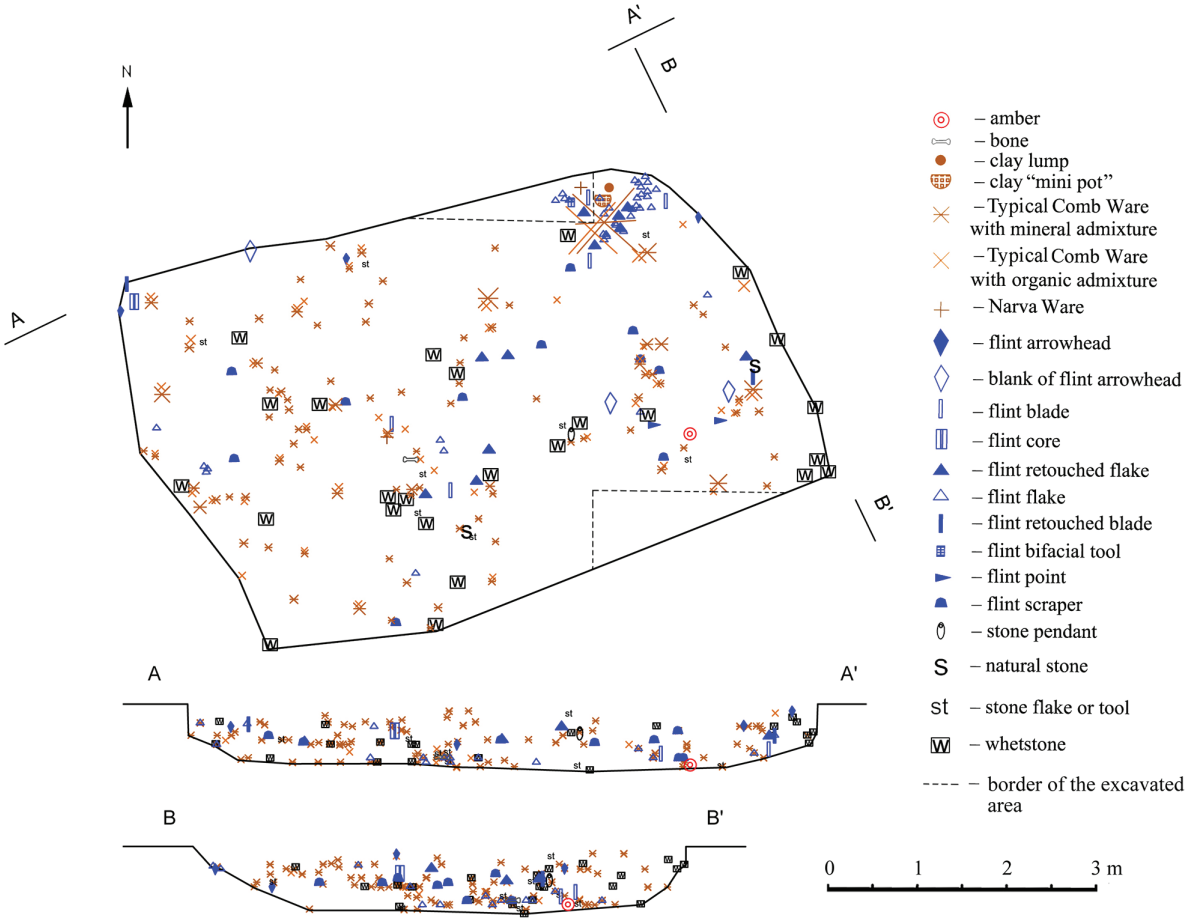


Fig. 7. Lommi III, horizontal and vertical outlines of the pit-house, drawn according to the concentration of artefacts. The size of the symbols on the horizontal plan depends on the amount of artefacts recorded with the same number.* A–A' *projection of all artefacts onto the northern 'wall' of the pit-house and* B–B' *projection of all artefacts onto the eastern 'wall'. Artefacts without elevation data were excluded from vertical projections.

fragments showed that the crust does not contain aquatic markers (pers. com. Ester Oras, 29 June 2021). Therefore, we have no reason to suspect the existence of a reservoir effect in the obtained dates, which are also not inconsistent with the archaeological material of the southern shore of the Gulf of Finland. The predominance of mineral-tempered pottery and the use of flint raw material may indicate the earlier phase of the Comb Ware culture, as the settlements of the late 4th millennium cal BC are already dominated organic-tempered pottery and quartz is the main material compared to flint (*Kadakas* et al. *2010.35, 37; Khrustaleva* et al. *2020.14; Kriiska* et al. *2020.126*).

Prior knowledge and preconceptions play an important role in archaeological discoveries and interpretations, because much depends on the personal experience of the archaeologist, on what one has encountered during earlier excavations, what one has read or heard about and what one is 'ready to see' (for a discussion of the same question regarding the study of Stone Age architecture, see *e.g., Seitsonen 2006.141; Fretheim 2017.17*). This can probably explain the fact that Indreko did not recognise the pit-house in Lommi III, since according to the main ideas of that time huts with a tent-like construction were supposed to exist during the Stone Age in the Baltic region (*Pälsi 1918.28–31; Indreko 1932.216–217*; see also *Johanson* et al. *2013.108–109*). According to Indreko (*1937.103,105*), Stone Age houses had parallels even in the Estonian folk architecture, where "*the rudiment [of the houses] has been preserved to this day as an outdoor kitchen, especially on the islands and in coastal areas, where they are mostly conical structures of stacked stakes*", and in the architecture of modern Siberian peoples like 'Voguls, Ostyaks, *etc.*' (modern names Mansi and Khanty, see *Indreko 1937.103, 105*). Lommi III is not the first example of the discovery of a Stone Age dwelling decades after its excavation in eastern and northern Europe (*Rogachev, Anikovich 1984.190; Pesonen 2002.16; Seitsonen 2006; Fretheim 2017. 17*).

Nowadays the main field methodology of studying Stone Age settlement sites consists of careful excavation, observation of lithological layers, analysis of the stratigraphic situation and detailed documentation of all objects and features of the cultural layer. However, the methods used at different sites vary, and not all information extraction possibilities are used everywhere. Field methodology has changed mainly with the development of post-excavation information processing technologies and methods. Among the methods used to uncover and study Stone Age architecture, the most important are spatial analysis (using visual or various statistical and three-dimensional computer visualization and modelling methods) and refitting analysis (*Grøn 1995. 5–11; 1998; Katiskoski 2002; Halinen* et al. *2008. 257; Gelhausen* et al. *2009*). Since all of these methods started to develop gradually only from the 1960s on, the materials from old excavations are often unsuitable or only partially suitable for such analyses (*Leonova 2004.63; Larionova 2019*), because the documentation does not contain enough data.

The main difficulty in studying Stone Age architecture is the discovery and interpretation of its remains. Most pit-houses can easily be found during excavations due to the depressions (sunken house floors filled with cultural layer) visible at the natural lithological level, and in some regions the house depressions can be observed even in the modern landscape, although there are variations. More than 100 years of research into Stone Age architecture in eastern and northern Europe has gradually accumulated knowledge, but the process has been slow and irregular (for a more detailed research history see *Bryusov 1959; Loze 1978; Gurina 1996a.141, 143; 1996b.150; Karjalainen 1996.75–80; Pesonen 2002; Zhulnikov 2003; Leonova 2004; Norberg 2008; Mökkönen 2011; Zimina 2014*). From published accounts on Stone Age pit-houses, it can be concluded that the first were excavated in the first quarter of the 20th century on the East European Plain (*Gorodtsov 1914*) and in Finland (*Itkonen 1913.3–4; Pälsi 1918; 1920.45,105; Europaeus 1922.67–68; Tanner 1929.13–15*). However, research interest in these objects increased mainly after the 1980s, although there were also a few earlier waves of research in the 1950s and 1970s (*Pesonen 2002.Tab. 2; Zhulnikov 2003.5; Norberg 2008.Fig. 2.3; Fretheim 2017. Fig. 1.3*).

The distribution of discovered pit-houses in eastern and northern Europe is uneven. Thousands of dwelling depressions visible in the modern landscape are known in Scandinavia (*Norberg 2008.16, Fig. 6.1*), Finland and the Karelian Republic of Russia (*Pesonen 2002.14; Zhulnikov 2003.Tab. 1*), while in the territory of the Baltic countries and in the northern part of the European Russia to the Middle Volga region pit-houses have been discovered only during excavations. According to published data and excluding the pit-houses of Scandinavia, more than 350 buildings have been excavated in this area, includ-

ing over 310 in Finland, Karelia and the Baltic countries (*Gurina 1967.22–30; Girininkas 1994.212; Ostrauskas 2001.180–181; Pesonen 2002.14, 30–31; Zhulnikov 2003; Filatova 2004.23–50; Grasis 2010; Juodagalvis 2016.71, Figs. 8, 9; Marcinkevičiūtė 2016.61–63; Šatavičius 2016.27, 32, 37–38; Kriiska* et al. *2016; Rostedt, Kriiska 2019; Khrustaleva* et al. *2020*) and about 40 in the forested part of western area of European Russia (excluding Karelia) (*Oshibkina 1978.106–107; Koltsov 1985; Vereschagina* et al. *1995; Koltsov, Zhilin 1999.11–44; Polkovnikova 2003; Leonova 2004; Mazurkevich* et al. *2012; Zimina 2014; Khrustaleva 2016*). The earliest pit-house is dated to the Late Palaeolithic (*Šatavičius 2016.27*), and this form of architecture was used throughout the Stone Age (*Grasis 2010.61–62; Kriiska* et al. *2016.23–24*). However, of the more than 220 pit-houses that can be dated to the 4th and 3rd millennia cal BC in the territory of Finland, Karelia and the Baltic countries, over 150 are associated with the Comb Ware culture and its contemporaries (*Pesonen 2002.Tab. 5; Zhulnikov 2003.Tab. 2; Khrustaleva* et al. *2020*).

Stone Age pit-houses are rare finds, especially in Estonia and Ingria, where only nine of them are known and associated with different cultures (*Khrustaleva* et al. *2020*). Of the 91 known settlements of the Comb Ware culture in this area (*Gerasimov 2019; Sikk* et al. *2020.93*), the remains of a dwelling were only revealed at one other site besides Lommi III, namely at the Jägala Jõesuu V site in northern Estonia. Here, too, the pit-house had an almost rectangular shape and contained the main concentration of the site's artefacts inside. In addition, at the Riigiküla I settlement site in northeastern Estonia, some settlement structures of the Comb Ware culture are known, but their construction cannot be distinguished (*Khrustaleva* et al. *2019*).

The distribution area of Comb Ware and contemporary cultures discussed here covers Finland, the Karelian Republic and the Pskov, Novgorod and Leningrad Regions in Russia, Estonia, Latvia, as well as the northern parts of Lithuania and Belarus (see *Kriiska* et al. *2020.Fig. 25*). The pit-houses of these cultures are currently known mainly in areas north and northeast of the northern coast of Estonia. They are usually rectangular or rarely square in shape, with an average size of 20–50m^2 (although some can reach 80m^2) and a depth of 0.2–0.6m, and are often surrounded by an embankment of sand dug from the house pit (*Halén 1996.284; Ojanlatva, Alakärppä 2002; Pesonen 2002.27–31; Zhulnikov 2003.56–57, Tab. 4; Mökkönen 2009*). For Karelian and Finnish pit-house sites, the most typical locations are sheltered places on the lake shores or along the sea bays of the Finnish Ostrobothnia (*Kankaanpää 2002.66; Mökkönen 2002; 2009.143–145; Zhulnikov 2003.53; Seitsonen 2006.142; Nordqvist, Lavento 2008.155*), and the known sites in Estonia are also connected to the shores of the bays (*Khrustaleva* et al. *2020.15*). Lommi III is also located on the coast of the Litorina Sea, along a lagoon and possibly on the bank of a small river that flowed into it (*Rosentau* et al. *2013.Fig. 7*; the Litorina phase of the Baltic Sea dates back to 7800–2500 cal BC).

The Fennoscandian pit-houses mainly correlate with the main find concentration in these settlement sites (*Boaz 1999.135; Grøn 2003.692*), and this is also true for Lommi III. In some pit-houses, most of the finds are concentrated along the walls (*Zhulnikov 2003.54*). Usually micro debris (first of all, flint or quartz and bone) is the best indicator of the dwelling floor in both horizontal and vertical projection (*Grøn 1995.34; Ojanlatva, Alakärppä 2002.116*), but this material is missing in Lommi. The elevation of the artefacts in the Lommi III pit-house is not tied to any particular level, they are almost evenly distributed throughout its entire filling. This may indicate a long lifespan of the pit-house, during which repeated living and cleaning episodes could have contributed to the formation of floor fillings. In numerous other cases, the finds correlate only with the bottom level, as documented, for example, in some Karelian pit-houses (*Zhuravlev 1990; Zhulnikov 2003.5*).

No fireplace was revealed in the Lommi III pit-house by Indreko, although a fireplace or hearth is often one of the main attributes of a dwelling. However, aboveground fireplaces without any construction may not have been preserved at all. In rare cases only small pieces of charcoal, calcined bones or other burnt finds may be present, less often spots of ash or burnt soil (*Pesonen 2002.15*). In the pit-houses in Karelia and Finland, in many cases no stone hearth was revealed and other traces of fireplaces, even if documented, were not given due attention (*Karjalainen 1996.76; Zhulnikov 2003.54*). In some sites where fire cracked stones were found in or near the pit-house, heating with hot stones or reuse of the house for purposes other than living is assumed (*Kankaanpää 2002.77*). In the Lommi III pit-house, some charcoal pieces, burnt bone, flint artefacts and stones were found, as well as an ash lens. Currently, ash and charcoal pieces can no longer be clearly as-

sociated with the Stone Age and, in particular, with the construction. The location of other burnt items does not reveal any system that would indicate the location of the fireplace, but we cannot say for sure that there was no fireplace in the dwelling.

Since no construction details were preserved or recorded, the location of the entrance cannot be determined either. Linking the artefacts based on their raw material can provide additional information about the characteristics of the dwelling (*Petersen, Johansen 1996.81–83; Boaz 1999.135*), although this method is rarely used in Stone Age sites with pottery (*Cuenca-Solana* et al. *2018.904*). When studying the remains of an ancient dwelling, the directions and concentrations of these links can reveal not only the so-called 'wall effect', but also the location of the entrance if there is sufficient documentation (*Grøn 1998; Leonova 2004.63; Gelhausen* et al. *2009*). In Lommi III, the 'wall effect' cannot be shown, firstly, due to the small number of links found between the artefacts, and secondly, due to the absence of micro debris. Although most of the links run to the west from the house, it is not known what was to the east of it, as this territory was already destroyed before the earlier studies and was not excavated. Thus, the location of the entrance (or the entrances) of the pit-house in Lommi III remains an open question.

Despite the fact that many individual details of construction cannot be distinguished, the shape and size of the pit-house in Lommi III and the types of artefacts inside it are analogous to those of the Stone Age houses of Fennoscandia (*Halinen* et al. *2002. Fig. 6; Pesonen 2002.15–22*). The diversity and number of artefacts inside the pit-house in Lommi III can probably show its (semi-)sedentary way of life of its inhabitants. It was likely a timber building, similar to the analogies from the surrounding areas (*Halén 1996.284–285*), but it is impossible to determine whether it was based on a post or log construction, since no traces of posts or logs have been preserved or were documented during excavations. The regular shape of the pit indicates that it most probably had straight vertical walls, at least in the subterranean part.

Conclusion

The discovery of the archived plans of the Lommi III settlement site and its largest excavation area, with the expressive concentration of finds drawn on it, marked the beginning of the present research. All finds from this excavation area were analysed, and it turned out that *c.* 80% of finds are concentrated in an area of 7.1x4.4m, forming a rectangular pit with a depth of 0.7–0.75m from the ground surface. Most of the artefact assemblage consists of fragments of Typical Comb Ware (mineral and organic-tempered), flint tools and debris, and sandstone whetstones. Links between artefacts, determined by their raw materials, connect items both within the concentration and between it and the area outside, and indicate the homogeneity of the cultural layer, at least in this part of the site.

Based on the shape and size of the concentration, the composition and variety of finds (including pottery, flint tools, whetstones and other stone items, as well as an amber bead, stone pendant and clay figurine), and parallels from neighbouring areas, it is concluded that a pit-house existed in this location. The distribution of the different artefact types is unsystematic and cannot be used to distinguish any structural features in the pit-house, although its borders are indicated by whetstones. The number of finds, their relatively regular vertical distribution over the entire thickness of the pit filling and the lack of correlation to a particular elevation level indicate the (semi-)sedentary way of life. The absence of clearly identified traces of fireplace does not contradict this conclusion, as without a stone construction, it may not have preserved and recognized during fieldwork. All these arguments are supported by numerous analogies from other contemporaneous settlement sites in Finland, Karelia and Estonia.

According to the radiocarbon analysis of organic crusts on pottery, the Lommi III pit-house can be dated to the first half of the 4th millennium cal BC. This date is broadly supported by the typo-chronological date of the archaeological material, which shows the predominance of mineral admixture over organic-tempered pottery, together with the predominance of flint raw material. While the history of the study of Stone Age architecture started in eastern and northern Europe at the beginning of the 20th century, the main research methods were mainly developed from the 1960s or even the 1980s on. However, assuming high-quality documentation is available, these methods can provide new information for old excavations even decades later. While the interpretation is influenced by prior knowledge and preconceptions of the researcher, the main task during fieldwork is the thoroughness of the excavation and documentation processes. The case of Lommi III is a good example of such an approach.

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Pile dwellings in the Circum-Baltic area

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ABSTRACT – *The phenomenon of northern pile dwellings has been found in different geographical zones and landscapes of the Circum-Baltic region: in sea landscapes and on the shores of inland lakes and rivers. Inland sites were established in specific lacustrine landscapes, appearing within former post-glacial basins. The pile dwellings revealed here are characterized by different types of wooden buildings, including structures with raised floors. They are dated to the 4th millennium BC to 4th century BC in Central Europe and the Baltics, and to the end of the 4th to end of the 3rd millennium BC – in NW Russia and Belarus. They appeared in major cases independently and followed different cultural trajectories. The article presents an overview of a number of sites which can be attributed to pile dwelling settlements distributed in the Circum-Baltic area. It discusses particular features of their construction, traits of material culture, and site location patterns.*

KEY WORDS – *pile dwellings; Eastern Europe; Circum-Baltic; Neolithic; limnic landscapes*

Kolišča ob Baltskem morju

IZVLEČEK – *Fenomen severnih kolišč je bil odkrit v različnih geografskih območjih in pokrajinah ob Baltskem morju, tako ob morju kot na obalah jezer in rek v notranjosti. Najdišča v notranjosti ležijo na posebnih jezerskih območjih, ki so se oblikovala znotraj nekdanjih bazenov po ledenih dobah. Za ta kolišča so značilni različni tipi lesenih stavb, med njimi tudi strukture z dvignjenimi tlemi. Te stavbe so na območju Srednje Evrope in Baltika datirane v čas med 4. tisočletjem pr. n. št. in 4. stoletjem pr. n. št.; na območju SZ Rusije in Belorusije pa v čas med koncem 4. in 3. tisočletjem pr. n. št. Stavbe so se v večini primerov pojavile neodvisno in so sledile različnim kulturnim trajektorijam. V članku predstavljamo pregled koliščarskih najdišč na območju Baltskega morja. Razpravljamo tudi o posebnih značilnostih pri njihovi gradnji, sledovih materialne kulture in vzorcih poselitve.*

KLJUČNE BESEDE – *kolišča; Vzhodna Evropa; območje Baltskega morja; neolitik; limnične krajine*

Introduction

The first lake dwellings in the Circum-Baltic region were discovered and investigated in the second half of the 19th century. Starting with the works made by Johannes Heydeck in the early 20th century, the investigations and surveys were carried out by East Prussian researchers inspired by the discoveries of the settlements found in Switzerland and what was then German territory (*Heydeck 1909*). Land-reclamation works held in the 1930s–1960s led to a significant increase in the discover of lake dwellings. New examinations of prior investigations and new studies started in the 1990s (*Gackowski 1998; Łapo, Ossowski 2000*).

In Russia, the first peat-bog sites were found in the 19th century in the Ural Mountains, when gold depo-

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sits were mined. Gold mining conducted on the eastern slope of the Middle Ural Mountains led to uncovering the Shigirsky peat-bog site (*Tolmachev 1914; Savchenko 1999*). Some of the constructions found on the sites located in Shigirsky and Gorbunovsky peat-bogs were interpreted as the remains of platforms left on marshy areas (*Bryusov 1951*). Land-reclamation works carried out in the 1960s in NW Russia led to the uncovering of a number of Neolithic pile-dwelling sites (*Mazurkevich, Dolbunova 2011*).

More than 100 peat-bog sites dated to the Mesolithic – Bronze Age were found in Estonia, Latvia, Belarus, and in the forest zone of Eastern Europe (North-Eastern Russia – Eastern Onega: sites of the Veretie 1 type and Modlona, Vissky peat-bog; Volga-Oka basin – Ivanovskaya, Moskovskaya and Ryazanskaya Regions; and in North-Western Russia – Pskovskaya, Smolenskaya, Leningradskaya Regions). Some of these sites were attributed to pile-dwelling settlements (*Oshibkina 1996*) (Fig. 1).

The phenomenon of northern pile dwellings has been found in different geographical regions and landscapes of the Circum-Baltic Region: in sea landscapes and on the shores of inland lakes and rivers. Inland sites of this type were established in specific lacustrine landscapes, appearing within former postglacial basins. These sites were situated on lakeshores located in front of the morainic formations of the Würm Glaciation (*Dolukhanov, Mazurkevich 2000*).

A particular type of prehistoric lake shore dwellings dated from the end of the 6th to 1st millennium BC, including structures with raised floors (*Martinelli 2014*), were regarded mainly as a Southern and Western European phenomenon (*Schlichtherle* et al. *2013*). In this article, we want to emphasize that these specific building techniques and types also existed in the Circum-Baltic area. They appeared in major cases independently and followed different cultural trajectories, which will be shown through an analysis of the number of sites, distribution in various regions and different prehistoric periods. Contextualization of each case is thought to be crucial to obtain the full variety of this phenomenon.

Regional studies

Lithuania

In Lithuania pile dwellings have been recorded from the Stone Age and Early Metal periods. However, among the many wetland settlements that have been explored, only a few of them have dwellings with raised floors.

Neolithic and Early Bronze Age

More than 60 sites dating from the late Mesolithic to the Late Bronze Age were discovered in the Šventoji marshlands on the Baltic coast of Lithuania. The sites contained remains of dwelling zones, refuse layers and fishing stations (*Rimantienė 2005; Piličiauskas 2016a*). Šventoji 6 site is suggested to be a pile-dwelling settlement (*Girininkas 2005; Piličiauskas 2016a*). It was located at a transitional zone between a narrow channel and a wide lake. Various fishing items made from bone and wood, pottery (Narva and Globular Amphora culture wares), amber ornaments, and flint tools were found here. Most of the ^{14}C dates from the site pointed to the

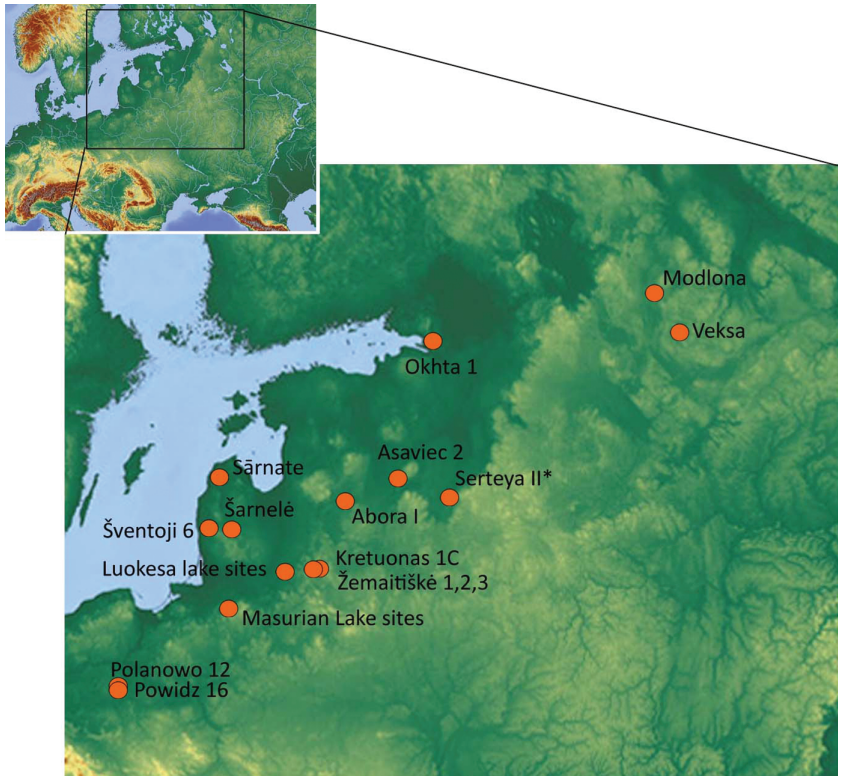


Fig. 1. Map of the sites mentioned in the text (* including sites Usviaty IV, Naumovo, Dubokray V, X) (drawing by E. Dolbunova).

period 3000–2500 cal BC (*Piličiauskas* et al. *2012*). In the excavated area 66 piles were registered, most of which constituted pile dwellings. However, some of the piles are believed to belong to stationary fishing constructions (*Piličiauskas 2016b*).

In the basin of Lake Kretuonas (Eastern Lithuania) approximately 60 archaeological sites from the Stone and Bronze Age have been found so far (*Girininkas 1990; Šatavičius, Marcinkevičiūtė 2013*). A few sites, Kretuonas 1C site and the Žemaitiškė 1, 2, 3 sites have been interpreted as pile dwellings.

In Žemaitiškė 2 site, which dates back to the Late Neolithic, more than 1000 pieces of wooden constructions were recorded in the excavated areas. The site was located on the shore of a former lake, near the source of a stream flowing from the lake (*Girininkas 2004; 2010*). Some of the wooden piles with a small diameter were identified as fishing traps. Groups of larger piles were arranged in separate parallel lines perpendicular to each other. These lines of piles coincided with the distribution of finds, marking the form of the dwelling platform. The largest concentration of archaeological finds indicates areas behind the platform where they might have fallen down. According to Algirdas Girininkas, this pile-dwelling settlement was established above water. This site was ascribed to the Late Narva culture (*Girininkas 2005*). Archaeological finds, including bird and fish bones, indicate the importance of hunting and fishing for the community.

At the Kretuonas 1C site (*Girininkas 1984*) pile-dwellings were constructed on a low, seasonally flooded terrace. They are dated to the Early Bronze Age, manifesting the continuity of pile constructions (*Brazaitis 2003; Girininkas 2005*). However, a clear plan of the distribution of piles cannot be reconstructed. The remains of fishing baskets and fishing fences were also found next to them.

Žemaitiškė 1, 3 sites were also interpreted as sites with pile constructions, although the data is not yet sufficient (*Pranckėnaitė 2011*). Both sites were found on the shore of a former lake. Perpendicular groups of piles, which did not form any clear construction, were recorded. Both sites were ascribed to the Middle and Late Neolithic Narva culture (*Girininkas 2005*).

In the western part of Lithuania, the Šarnelė site was detected in shallow water near the source of the river at the lake (*Butrimas 1996*). Over 400 vertical piles have been detected (*Girininkas 2005*). Certainly, some piles, especially those which are small in diameter, should be ascribed not to pile buildings but to fishing traps (*Girininkas 2010*). Ceramics found on the site were attributed to the Narva and Corded Ware cultures. The importance of fishing is exemplified by the discovery of such archaeological finds as harpoons, nets, net-sinkers and net floats made of birch-bark. There were also bone points, amulets, and an amber ornament among the discoveries (*Butrimas 1996*).

Late Bronze to Early Iron Age

Two pile dwellings are known in the Lithuanian territory dating from the Late Bronze Age to the Early Iron Age. Lake Luokesa dwellings I and II were discovered in 2000–2001. The remains of two lake-settlements were located underwater in morainic shoals, at a depth of 2m. Two sites were built at the opposite sides of the lake (*Pranckėnaitė 2014*). The Lake Luokesa dwelling I consisted of a double or triple fence, and a central part. Together with these fences, the settlement occupies an area of 60x40m. Dwelling I of Lake Luokesa has one layer, 35–110cm thick, and consists of 5–7 layers of horizontal wooden structures (*Pranckėnaitė 2016*). The archaeological and archaeobotanical material testifies to agriculture and animal husbandry, but on the basis of the available data it is rather complicated to assess the contribution of the production economy and gathering-fishing and hunting economy at Luokesa I (*Pollmann 2014; Pranckėnaitė 2014*) (Figs. 2–3).



Fig. 2. Plan of the site Luokesa 1 (drawing by E. Pranckėnaitė).

The pile distribution at Luokesa site II shows a construction resembling a fairly large platform, linked to the shore by a walkway. During archaeological excavation, no clear cultural layer or archaeological artefacts were discovered (*Baubonis, Pranckėnaitė 2012*). The data of the Lake Luokesa dwelling II does not enable us to interpret it as a dwelling used for habitation, and its ultimate interpretation and purpose remain unclear (*Pranckėnaitė 2014*).

Constructions found at Lake Luokesa were pile dwellings raised above the damp ground (about 1m from the surface). Lake Luokesa dwelling I was situated on the exposed swampy shoal of the northern shore (*Ismail-Meyer 2014; Pollmann 2014*). Luokesa sites I and II are dendrochronologically dated to the period 625–353 BC, and site II was built 25 years earlier than site I. Lake Luokesa site I was established around 600 BC (*Bleicher 2014*). It is not possible to suggest that these two dwellings were part of one complex that was used at the same time (*Baubonis, Pranckėnaitė 2012*).

There is no indication for a specific purpose or unusual function of the dwelling. The inhabitants made full use of the surrounding territories and food sources. At the same time period during the Late Bronze Age hillforts appeared in Lithuania. Further research into the connection between lake dwellings and hillforts, and the possible seasonality of this, could reveal more inland-water inhabitation and complexity.

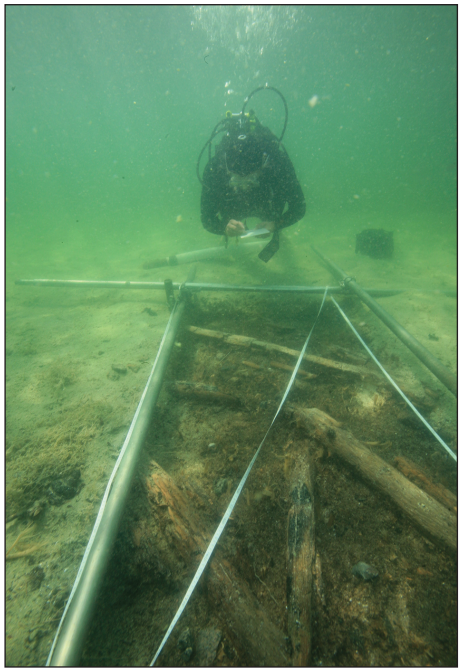


Fig. 3. Underwater excavation at Luokesa 1 site (photo by G. Krakauskas).

Latvia

Neolithic

There are large wetland areas which were inhabited during the Neolithic period in Latvia. The most important are those near Lake Babīte, Lake Kaņieris, the Lubāns wetlands and a coastal peatland area in Sārnate (*Loze 2011*). The Sārnate settlement is located in the north-western part of the Kurzeme Peninsula of western Latvia, 2km from the present coast. Sites were installed on a former lakeshore and possibly lay near the former outlet of the Sārnate River. The earlier period at the Sārnate sites is dated to 4365–3780 cal BC, and the next period to 3630–2850 cal BC. The houses of the Sārnate complex were quite substantial post-built structures, and cannot be regarded as pile dwellings (*Vankina 1970; Bērziņš 2008*). Comb Ware, Early Sārnate Ware (*c.* 4365–3780 cal BC) and Late Sārnate Ware (*c.* 3630–2850 cal BC) were recorded here (*Vankina 1970; Bērziņš 2008*). The dwellings with Early and Late Sārnate Ware have produced a range of net fishing gear, as well as components of eel clamps and fish-screens. The hearths consisted of a bed of sand, with a substructure of timber and bark. For the Early and Late Sārnate phases, the subsistence pattern was based on a diverse range of subsistence resources, mainly those of the eutrophic lagoonal lakes, and a semi-sedentary or sedentary way of life, with permanent occupation at Sārnate. A similar mode of subsistence and settlement was probably practiced at other lagoonal lakes along the East Baltic coast (*Bērziņš 2008*).

Sixteen settlements have been explored in the Lake Lubāns wetlands with a broad periodization from the Late Mesolithic to Early Bronze Age (6600–5510 cal BC to 2350–1750 cal BC) (*Loze 2011*). Possible evidence of pile dwellings from the Late Neolithic period in the Lake Lubāns wetlands is ascribed at the Abora I site. Lines of piles were preserved on a sloping riverbank, and buildings were suggested to be placed on wooden platforms (*Loze 1978; 2011*).

No lake dwellings dated to the Early Metal periods have yet been found on the territory of Latvia (*Apals, Apala 2005*). For now the only known lake dwellings built on the artificial islands were discovered in the Vidzeme region the Central Latvia and dating back to the 2nd half of the 1st millennium AD (Āraiši lake dwellings (*Urtans, Rains 2003*)). Possible lake dwellings dated to Iron Age were detected in Lake Sāviena (*Urtans 2016*).

Estonia

The earliest attempts at pile dwelling research could be traced to the 17th century in the territory of Estonia, but the existence of prehistoric pile-dwellings at the bottom of the lake was only traced in the 1960s (*Roio 2020*). The only construction remains of a pile settlement in Estonia were ascertained in Koorküla Valgjärv Lake (*Kriiska, Roio 2011*). Three inhabitation stages of Koorküla Valgjärv Lake settlement were specified: (1) Neolithic period (Late Comb Ware, *c.* 3300–3200 cal BC (*Roio 2007*)); (2) Early Metal period (313–246 BC based on dendrochronological dates, and a single metal ring was also found typologically of the same period); (3) absolute dating of archaeological artefacts also show 7th–9th century inhabitation of the site (*Roio 2020*). Until now, no archaeological excavations have taken place at this site. Two other prehistoric wetlands sites with the remains of wooden piles are known: Stone Age settlement sites in the prehistoric lake of Kunda, and on the shore of Tamula Lake (*Roio 2020*).

Poland

Bronze Age to Early Iron Age

Dwellings of grate-and-beam construction were built on horizontal beams strengthened by vertical piles and stones, forming the so-called artificial islands – the main feature of lake dwellings in the Masurian Lake district, *e.g.,* Orzyszo, Mołtajny, Pieczarki, Bogaczewo, and Rybno settlements (*Gackowski 2000; Pydyn 2007*). Over 40 sites of this type are known in Masurian Lake district and are attributed to West Baltic Barrow culture (*Pydyn, Gackowski 2011*).

Only two sites in central Poland were attributed to the pile construction type, Polanowo 12 and Powidzo 16, belonging to the Lusatian culture (*Pydyn 2010*). Archaeological finds (*i.e.* ceramics), dating and building techniques confirm that these two pile settlements were inhabited in the 6th century BC (*Pydyn 2007*). Pile dwellings were constructed in the direct vicinity of the shoreline, on marshy and presumably periodically flooded areas. More than 500 wooden architectural elements and archaeological artefacts were detected in an area of 40x60m, at a depth of 0.6–2m under water in the Polanowo 12 settlement. The Powidzo 16 settlement consists of around 100 wooden elements. The settlements do not have a clear scheme while the settlements' size was set according to the concentration of the vertical piles. The remains of the bridges or fences were not found (*Pydyn, Gackowski 2011*). Animal husbandry and developed agriculture were recorded. The content of two vessels found in the Polanowo 12 settlement provided remains of 120 species of plants and presumably can be attributed to votive offerings (*Latałowa, Pinska 2010*).

Belarus

Different wetland sites were found in Northern Belarus, in Kryvina peatbog, including Neolithic and Bronze Age settlements (*e.g.,* Asaviec 1, 2, 3, 4, 5, 6, 7 and Kryvina 1, 2, 3). The remains of rectangular wooden constructions consisting of poles and sharpened stakes were found at the Asaviec 2 site, dated to the time period of the Usviaty culture (Middle Neolithic) and North-Belarusian culture (Late Neolithic) (*Charniauski, Kryvaltsevich 2011; Charniauski 2020*). Flint artefacts are rather rare due to the absence of such outcrops in the area. Rich antler and bone industry included hunting and fishing tools, household items, ornaments, musical instruments and items interpreted as ritual ones (*Charniauski, Charniauski 2010*). A number of amber ornaments were also found. Similar materials were found on other sites which were supposed to be established on the dried peaty lakeshore during a regression phase (Asaviec 7 site). The remains of wooden constructions with more than 100 piles (with a diameter from 5 to 30cm) and a number of wooden fragments lying horizontally were uncovered. Inclined poles driven into the ditch were interpreted as the remains of the wall. The location of wooden construction corresponds to the concentration of finds and sandy filling. A large number of animal bones was found on the sites with moose, wild boar, marten and beaver predominating. A quite high number of domesticated animals was also noted (16% at Asaviec 7 site). One particular feature of the latter site is a large number of burnt bones, some of which are human. The remains of a skeleton, scattered human bones and their fragments were also found here. Traits of different archaeological cultures were traced in the ceramic complex of the Late Neolithic phase: Globular Amphora culture, Corded Ware, and Middle Dnieper culture. One of the earliest bronze and copper awls was recorded here (*Charniauski, Kryvaltsevich 2011*). The remains of fishing net floats made from birch bark, fragments of fishing traps and paddles were found on the site. The dominance of a hunting-gathering subsistence strategy has been suggested for this region.

Several wetland sites of the Neolithic-Bronze Age, some with the remains of wooden constructions, were also discovered in Southern Belarus (*e.g.,* Kuzmichy 1, Aziarnoye 2B, Kamen 8, and Voikavichy 1) (*Charniauski, Kryvaltsevich 2011*).

NW Russia

A range of sites with dwellings with raised floors located on marshy areas of paleolakes were found in the Upper Western Dvina River at the beginning of the 1960s by Alexander M. Miklyaev (*1969; 1995; Mazurkevich 2014*). Today, 30 pile settlements are known in this region (*e.g.,* Serteya II, Usviaty IV (Fig. 4), Naumovo, Dubokray V, X, *etc.*). Pile dwellings appeared *c.* 3700–3450 cal BC (Usviaty culture), and were concentrated in a very restricted area within NW Russia, surrounded by other types of sites and archaeological cultures. To the east and north there were sites with Pit-Comb pottery and Volosovo culture, to the south there were sites with Rhomb-Pit pottery. Pile dwellings existed until the end of the 3rd millennium cal BC (Zhizhitsa and North-Belorussian cultures) (see the detailed chronology in *Mazurkevich* et al. *2017*).

The form of the pile constructions changed over time: oval construction was found at an earlier stage, with rectangular constructions coming later. Pile dwellings of the Zhizhitsa and Northern Belorussian cultures consisted of one or several rectangular constructions measuring 5.5×4.5m (Fig. 5). Rectangular platforms formed the base of the pile dwellings, which were elevated 50–70cm above the surface of the shore. Logs were attached to piles with the aid of ropes and supported by 'horned' piles. Poles *c.* 5–8cm in diameter were densely laid transversely on top of the logs (Fig. 6.f); pine slabs *c.* 3–6cm thick (without bark) were placed above them (Fig. 6.c,e). The floor was covered by a layer of coarse white sand. Piles 14–22cm in diameter were placed around the periphery (Fig. 6.a). They served as a framework for walls that may have been made of branches and thin sticks (Fig. 6.d) covered by clay, as shown by daub fragments. The row of piles in the middle of the construction may indicate the existence of a pitched roof, covered by large bark pieces (Fig. 6.b). The platforms were encircled by garbage dumps (*Mazurkevich, Dolbunova 2011*). Dendrochronological analysis conducted for part of the piles of the Serteya II site allowed establishing a floating dendroscale and suggested successive phases of dwelling construction, coexistence of several dwellings at a later stage, and periodic reconstruction of the dwellings (*Hookk 2014*). Today, 363 piles have been recorded for the Serteya II site.

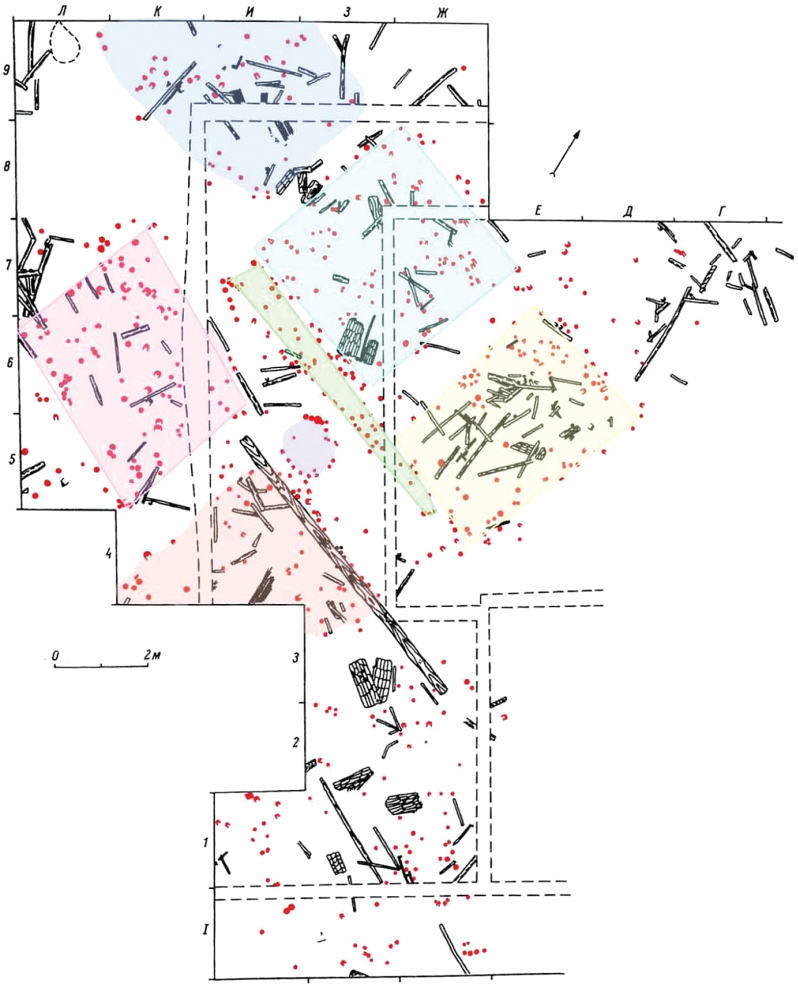


Fig. 4. Plan of the Usviaty IV site with piles distribution, remains of wooden structures and objects found (after* Miklyaev 1969*, modified by E. Dolbunova).

The faunal and botanical records indicate that lacustrine dwellers relied heavily on wild resources, with year-round procurement of meat and fur animals as well as fishing. Food gathering was of considerable significance as well. At least 30 edible wild plants were identified at the Naumovo site (*Guman 1978*). Serteya II site allowed the reconstruction of various zones of inhabitation and household activities showing different areas involved in a pile-settlement area (*Mazurkevich* et al. *2020a*). The palaeoenvironmental research conducted on this site showed a dynamic lacustrine-riverine system and important rebuilding of palaeoenvironmental conditions forced by

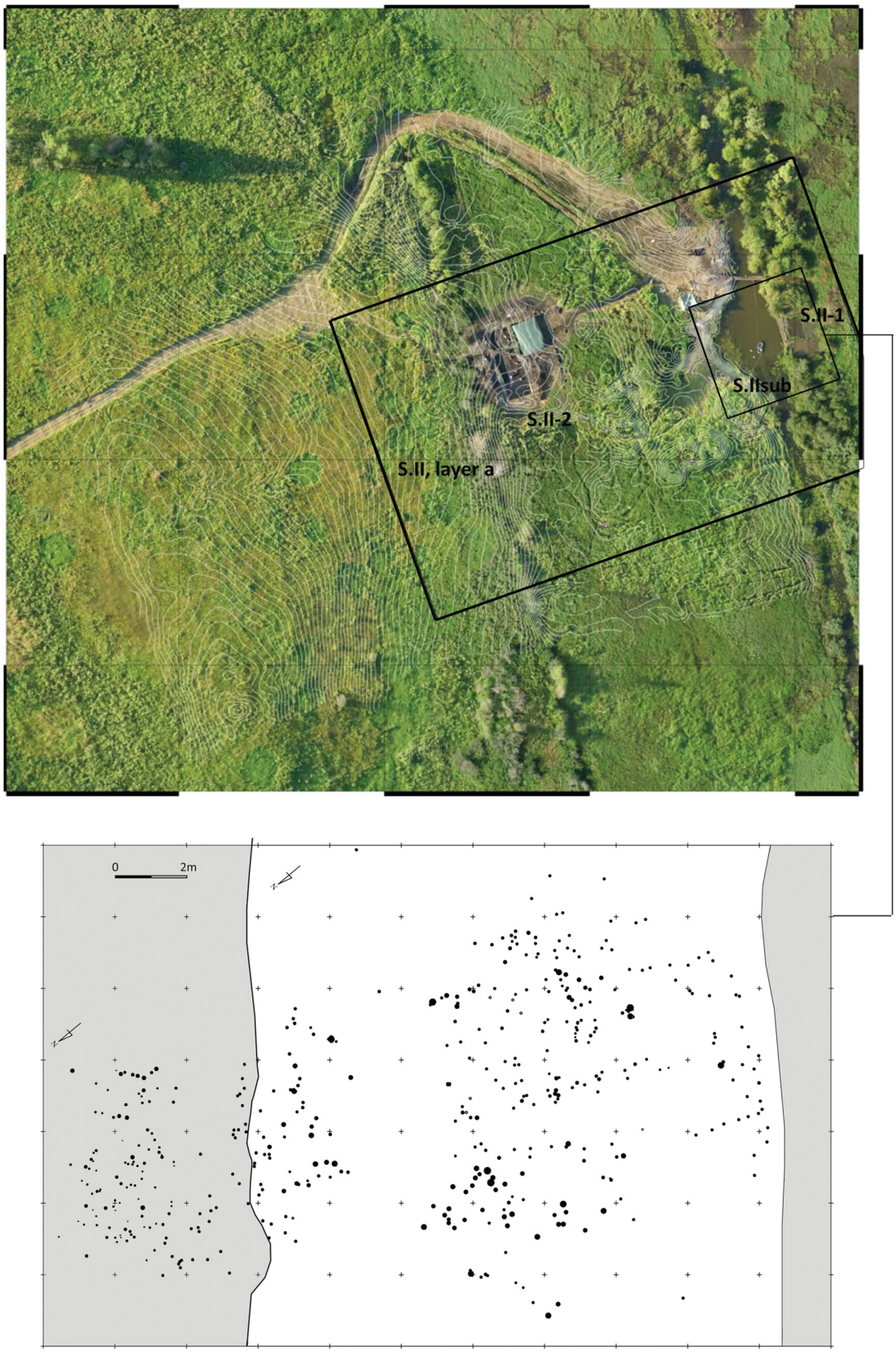


Fig. 5. Serteya II pile-dwelling site with different areas indicated (drawing by E. Dolbunova).

global climatic changes during *c.* 3900 and 2200 cal BC. The pile dwellings should be recognised here as an adaptation to the changeable ecological conditions (*Kittel* et al. *2020a*). Renewal of the lacustrine system led to the devastation of the pile dwellings, the settlement moved to higher places, and Serteya II, layer *a* site appeared (Fig. 5) (*Kittel* et al. *2020b*).

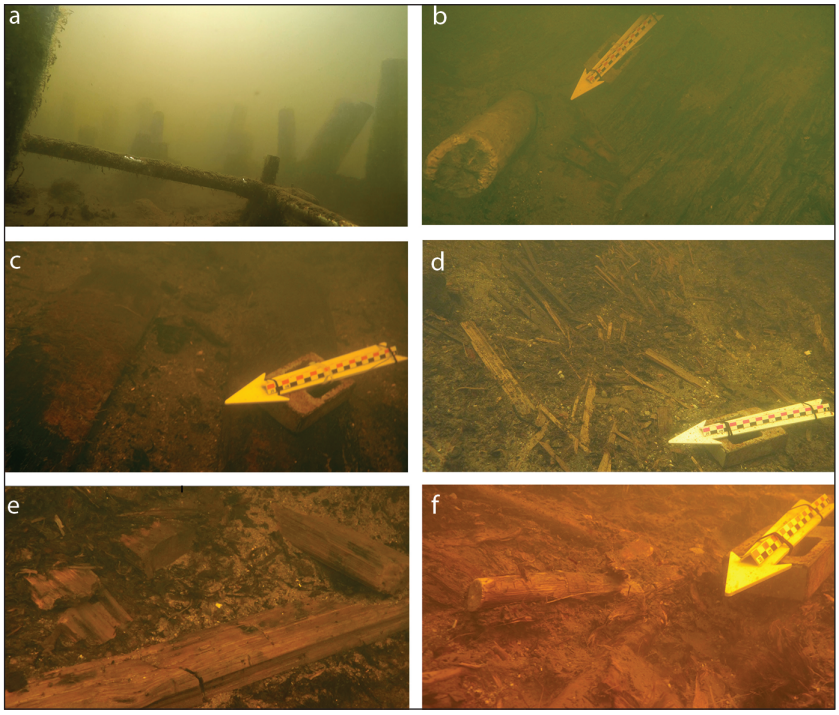


Fig. 6. Serteya II. Submerged remains of pile-dwelling constructions (photos by A. Mazurkevich, Y. Krotov, and E. Dolbunova).

Rich evidence of everyday life as well as the remains of art survived. The syncretic character of this ancient art reflects the intertwining of technical and ritual activities, aesthetic and psychological needs, as well as the worldview of the society. A new way of life could also influence the social structure and ritual culture (*Mazurkevich 2013*).

The pile-dwelling settlements were situated in the close vicinity of different landscapes that favoured sustaining a highly efficient hunting, fishing and gathering economy. This delayed the initiation of agriculture and cattle-breeding economy despite direct and/or indirect contacts with communities who practiced it, which is visible through new pottery styles and imported objects (amber pendants, flint daggers, copper items, *etc.*) (*Mazurkevich, Dolbunova 2011; Mazurkevich* et al. *2020a; Mazurkevich 2013*). Pile settlements remained the major settlement pattern in NW Russia for over a millennium.

No pile dwellings from the Early Metal period were found in the Middle and Upper Western Dvina or Dnepr Rivers. The transgression in the first half of the 2nd millennium BC led to flooding of large wetland areas and the sites were moved to a mineral shore.

Wetland sites at the eastern periphery: one more pile-dwelling settlement?

Other Neolithic wetland sites known in NW Russia have remains of fishing fences and/or traps, *e.g.,* Okhta 1 (3600–2700 BC) (*Gusencova, Sorokin 2011*), multilayer Veksa sites (*Piezonka* et al. *2020*) and Karavaikha 4 (*Bruysov 1951; Kosorukova* et al. *2016*). Only one site was interpreted as a pile-dwelling settlement, named Modlona (*Bryusov 1952; Oshibkina 1978*). It was excavated at the same time as key sites in the Baltics, when a wider scientific network existed which facilitated the exchange of knowledge about this new type of site, uncovered for the first time in this region. Aleksandr Yakovlevich Bryusov participated in excavations of the Sarnate site conducted by Lūcija Vankina (*1970.12, Figs. 42, 45*), and field seminars were organized on major peat-bog sites of Eastern Europe (*Velichko* et al. *1984*).

The Modlona site (Fig. 7) is located on Lake Vozhe on a narrow and long cape. The archaeological layer of the Modlona site is deposited in a peat layer over sand, and part of the site is located under water, another part on the shore (*Oshibkina 1978*). Dwellings were connected by passages, which led to the shore (Fig. 7), where rafts were left (*Oshibkina 1996.228*). Buildings had wooden floors, vertically placed beams were covered by clay, with, probably, a double pitch roof, covered by birch bark, pressed by large stones. Buildings were up to 12m^2, probably, of log-house construction. Fireplaces were located inside the houses, and the remains of floors and piles were burnt in one building. Garbage piles were recorded mainly to the south, and less frequently to the east of the buildings. The remains of large fishing constructions, made from thin planks, were

found near some of the dwellings (Fig. 7) (*Bruysov 1951*).

Inhabitants of the site practiced hunting and fishing. A great amount of hunting gear, and bones of wild animals were found. Fishing gear included the remains of fish traps, fish hooks and harpoons. Thick-wall pottery was tempered by shell, sometimes asbestos, and the whole surface was decorated by short, oval and long comb impressions. A great number of diverse wooden artefacts were found, including the fragment of a paddle, ash water scoop with a handle with a carved dog head. Amber ornaments were also recorded (roundish buttons with V-drilling, pendants, and fragment of a ring). Analogies can be found within the ceramic assemblage of eastern Latvian sites of the Piestinya type, and some similarities can be traced with the materials of the Upper Volga (Volosovo culture). Amber ornaments are similar to the materials found at Eastern Baltics sites (*Oshibkina 1978*).

Dating (4850±120 BP (3819–3371 cal BC) (Le-994)) was carried out on charcoal from the cultural layer, other dates originated from layers lying above this (4360±130 BP (3370–2630 cal BC) (Le-993), 3960±150 BP (2886–2125 cal BC) (Le-992)). The remains of the site were covered by a thick sandy layer, left by a transgression, which could have led to abandonment of the settlement (*Bruysov 1951*).

The Modlona settlement differs greatly from other Neolithic sites in the Eastern Onega region and neighbouring territories. Newcomers who arrived here left a small number of very particular sites that existed for a short period of time (*Oshibkina 1996*). Sites of the late stage include Modlona II, Ol'skyi mys, Lisja Gorka sites, and Kargullino burial ground. The latter is located on dune elevations of the southern shore of the White Sea, where 160 amber ornaments and ochre spots were found (*Oshibkina 1996. 230*).

Settlements of the Modlona type were erected in marshy and riverine landscapes surrounded by large and dry areas with birch-coniferous forests inhabited by bearers of local Kargopolskaya archaeological culture (*Oshibkina 1978*).

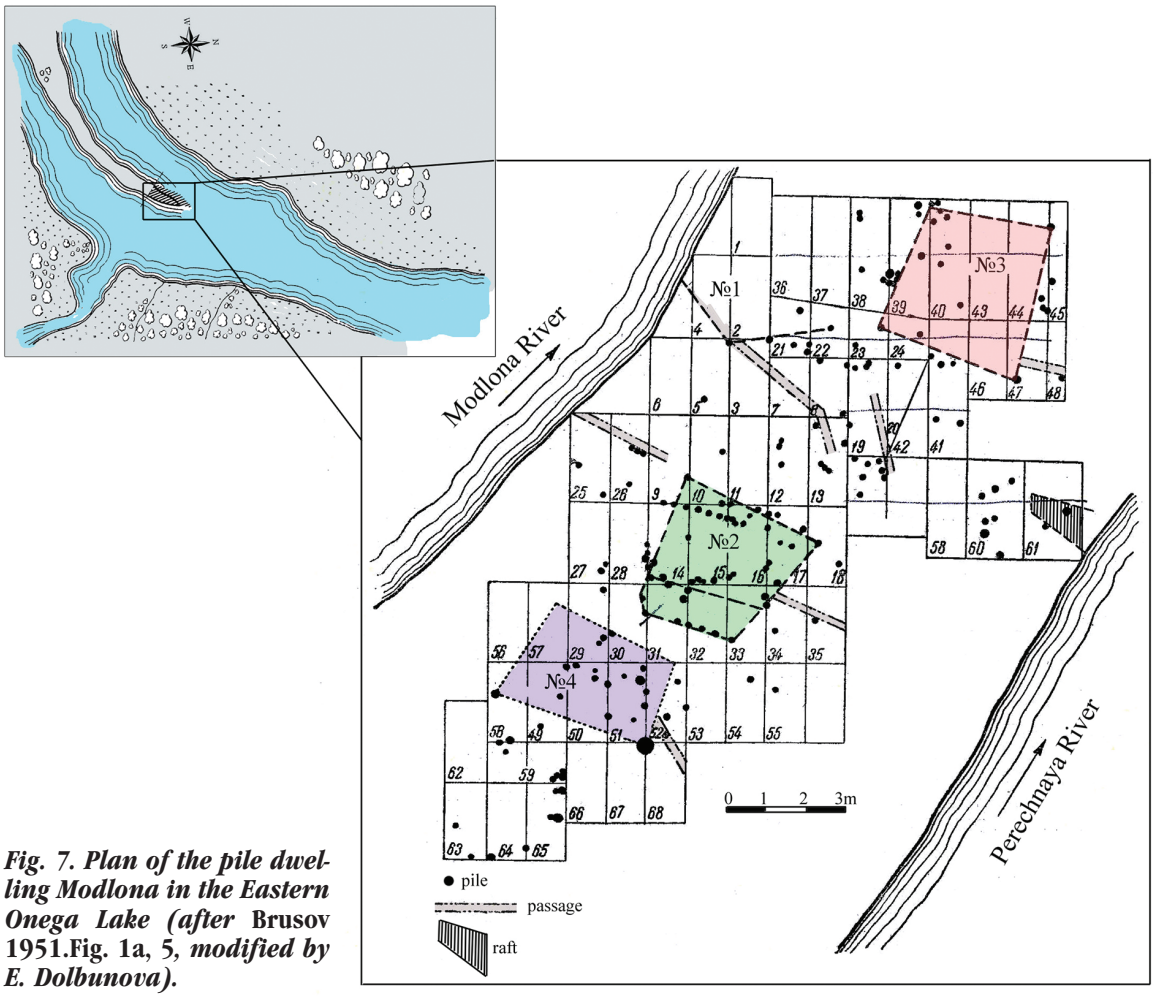


Fig. 7. Plan of the pile dwelling Modlona in the Eastern Onega Lake (after* Brusov 1951.Fig. 1a, 5*, modified by E. Dolbunova).

Discussion

Northern wetland settlements include sites with different types of constructions located in various limnic landscapes: seacoast, lacustrine and riverine landscapes. There are post-built structures with ground-level floors, constructions with raised floors and dwellings of grate-and-beam construction. Pile dwellings with raised floors appeared and existed within the end of the 4th millennium to the end of the 3rd millennium BC in the Circum-Baltic area manifesting a possible common cultural phenomenon. The Early Metal Period pile dwellings with raised floors in the Circum-Baltic region were found only in Lithuania and Poland. These lake dwellings were established during a transitory period – between the Late Bronze Age and Early Iron Age. According to ^{14}C dates and dendrochronological research, they cover a time span between 700 to 400 cal BC. All of these sites were located in wetlands where rich organic finds were preserved, which could be crucial for pile-dwellings phenomenon. The choice of particular architectural techniques was caused by technological, cultural and environmental factors (*Martinelli 2014*).

Different types of structures and settlements were formed as the result of intensive cultural contacts or the development of a local household strategy, influenced by both environmental factors and cultural choices. They appeared in some cases independently, and in others similarities between different complexes were traced (similarities between wooden artefacts, pottery and bone assemblage of the Late Narva culture sites in the Eastern Baltics and Usviaty culture in NW Russia (*Miklyaev 1998; Vankina 1970*)).

Research into several Neolithic pile-dwelling sites in NW Russia suggests that the population remained small, which is evidenced by the small number of synchronous dwellings found at one site. The lack of strong demographic pressure on resources, especially food resources, might not force the active development of a productive economy. Aquatic resources could play an important role both in food resources and the organization of the settlement, that was intentionally installed in a 'limnic landscape'. A wide diversity of natural substances was traced in the Middle Neolithic pottery of pile dwellings in Western Europe (*e.g.,* ruminant adipose fats, dairy products, plants substances and beeswax) along with a scarcity of aquatic products (*Drieu* et al. *2020*), in contrast to what has been found in the pile-dwelling pottery in NW Russia (preliminary results see in *Kulkova* et al. *2015*). The uneven emergence of a productive economy in the regions under consideration can thus be traced. In recent years, more evidence has appeared that the skills needed for agriculture and a cattle-breeding economy penetrated this area from the 4th millennium BC onwards, but were not completely established in some regions (*Dolukhanov, Mazurkevich 2000; Tarasov* et al. *2019; Alenius* et al. *2017*).

Among the many wetland settlements that have been explored, only a few have been found with dwellings with raised floors. They have a set of particular features which allow such interpretation: location on periodically flooded wetland areas, definite sets of architectural elements which allowed raised floors to be sustained (fields of piles 5 to 30cm in diameter combined into rectangular platforms often manifesting several phases of inhabitation and reconstructions, 'horned' piles or wooden items used to support horizontal beams of a raised floor construction, traces of ropes used to attach wooden planks to piles), traces of clay or burnt adobe fragments – markers of clay used to cover the walls, a sandy layer used as floor covering under the fireplace, burnt stones, dwelling context testified by different household items, tools, pottery located within or along the platform, and the presence of coprolites beneath and nearby the remains of constructions. Several phases of construction and reconstruction can be traced by dendrochronological and ^{14}C analysis and 3D recording of the upper part of the piles' depth and levels of the floors. Pits filled with bones, shells, water-chestnuts, chestnuts and acorns can also be traced nearby. Periodic drying out can be testified by a thin layer of shell and sand penetrating around piles. Some or all of these features can be traced on dwelling sites. Fishing structures show a particular difference, as manifested by the absence of a dwelling context, the presence of discarded thin planks – parts of fish traps or fences – a thin archaeological layer, often with clear traces of a shore or deep water area, and different sets of macroremains. The small diameter of the stakes driven in the bedrock used for fishing constructions has often been suggested to be another marker of a fishing structure. However, the smaller diameter of the piles used for the dwellings was also noted in ethnographical cases (*Pétrequin, Pétrequin 1984*).

Conclusion

Pile dwellings are regarded not only as a new form of architecture, but as a reflection of a new way of life, a 'symbol' of this society (*Begleiband* et al.

2016). The reasons of the formation of this type of architecture have been always in dispute. The great role of the surrounding waterscapes in the life of pile-dwelling cultures was suggested to be conceptualized as 'limnic cultural landscapes' (*Mainberger* et al. *2020*). Ancient people had to take into account numerous factors when building settlements inhabited all year round. Leaving places suitable for agriculture and cattle-breeding could be one of the reasons for the construction of Central Alpine pile settlements (*Monnier* et al. *1991*). Climatic changes, followed by regressions and the formation of peatbogs, might have led to the construction of dwellings in close vicinity to the water, along a shoreline to avoid damage due to a freeze-up. Construction of pile dwellings could also make them independent of seasonal and gradual increases in the water level. Many theoretical approaches to explain the reasons for building in this manner have been raised in the Circum-Baltic area: defensive purposes (*Pydyn 2007*), 'easy' building (*Menotti, Pranckėnaitė 2008*), economic reasons (*Dolukhanov* et al. *2004*) and as well as social ones (*Pydyn, Gackowski 2011*).

Though a variety of wetland sites has been found, only few pile-dwelling settlements with raised floors have a clearly determined architectural structure and features of building techniques. The criteria of pile-dwelling site determination, description of architectural remains, size and development stages are among the most complicated questions to be further elaborated. Further interdisciplinary research is needed for proper identification or reinterpretation of the remains of habitation sites. The major question remains as to whether the same factors could have influenced and triggered the formation of similar types of dwellings within societies that in many cases practiced different methods of environment exploitation, and how different these constructions were.

The catchment area of pile dwellings was not restricted to wetlands, but encompassed also drylands, as is shown by a number of cases in different regions (*Giagkoulis 2020; Mazurkevich* et al. *2020b; Naumov 2020*). Finding the connection between particular dwellings and dryland settlements will allow contextualizing of pile settlements and involving them into the larger landscape and historical context.

The earliest pile dwellings in the Circum-Baltic area were left by communities of hunter-gatherers who sustained their economy for a long period of time and chose to erect a completely new type of dwelling compared to the synchronous forms of architecture known on other sites nearby. This might have coincided with the formation of a new social structure, as testified by the distribution of weapons and prestigious artefacts. The latter include amber materials, flint daggers and copper items, which were found in Northern Belarus (*Charniauski 2020*) and NW Russia (*Mazurkevich, Dolbunova 2011*). Such coincidence in the distribution of prestigious items and a new form of architecture – pile dwellings – should be stressed. The invention and implementation of this innovation in the Neolithic environment might have had a distinctly symbolic significance, in addition to its practical utility, which is yet to be fully understood.

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The Freston causewayed enclosure: new research on the Early Neolithic of Eastern England (Suffolk)

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ABSTRACT – *Current models view southeast England as where Neolithic lifeways were first introduced to Britain from continental Europe* c. *4000 cal BC, however, there has been little work detailing this process in coastal East Anglia. In 2019, work at the Freston causewayed enclosure provided the first view of a major gathering space associated with semi-mobile farming communities of the Early Neolithic in the county of Suffolk and located on a major estuary close to the North Sea. Excavation produced a rich assemblage of worked flint and Mildenhall Ware pottery (potentially for feasting), plus evidence for the consumption of cereals and hazelnuts.*

KEY WORDS – *Britain; East Anglia; Neolithisation; Early Neolithic; causewayed enclosure; social gathering*

Frestonska ograda z nasipi: nova raziskava zgodnjega neolitika v vzhodni Angliji (Suffolk)

IZVLEČEK – *S trenutnimi modeli vidimo jugovzhodno Anglijo kot prostor, kamor je ok. 4000 pr. n. št. prvič prispel neolitski način življenja v Veliko Britanijo iz kontinentalne Evrope. Do sedaj je bilo znanih le malo podatkov o tem, kako je ta proces potekal na priobalnem območju vzhodne Anglije. Leta 2019 so nam raziskave ograde z nasipi v Frestonu omogočile prvi vpogled na velik prostor za zbiranje, ki je vezan na delno mobilne poljedelske skupnosti iz zgodnjega neolitika v okrožju Suffolk in se nahaja ob glavnem izlivu blizu Severnega morja. Z izkopavanji smo pridobili bogat zbir obdelanih kamnitih orodij in lončenino tipa Mildenhall (morda uporabljena za pogostitve) ter dokaze o uživanju žit in lešnikov.*

KLJUČNE BESEDE – *Velika Britanija; vzhodna Anglija; neolitizacija; zgodnji neolitik; ograda z nasipom; družabno srečanje*

Introduction

The prevailing view concerning the 'Neolithisation' of Britain involves an influx of migrants from continental Europe towards the end of the 5th millennium cal BC (*Cummings, Morris, 2018; Brace* et al. *2019*), who brought with them a developed agro-pastoral regime, potting traditions, and an advanced know-how for extracting lithic raw materials and their exchange over great distances (*Miles 2016; Sheridan 2010*; see also *Edinborough* et al. *2020; Schauer* et al. *2020*). While evidence for pre-Neolithic contact between continental farmers and British hunter-gatherers suggested to some that farming spread through the island via processes of acculturation, genetic studies indicate that ultimately the

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indigenous population was largely replaced over time (*cf. Thomas 2008*).

A major synthesis and Bayesian analysis of radiocarbon dates from Neolithic sites in Britain and Ireland has generated a robust model concerning the introduction and spread of Neolithic activity throughout the British Isles (*Whittle* et al. *2011*). Perhaps unsurprisingly, given its proximity to the mainland, the initial colonisation ('Earliest Neolithic') appears to have entered southeast England around 4050 cal BC (Fig. 1). Neolithic subsistence and other practices thereafter moved into south central England ('Early Neolithic') by the second half of the 38th century cal BC (*Whittle* et al. *2011.848–861, Fig. 15.8*). This paper engages with some of these issues, with specific reference to that region of southeast Britain referred to as 'East Anglia' (here defined as the counties of Suffolk, (north) Essex, Norfolk, and Cambridgeshire). Our specific focus is the Early Neolithic [EN] 'causewayed enclosure' at Freston, on the Shotley peninsula in southeast Suffolk (Fig. 2).

It is not unreasonable to suggest that the introduction of domesticated plants and animals into the East Anglia area was partly achieved by waterborne movement, considering the cross-channel seafaring capabilities of the original farming populations and the proximity of East Anglian Neolithic sites to rivers (*Garrow 2006.20, Figs. 3.9–3.11; Healy* et al. *2011.263–265, Fig. 6.1; Martin 1999*). Whether we are dealing with the budding-off of initial colonist populations from the south, or a direct influx of farmers from across the North Sea to the east, we suggest that their settlement of Suffolk was achieved via the major river courses (*Garrow 2006.16, Fig. 3.5*). These major rivers comprise the Orwell, Deben and Alde, with the Stour on Suffolk's southern boundary, and the Waveney to the north (Fig. 2). While this constitutes an obvious area to research the processes involved in the 'Neolithisation' of Britain, there has hitherto been little dedicated fieldwork in this part of East Anglia. Thus far, only a handful of Neolithic sites have been excavated in Suffolk, mainly in the form of occupation sites made-up of clusters of round or oval pits containing pottery, worked and burnt flint, and charred plant remains inter alia (*Garrow 2006*). These features are interpreted as the remnants of what were short-term seasonal settlements of particular places that were likely (re)occupied over time by small-scale mobile agro-pastoral family groups, with little evidence for the construction of permanent structures. The current wisdom would not associate these sites with the Earliest Neolithic, *i.e.* the phase of colonisation, but rather the subsequent Early Neolithic [EN] period of the later 38th century cal BC onwards (*Whittle* et al. *2011.875–878*).

The most well-known pit cluster site in Suffolk is Hurst Fen, Mildenhall at the western end of the county on a tributary of the River Great Ouse (*Clark* et al. *1960*). The excavation of this site gave us 'Mildenhall Ware', a primarily East Anglian iteration (*Healy 2013.14–16*) of a wider EN Decorated Bowl tradition that appeared across southern Britain beginning in the 38th to 37th centuries cal BC (*Gibson*

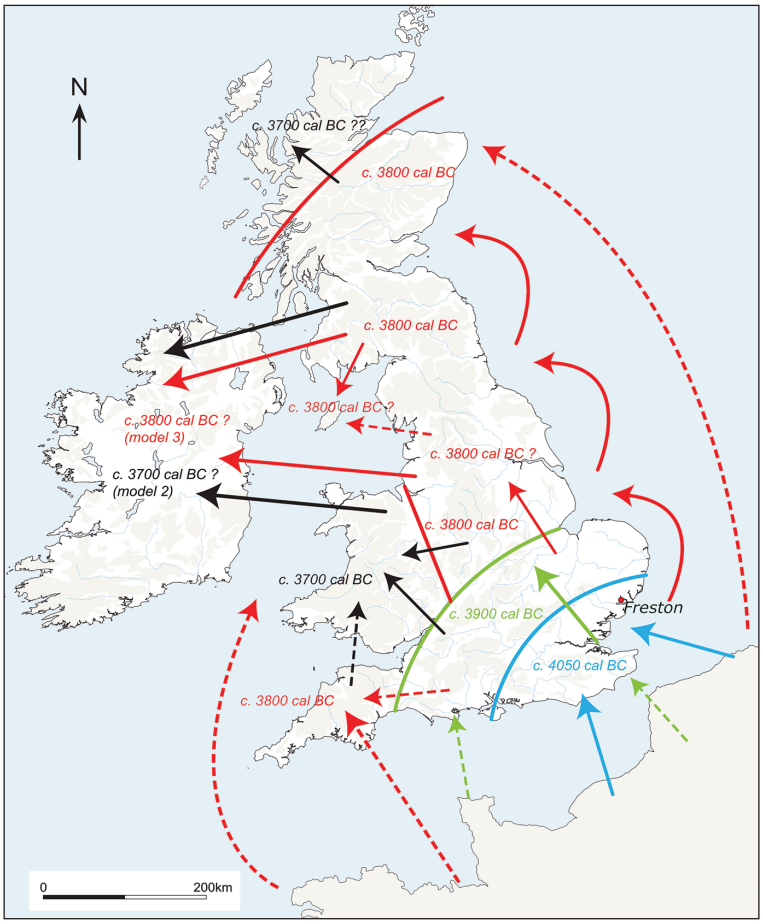


Fig. 1. Interpretive map of suggested dates, source areas and directions in the spread of Neolithic objects and practices across Britain and Ireland (modified from* Whittle *et al.* 2011.Fig. 15.8 *and reproduced with permission).

2012.73–74, Fig. 34; Smith 1956; Whittle et al. *2011.875*). There is also Reydon Farm in northeast Suffolk, close to the River Blyth that runs into the North Sea, which is the only site in the county with published radiocarbon dates for the EN (*Harding* et al. *2017*). EN pit clusters have also been excavated at Sutton Hoo, situated above the River Deben, a few kilometres inland from the coast (*Hummler 2005*). More broadly, pit cluster sites are now appreciated as a 'particularly prevalent' phenomenon in East Anglia compared to elsewhere in EN southern Britain (*Garrow 2012.4*). The largest numbers are known from the Fen edge in Cambridgeshire and Norfolk (Fig. 2), most notably the well-published examples of Sutton Gault North Fen, Broome Heath, Kilverstone, and Spong Hill (*Wainwright 1972; Garrow* et al. *2006; Healy 2013; Tabor 2016*).



Fig. 2. Location map showing the main sites mentioned in the text.

While EN British society is typified by dispersed, small-scale communities, there were times when these populations came together in formal settings to initiate and maintain social relations between groups (*Edmonds 1999.80–108*). From the 38th century cal BC onwards, these social gatherings began to take place at a type of monument referred to as a 'causewayed enclosure' (*Whittle* et al. *2011.xi*). These earthworks represent Britain's earliest known enclosures of open space. Comprised largely of interrupted bank and ditch systems (often rounded in shape), the numerous causewayed entrances suggesting that their primary purpose was neither defensive, nor for corralling livestock (*Oswald* et al. *2001*). Ranging in size from 0.4 to 26ha, the monuments' construction likely required a workforce drawn from several communities (*cf. Ashbee, Cornwall 1961*), whereby their very creation would have served to cement inter-group connectivity.

The past 20 years have witnessed the publication of several major works on these EN monuments, detailing their chronology, location, form, and the activities performed within them. These events included gathering, feasting, exchange, marriage, burial, and conflict (*Allen* et al. *2008; Clark* et al. *2019; Evans, Hodder 2006; Evans* et al. *2006; Mercer, Healy 2008; Neil* et al. *2018; Oswald* et al. *2001; Whittle* et al. *2011, inter alia*).

An early discussion of British causewayed enclosures claimed regional distinctions in where these monuments were situated. Those located in southeast and southwest England were conceptualized as related to the hill 'folk', while those in the east were the peoples of the rivers and coast (*Piggott 1934.375*). It remains true today that in East Anglia the pit cluster sites and causewayed enclosures of the EN are associated strongly with lowland river valleys on lighter soils lower than 50m OD (Ordnance Datum). While these are low-lying compared to southern British EN sites, most occupied positions that would have been elevated by local standards, usually above the floodplains of rivers (*Garrow 2006.16, 26*).

Compared to most of southern Britain, causewayed enclosures and other Neolithic monuments are relatively rare throughout most of Suffolk and Norfolk (*Healy* et al. *2011.265, Fig. 6.1*). In Suffolk there are only a handful of causewayed enclosures recognised by aerial photography (Fig. 2). Two have been recognised at Fornham All Saints, then individual monuments at Freston and Kedington, plus a possible fourth at Bentley (*Martin 1999; Oswald* et al. *2001.154–155*). We began the *Freston Archaeological Research Mission* [FARM] in 2018 in part to redress the regional research bias that had hitherto seen no excavations of the Suffolk monuments, and to initiate a longer-term project that could engage the larger debates concerning the processes of 'Neolithisation'.

Background to the site

The Freston interrupted ditch system is located 3km south of Ipswich, the modern county-town of Suffolk in eastern England (Fig. 2). The site was discovered by aerial photography in the 1960s and from the outset was believed to be a Neolithic causewayed enclosure (*Palmer 1976.175; Wilson 1975.180–181*). At 8.55ha, Freston is one of the largest known British causewayed enclosures (with large being defined as 6ha and above), second only to Haddenham, Cambridgeshire (8.75ha) within an East Anglian context (*Evans, Hodder 2006.239, Fig. 5.1*). Freston is also one of the closest of these monuments to the North Sea. Today it is located some 13km from the modern coastline, though due to intervening sea-level rises this is likely to have been *c.* 5km further away in the EN (*Burningham, French 2011. 105–106, Figs. 1–2*).

The site plan produced from the aerial photographs (*Dyer 1995*) indicated that the perimeter of the roughly circular monument is defined by two closely spaced, concentric and interrupted ditches (Fig. 3). The cropmarks further revealed traces of what has been interpreted as a palisade trench running between the two circuits. This feature is discontinuously traced, and best detailed in the north and northeastern part of the site, and only partly visible to the west. Just within the perimeter of the enclosure's northeast quadrant is the outline of a very large rectangular structure, measuring *c.* 37 × 9m, with the long sides and two internal cross-partitions defined by postholes, and the short-ends delineated by trenches (*Hegarty, Newsome 2004.65; Martin 2007.1*). This building has been interpreted as a possible Neolithic longhouse (*Oswald* et al. *2001.126*), or an Anglo-Saxon hall. Either case "*would make it of potentially national importance*" given the rarity of such structures in Britain (*Martin 2007.1*), while the size of the Freston building would make it one of the largest examples of either category (*Marshall, Marshall 1991; Sheridan 2013*). If it were a Neolithic longhouse then it would likely relate to a pre-enclosure period of occupation at the site, given that these timber structures relate to the Earliest Neolithic in Britain, typically dating to the first two or three centuries of the fourth millennium BC (*Bayliss* et al. *2011.719–724; Last 2013.273–278; Sheridan 2013*).

Between the structure and the enclosure ditches to the north are the outlines of what appear to be two round-cornered roughly rectangular pits which, following the above discussion, could be Saxon Sunken Featured Buildings (SFBs) as these are often found in association with Anglo-Saxon halls. That said, at *c.* 6.5 × 3m and 4.5 × 2.5m they are quite large for SFBs, and thus might instead date to the Neolithic and relate to the nearby ditch system, given they are not dissimilar in width (*Hegarty, Newsome 2004.66*).

The site at Freston is located on the Shotley peninsula, between two large estuaries: the Orwell less than 2km to the northeast, and the Stour *c.* 3.5km to the south (Fig. 2), and occupies a relatively elevated position – by Suffolk standards – around 31m OD. While Rog Palmer (*1976.164*) originally described the site as having a controlling position regarding movement along the estuaries, the location is much more in keeping with other British low-lying causewayed enclosures (*Oswald* et al. *2001.96–97*). We suggest an alternative reason as to why the site was created in this locale, namely that the enclosure was centred on a spring (Fig. 3). While the significance of the spring to the monuments' construction could be viewed in functional terms, regarding the provision of fresh water to people and livestock, we suggest that this feature also had symbolic importance. There is good evidence to suggest that springs had ritual importance in the British Neolithic (*Ri-*

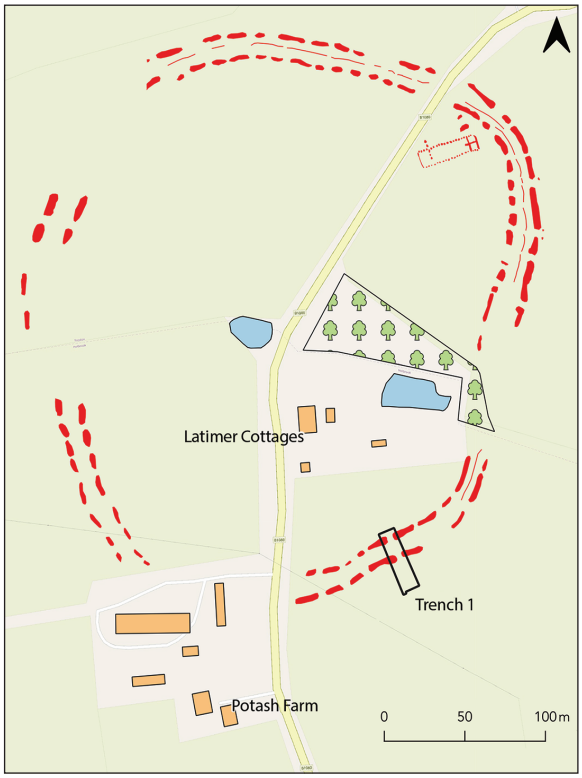


Fig. 3. The Freston causewayed enclosure showing the location of Trench 1 (modified after* Dyer 1995*).

chard 1996), a significance that may have derived from indigenous Mesolithic hunter-gatherer ontologies (*cf. Tilley 1996.65*). More generally, an association with water, in the form of rivers, has been made for several other British causewayed enclosures (*Oswald* et al. *2001.91–94*). East Anglian examples include Fornham-All-Saints and Kedington, while at Etton local hydrological conditions likely ensured that some of the circuit ditches would have contained standing water for part of the year.

Today there is nothing to see of the Freston enclosure at ground level. The 2019 excavation suggests that the ditches were largely infilled during prehistory and their banks eventually levelled by ploughing possibly during the Iron Age or Roman period, the impact of which is documented at nearby Sutton Hoo (*Hummler 2005.391–393*). There is also evidence for the monument being disturbed in the early modern period. The enclosure is bisected by a road, while a farm was built atop the southwest quadrant's ditches in the 16th century, and two cottages were constructed inside the enclosure in 1875. Currently the site is located on private land, much of which has been intensively farmed, though the monument's eastern half has been left as grassland in recent years. Despite being accorded protected status in 1976, the site has only received limited formal archaeological investigation (*Meredith 2007; Wightman 2011*). The most important work was conducted in 2007, during which *c.* 2.9ha of the monument's northeast quadrant underwent a geophysical survey. This work largely substantiated what could be seen from aerial photography, while also identifying a trackway entering the enclosure through a causeway and over the corner of the longhouse (*Martin 2007.4*).

In 2018, we initiated work at Freston in order to characterize and date the site. Our larger research aims are to contribute to a dynamic field of research dedicated to causewayed enclosures (*cf. Oswald* et al. *2001; Whittle* et al. *2011*), and to fulfil the team's more general research interests in processes of 'Neolithisation' (*Carter 2019a; Carter* et al. *2013*) and 'the archaeology of social gathering' (*Carter* et al. *2016*). The first stage of fieldwork comprised the systematic survey of Latimer Field due south of the enclosure's eastern half, which produced a low density of diagnostic EN flaked stone artefacts plus a consistent distribution of Victorian pottery tile and glass that had been introduced via manuring (*Carter, Aubert in prep; Carter 2019b*). With permission from Historic England and local landowners, we then shifted from survey to excavation the following year.

Aims of the excavation

The first excavation season was conceptualised as a pilot study for a larger project, with a relatively modest budget, team, and research objectives. Our main aim was to ground the claim that Freston was an EN causewayed enclosure, and to recover short-life organic material for AMS radiocarbon dating so we could begin producing an absolute chronology for the monument's construction and abandonment (*Bayliss* et al. *2011. 38–42*). These data would further contribute to a larger model for the establishment of such monuments throughout Britain (*Whittle* et al. *2011*), while expanding the number of absolute dates for EN Suffolk specifically. These aims were to be achieved by targeting ditch termini, as these are typically artefact-rich contexts at causewayed enclosures (*Oswald* et al. *2001.120–124*). Theoretically, any pottery and stone tools would help to typologically date the site and provide an insight to the activities that took place there (*cf. Beadsmoore* et al. *2010; Bye-Jensen 2019; Copley* et al. *2005; Garrow 2012; Saville 2002*), while faunal or archaeobotanical material would reflect both subsistence strategies and the local environment (*cf. Jones, Rowley-Conway 2007.407–408; Serjeantson 2011*).

The project was developed in consultation with Historic England, the site's legal custodians. This relationship raised another project aim, which was to detail any damage to the site by modern farming to help update the monument's management plan (*cf. Department for Culture, Media and Sport 2013*). A final objective was to dialogically engage with the various groups who are personally, economically and/or intellectually invested in the site (*cf. Bartu 2000; Carter 2017; Merriman 2004*), a process that has involved in-person and online talks, a site tour, volunteer fieldworkers, and the creation of a non-academic website (*FARM 2021*).

The 2019 fieldwork season

In 2019 a small team undertook the first research excavation at Freston. The fieldwork began with a geophysical survey of the southeast quadrant, the results of which are published elsewhere (*Schofield* et al. *2021*). Here we focused on the excavation of a 10 × 35m trench that, with the guidance of the geophysical survey, was established over two sets of

ditch termini, encompassing an area both directly within and outside of the enclosure (Fig. 3).

The Freston site was constructed on an extensive sheet of loamy soil overlaying glacial outwash gravels characterised by flint content and impeded drainage, due to the underlying London Clay (*British Geological Survey 2020; Wymer 1999a*). In the northwestern part of the trench, the archaeology was exposed directly beneath these loamy soils, while in the southeastern half there was an intervening fine-grained windblown sand, or loess, that overlayed the archaeological deposits. The trench was stripped mechanically to the natural sands and gravels at a depth of 0.4–0.5m, after which manual cleaning and excavation defined 14 anthropogenic and natural features (Fig. 4, Tab. 1). These features include our four target ditch termini (F#001–F#004), a palisade trench (F#011), as well as pits, hollows, and a curvilinear feature (F#014). All soil was sieved, and its volume tallied to quantify the relative abundance of material culture, while ≥40 litres of soil were taken per context for flotation and the retrieval of charred plant remains and micro-debitage (for sampling protocols see *Bogaard* et al. *2013.93*). Despite concerns that modern farming had impacted

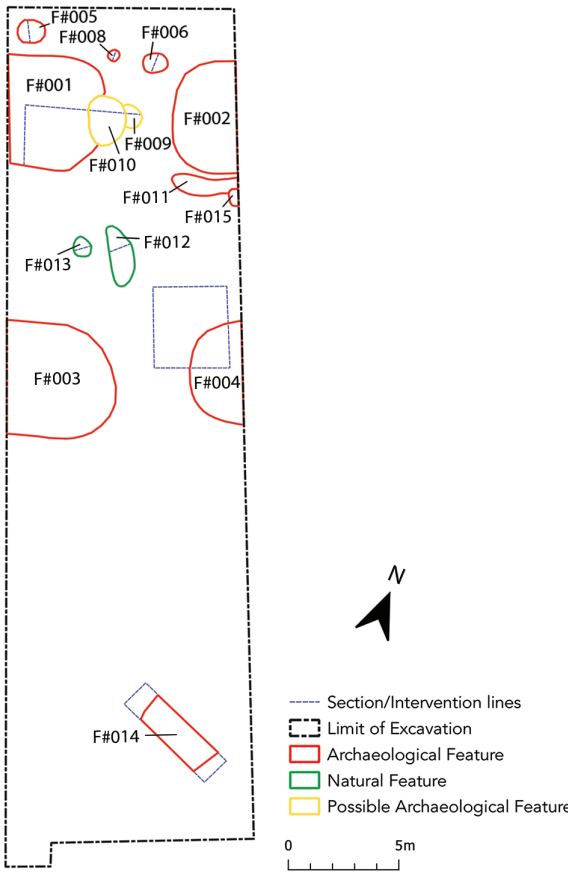


Fig. 4. Trench 1 features.

the site, only a few shallow plough scars were recorded, with the uppermost deposits of ditch F#001 producing a small amount of modern glass and iron.

The excavation focused on the two ditch termini of the enclosure's inner circuit. Feature #001 (F#001) was the western terminus, of which a quadrant was dug to natural at *c.* 2.4m, while the opposite eastern ditch Feature #002 (F#002) was excavated fully in section to *c.* 2.2m deep (Fig. 5). The slightly different depth may relate to the undulating nature of the London Clay deposits that seem to mark the base of these ditches, the material likely proving far more resistant to the Neolithic digging tools than the sands and gravels. The stratigraphic sequences of the ditches were broadly similar. The upper fills with their relatively fine-grained sandy loam and low-density finds suggest the ditches gradually silted-up after the site had fallen out of use. The subsequent layers were more compact, indicating that these deposits had sat for a longer period, with clay lenses and iron staining indicating occasional waterlogging; these strata likely represent the initial post-abandonment phase. The lowest fills comprised relatively thick accumulations of anthropogenic dumping events with clear tip-lines and artefact-rich deposits, including semi-complete ceramic vessels. The basal layers were formed of natural sand that had slumped back into the ditch, probably not long after it had been dug. In F#001, this stratum [011.06] produced significant amounts of pottery (Tab. 1) suggesting that the intentional deposition of material culture into these ditches began almost as soon as the monument was created. Work also commenced on the eastern ditch terminus of the outer circuit (F#004), wherein the upper fill produced a small amount of EN lithics and pottery. Unfortunately, the excavation of this feature could not be completed because of time limitations. Within an East Anglian context, these Freston ditches are notable for their depth, some 2.2–2.4m below the buried soil, in contrast to the shallower examples from Etton, 0.65–1.25m deep (*Pryor 1998.16, Tab. 1*), Great Wilbraham, 0.7–1.5m deep (*Evans* et al. *2006.125, Tab. 2*), Haddenham, 1.1–1.9m deep (*Evans, Hodder 2006.245–265*), Kingsborough, a maximum of 1.7 and 1.3m deep (enclosures K1 and K2 respectively [*Allen* et al. *2008.239–244, Figs. 4, 6*]), and St. Osyth, 0.4–1.6m deep (*Germany 2007.Fig. 15*).

Linear feature #011 (F#011) was situated due south and parallel to F#002 (Fig. 4), running 2.75m in length into the side of the trench where it was cut by a small pit (F#015). Measuring 0.4m wide and

				Pottery		Flaked Flint		Burnt Flint	
Feature	Context	Description	Vol. (L)	Weight (g)	g/L	Weight (g)	g/L	Weight (g)	g/L
F#001	11.01	ditch terminus	5630	73	0.01	347	0.06	1890	0.34
F#001	11.02	ditch terminus	2055	30	0.01	123	0.06	913	0.44
F#001	11.03	ditch terminus	879	318	0.36	173	0.20	362	0.41
F#001	11.04	ditch terminus	775	4048	5.22	622	0.80	1286	1.66
F#001	11.05	ditch terminus	1490	2453	1.65	449	0.30	850	0.57
F#001	11.06	ditch terminus	1050	950	0.90	377	0.36	912	0.87
F#002	5	ditch terminus	2826	105	0.04	349	0.12	589	0.21
F#002	6.01	ditch terminus	5331	0	0	432	0.08	867	0.16
F#002	6.02	ditch terminus	1370	2946	2.15	965	0.70	0	0.00
F#002	6.03	ditch terminus	540.8	3423	6.33	1001	1.85	974	1.80
F#002	6.04	ditch terminus	2990	24	0.01	51	0.02	665	0.22
F#004	016	ditch terminus	1590	18	0.01	87	0.05	243	0.15
F#004	017.1	ditch terminus	336	7	0.02	0	0.00	119	0.35
F#005	7.01	pit	130	0	0	12	0.09	209	1.61
F#005	7.02	pit	315	0	0	12	0.04	131	0.42
F#006	13.01	pit	180	0	0	41	0.23	6	0.03
F#008	8.01	pit	109	22	0.20	1	0.01	0	0.00
F#009	9.01	tree hole/pit?	319	7	0.02	9	0.03	34	0.11
F#010	10.01	tree hole/pit?	75	0	0	4	0.05	2	0.03
F#011	19.01	palisade trench	501	33	0.07	107	0.21	452	0.90
F#014	22.01	ditch	1500	0	0	22	0.01	25	0.02
F#015	23.01	pit	50.6	0	0	4	0.08	8	0.16
			Totals	**14 446 g**		**5188 g**		**10 537 g**	

Tab. 1. Quantification of pottery, flaked and burnt stone by context and feature from the 2019 Freston excavation.

0.32m deep, (F#011) produced small quantities of EN ceramics and lithics and is believed to form part of the palisade trench. This section of the palisade had neither been visible in the crop marks nor prospected by the geophysics.

The excavation investigated a further ten cut features, four of which were roughly circular in form (F#005, F#006, F#008, F#015) and contained varying quantities of pottery, lithics, burnt flint, charred plant remains and wood charcoal (Tabs. 1–2). The two largest features measured 1.11m wide × 0.41m deep (F#005), and 0.80m wide × 0.25m deep (F#006). These measurements are entirely in keeping with the size of pits at other East Anglian EN sites, such as the settlements of Kilverstone (average width 0.7m), Hurst Fen (≤1.21m wide), and Reydon Farm (average 0.94m wide), and the causewayed enclosure at St. Osyth (typically 0.77–1.16m wide) (*Clark* et al. *1960.206; Garrow* et al. *2005.141; Germany 2007.25; Harding* et al. *2017.3–5, Tab. 1*). While the scale of the two smaller features (F#008, F#015) might suggest that they could be viewed as 'postholes' (the latter being only 0.35m wide × 0.32m deep), they lack the vertical sides and flat base usually attributed to such features in the region (*Garrow 2006.33*). Ultimately, we feel that any inference that these Freston examples relate to upright timbers and/or architecture is an interpretation that can only be put forward when we have more contextual information.

Between the ditches there were two cut features (F#012, F#013) that were deemed natural due their uneven form and lack of finds. These may represent the depression left in the ground where a tree was uprooted during land-clearance, or felled by natural processes or, where the roots had rotted away *in situ*, a 'tree-throw hole/-bole' (*Evans* et al. *1999; Lamdin-Whymark 2008.73–82, Figs. 29–30*). Another two somewhat irregular pits containing small amounts of EN artefacts were cut into the end of ditch terminus F#001 (F#009, F#010, the former cutting the latter). Given that the stratigraphy of F#001 (Fig. 5) suggests the ditch was largely infilled by the Late Chalcolithic/Early Bronze Age (see below), it is highly unlikely that these two features are of EN date. Instead, their contents are likely to be residual, having been disturbed from the lower strata that these pits dug into. If these features are cultural then they should relate to the late 3rd/earlier 2nd millennium cal BC, or later. However, they might be tree-holes.

Remains	F#001	F#002	F#005	F#011
Charcoal (ml)	6.8	2.1	1680	10.05
Triticum sp.		1		1
Cereal grain indeterminate	3	3		1
Corylus sp.	4	3		
Vicia sp.		1		
Veronica sp.	1			5
Galium sp.	4			
Large grass indeterminate				1
Weed indeterminate	3	1		2

Tab. 2. Overview of all plant remains recovered from the 2019 Freston excavation.

Finally, the excavation sectioned a relatively shallow curvilinear ditch (F#014) that ran diagonally (SW-NE) across the bottom half of Trench 1. While only 2.1m wide and 0.12m deep, the geophysical survey detailed that it ran for around 70m in length (*Schofield* et al. *2021.114, 116, Figs. 5–7*). The small area investigated produced only a handful of worked and burnt flint (Tab. 1). Stratigraphically, the geophysics suggests that this feature precedes and is cut by the outer ditch system of the causewayed enclosure. We tentatively suggest that this represents the flanking ditch of a long barrow (burial mound), an argument we return to below.

The pottery

The pottery from Freston has yet to be studied fully, and thus the following details and discussion are preliminary in nature. While the excavation was limited in size, it nonetheless produced a very rich ceramic assemblage of 14.5kg. To appreciate the scale of this dataset we have calculated figures of relative pottery abundance from other East Anglian causewayed enclosure ditches. This was achieved in a crude manner by dividing the mass of ceramic sherds by cumulative ditch-length excavated. Given that the two fully dug Freston ditches (total 6.26m long) are deeper than those at the other sites, the following figures will be somewhat inflated for this site. Similarly, the Freston sample – in terms of ditch length excavated – is relatively small, with no guarantee that the abundance of pottery recovered from the 2019 excavation will be replicated in other ditches, or even the remainder of those part-dug. Nonetheless, these broad-stroke comparisons do allow us to suggest that the Freston pottery assemblage is significantly (≥100×) richer than those from Haddenham, and St. Osyth, and twice as abundant as the largest dataset from Kingsborough (Tab. 3).

Perhaps unsurprisingly, given the volume of soil removed from these features, most of the pottery (99%) came from the two ditch termini of the inner circuit (Tab. 1), while the limited investigation of the outer circuit's terminus (F#004) generated a further 25g. The remaining 62g of pottery came from the palisade trench (F#011), and the two pits F#008 and F#009, though this latter material might be residual from the ditch terminus (F#001) that it cut into. While the pits at Freston have thus far produced only small quantities of sherds, this is not always the pattern documented elsewhere. For example, at St Osyth, 70.5% of the EN pottery (33.3kg) came from such features within the monument rather than the ditches, some of which appear to have been dug specifically for pottery deposits and immediately backfilled thereafter (*Lavender 2007.68, Tab, 17*).

Upon excavation, the pottery was soft and friable, with some sherds having the consistency of wet cardboard. This may be due to the imperfect atmospheric conditions associated with the short, open firings (pits, or bonfires) of EN pottery production in Britain, where the interior of some pots may have reverted to their plastic state (*Gibson 2012.45*). There is also evidence of iron staining on the sides of the ditches, which indicates that the site was periodically waterlogged, so the pottery may have been submerged for significant periods of time. Firing regimes, vessel fragility and post-depositional processes cannot, however, explain the assemblage's overall fragmentation, as it was clear that many of the sherds had been broken prior to their inclusion in the ditch fill.

The pottery from Freston (Figs. 6–7) comprises both plain and decorated vessels consistent with the regional tradition of Mildenhall Ware (*Smith 1956; Clark* et al. *1960*). Typical characteristics of this ceramic style observed within the Freston assemblage are round-based open bowls, simple straight-sided or neutral vessels ('bag-shaped' vessels), 'S'-profiled vessels with or without carinated shoulders, and

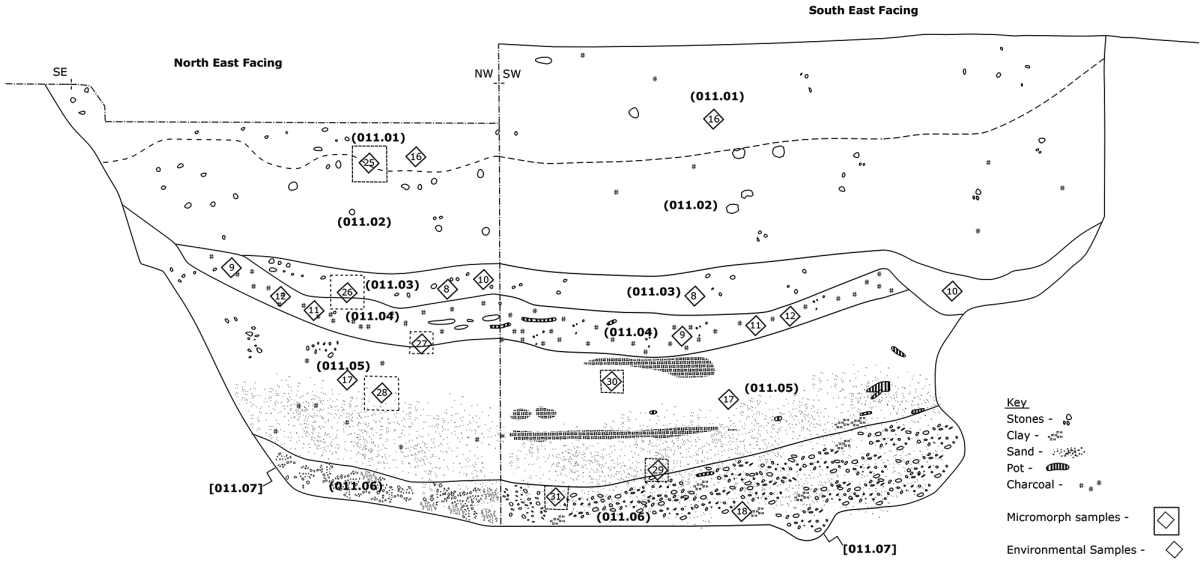
Site	Ditch Length (m)	Pottery (kg)	Richness (kg/m)
Freston	6.3	13.63	2.2
Haddenham	230	3.2	0.01
Kingsborough (K1)	34	35.6	1.05
Kingsborough (K2)	29	7.1	0.24
St. Osyth	180.4	13.7	0.08

Tab. 3. Contrasting relative abundance of pottery from Freston (F#001–F#002) and other East Anglian causewayed enclosure ditches.

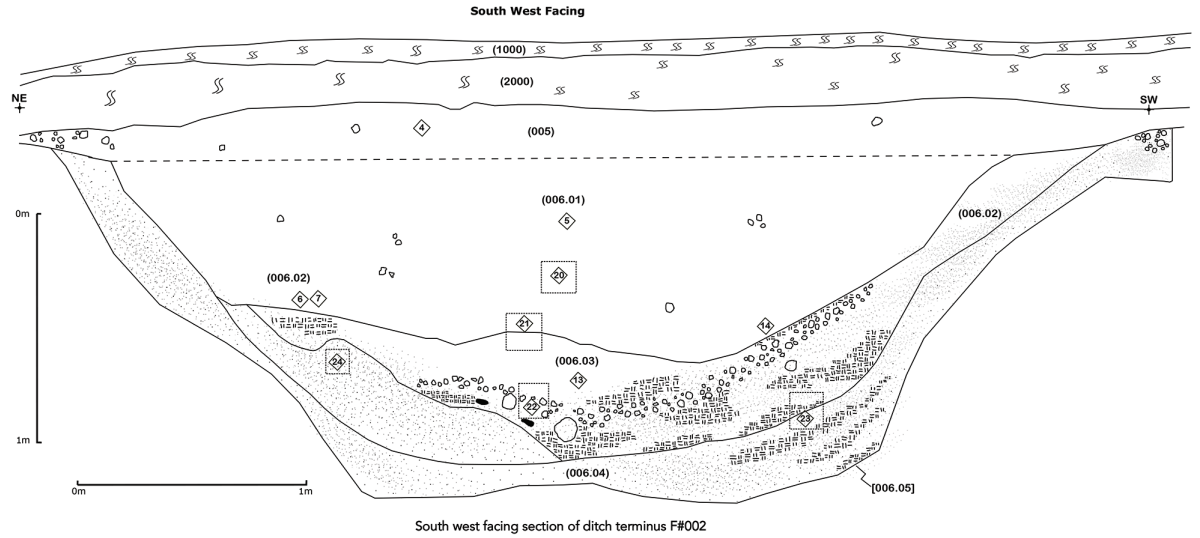
small open forms described as cups (*Knight 2006a. 136, Figs. 14–16*). Rim types are simple, heavy, externally thickened, expanded, and 'T'-shaped, while decorations (Fig. 6.A) – mainly restricted to the rim, neck, shoulder, and upper body – include finger fluting, incised lines (with vertical, diagonal, chevrons and herringbone patterns), and impressed dots (*Clark* et al. *1960.238, Fig. 27*). Construction techniques consist of coiling methods and clay addition to the rims, while surfaces were typically smoothed or burnished (*Pioffet, Ard 2017.13*). At Kilverstone, Mildenhall Ware bowls are reported to range between 11 to 28cm in diameter, with cups defined as *c.* 7cm in diameter; unfortunately, the highly fragmented state of most of these assemblages means that vessel sizes and profiles are often difficult to reconstruct (*Knight 2006b.30*).

While no whole vessels were found, F#002 [006.02] did produce the lower portion of a round-based bowl. It is currently unclear as to whether this vessel was complete when deposited into the ditch; it was placed at the interior edge and the very top of the primary artefact-rich fill [006.03], making it perhaps a closure deposit after the last EN use of F#002. Rim sherds seem to be particularly well-represented in the assemblage; however, further study will see if they were being deliberately selected for inclusion in these ditch fills, a practice previously suggested at the Etton and St Osyth causewayed enclosures (*Lavender 2007.69; Beadsmoore* et al. *2010.121*).

Some sherds have perforations beneath their rims (Fig. 6.B), which are features previously recorded in Mildenhall Ware assemblages (*e.g., Allen* et al. *2008.*



North East and South East facing sections of ditch terminus F#001



South west facing section of ditch terminus F#002

Fig. 5. Sections of ditch termini F#001 and F#002.

69, Figs. 46.29, 47.38; Clark et al. *1960.239–240, Figs. 21, 24; Knight 2006b.37–45, Figs. 2.16, 2.18; Gibson, Leivers 2008.246, Fig. 7*). In cases where the perforations are found in pairs they are interpreted as repair holes (*Cleal 1988.141*), while rows of perforations – as seen on the Freston vessels – are believed to have been used to strain the pot's contents (*PCRG 2010.34*), which in the British EN might relate to dairying practices (*Copley* et al. *2005*). Regarding colour, most sherds are various shades of brown (light reddish to dark brown [Fig. 7]); some have fire-clouded surfaces of soot from being directly exposed to fire. This could indicate that some vessels were used for cooking, though it could also have resulted from the pot directly touching the fuel during its firing (*Gibson 2012.45; Hall 1983.7–10; Orton, Hughes 2013.253*).

The EN pottery of East Anglia was initially grouped with the ceramic traditions of the greater southeastern region of England, referred to broadly as the Windmill Hill Complex, after the eponymous causewayed enclosure in Wiltshire (*Smith 1956.7*). Stuart E. Piggott (*1954.74*) argued that it was possible to observe three regional sub-groups of this tradition, which he referred to as Abingdon Ware (Upper Thames Valley), Whitehawk Ware (South Downs and Sussex coast), and East Anglian Ware (within the Ouse and Colne rivers). Smith (*1954.224*) then proposed the alternate term of 'Mildenhall Ware' for the East Anglian style, named after the type-site at Hurst Fen in West Suffolk, where an abundance of this material was recovered (*Clark* et al. *1960*). Radiocarbon dates associated with Mildenhall Ware assemblages indicate that this pottery style was in use for roughly 230–345 years (68% probability) beginning around 3730–3665 cal BC and ending around 3450–3355 cal BC (68% probability) (*Healy 2013.15, Figs. 1.10, 1.11*).

Those sites that provide Freston with the largest and most comparable assemblages include Hurst Fen, Mildenhall (*Clark* et al. *1960*), Kilverstone (*Knight 2006b*), Reydon Farm (*Harding* et al. *2017*), Spong Hill (*Healy 1988*), as well as Etton, Haddenham and Sutton Gault in Cambridgeshire (*Pryor 1998; Gdaniec 2006; Tabor 2016*). While it remains true that this pottery is associated primarily with the EN sites of East Anglia (including Northamptonshire to the west), ceramic vessels of this type have also been found as far south as Kent (*Allen* et al. *2008.239; Clark* et al. *2019*), plus Derbyshire and the Nottinghamshire/Lincolnshire border to the north (*Healy 1993.114*).

As to the uses of these vessels, Emilie Sibbesson (*2014.286*) argues that most EN pots were used for cooking both plants and animals, and that the types of meals consumed differed by context. Cattle typically dominate the faunal assemblages of causewayed enclosures, with lesser amounts of pig and sheep (*Darvil 1987.89, Tab. E*). The author suggested that larger animals were preferred for feasting events at these gathering places, while conversely, at pit cluster sites one tends to find the remains of smaller domesticated and wild animals (*Sibbesson 2014.286*). Similarly, vessels of different sizes are believed to have served different purposes. The lipid residues of larger vessels showed evidence for the cooking of animal carcasses (possibly in stews), while the residues from smaller vessels contained traces for the making, storing and/or cooking of dairy fats, such as butter (*Copley* et al. *2005.906*). Ultimately, given the various activities performed in different causewayed enclosures, any functional attribution to

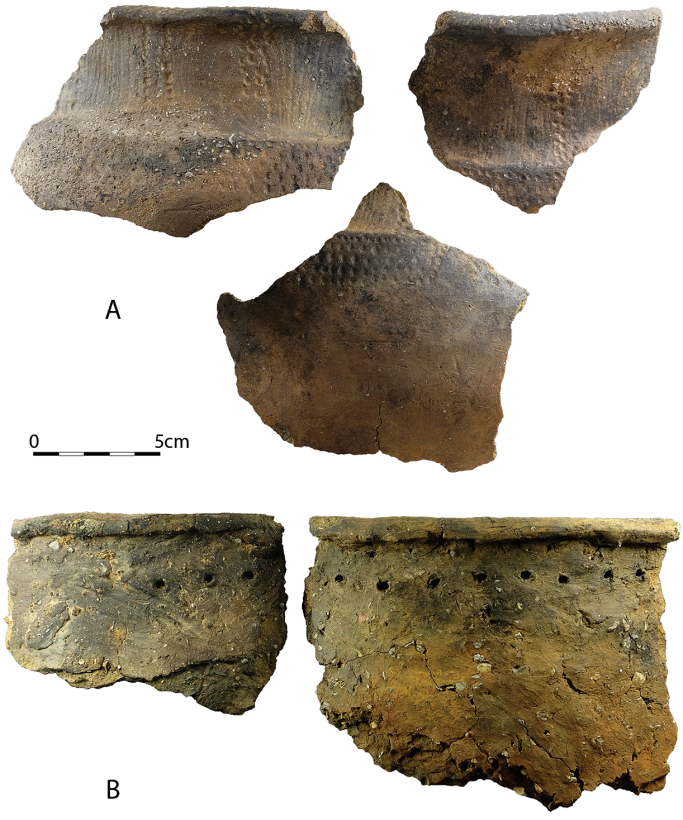


Fig. 6. A Mildenhall Ware vessel with characteristic decoration of incised lines and impressed dots from F#001 (011.04); B Mildenhall Ware vessel with continuous perforations beneath the rim from F#001 (011.04) (Cotswold Archaeology).

the Freston ceramic vessels should be based upon our own residue and contextual analyses.

The flaked stone

The flaked stone assemblage comprised 854 artefacts weighing 5290g, not including the heavy residue component from the water-sieve. As with the pottery, the richest assemblages came from the ditch termini of F#001 and F#002, both in terms of absolute quantity and with reference to the average number of artefacts per litre of soil (Tab. 1, Fig. 9). These artefacts were made almost entirely from flint, the sole exceptions being two quartzite flakes, and two part-cortical pieces of sandstone. The flint ranges in colour from dark grey to black, brown, orange, and honey-coloured, varying from opaque to translucent. The raw material is believed to be primarily local, with rounded flint cobbles a recurrent component of the Lowestoft Formation sands and gravels that underlay the topsoil at the site (*British Geological Society 2020; Rose* et al. *1999*). While most artefacts were quite fresh in appearance, just under a quarter of the assemblage had patinated surfaces (n=204, 24%). This patination may relate to micro-environmental differences in deposition (*Hochella, Banfield 1995*), rather than differences in age, with staining potentially due to some the material having been deposited in standing water within the acidic, iron-rich sands and gravels. In turn, 42 pieces (4.9%) had traces of burning, as evidenced by their reddened colour, pot-lid fractures (Fig. 8.L), and/or crazed surfaces.

The Freston lithics are typical for a southern British EN assemblage in terms of how the flint was worked, the tool-types produced and the blanks they were manufactured upon, with broadly comparable material from both causewayed enclosures, and domestic sites (*Edmonds 1995.35–48, Figs. 15, 19, 23–24; Saville 2002*). The assemblage was blade-based, the blanks percussion knapped on-site, as evidenced by the cores, cortical debris, rejuvenation pieces, and numerous end-products. Of the 54 cores, 17 related to the production of bladelets/blades, most of which were unipolar, though one had a more curved/carinated flaking surface ('Aurignacian-like'). There were also 37 multi-directional flake cores, three of which had originally been used to make bladelets. Rejuvenation pieces from blade/bladelet cores included three core-tablets, plus 31 flakes removed from the working face.

Some 12.5% of the artefacts were deliberately modified (n=107; Tab. 4) using direct and inverse retouch. The dominant forms were those pieces with simple linear retouch (n=58, 54%), followed by: scrapers (n=13, 12% [Fig. 8.L]), notched pieces (n=12, 11%), denticulates/serrated pieces (n=11, 10%), piercers (n=6, 6% [Fig. 8.J]), leaf-shaped arrowheads (n=4, 4% [Fig. 8.A-D]) plus single examples of a backed blade (1%), and a knife (1%). Just over two-thirds of these implements were made on flakes (n=72, 67%), followed by lesser quantities of modified blade-like flakes (n=18), blades (n=10), and bladelets (n=2). There was also a single end-scraper made on a bladelet core. The distribution of blanks by tool-type is detailed in Table 4, which shows that flakes were preferentially selected to make the piercers and all but one of the scrapers. Conversely, most denticulates were formed on blades, or blade-like flakes. The Freston formal tool-types and their relative proportion is broadly comparable to the patterns seen at other causewayed enclosures (*Saville 2002.Tab. 10.1*), where the dominant forms are (in descending order): scrapers, serrated pieces, edge-trimmed flakes, piercers, leaf-shaped arrowheads, and knives (see also *Bye-Jensen 2019. Fig. 215*).



Fig. 7. Mildenhall Ware rim sherds showing various colours and rim types from F#002 (006.03) (Cotswold Archaeology).

While the flint recovered from the pit and ditch fills clearly indicates that stone tools were being made and used at the site, we cannot be certain that this all took place within the causewayed enclosure, as some of the material could be residual and relate to a pre-monument phase of activity (*Saville 2002.91*). As to these implements' functions, recent use-

wear analyses indicates that various tasks relating to the preparation of foodstuffs and craft-working were being undertaken at causewayed enclosures (*Bye-Jensen 2019; Hurcombe 2000*). Scrapers seem to have been multi-purpose tools, employed for working hides, wood, and bone/antler (*Bye-Jensen 2019.261–272, Fig. 212*), while the function of the serrated implements remains uncertain, as the British examples do not display the 'sickle gloss' (*Meeks* et al. *1982*) that one often associates with Neolithic denticulates in continental Eurasia (*cf. Jensen 1988; Unger-Hamilton 1985*). Instead, it has been suggested that they were used for cutting fibrous plants, potentially for making rope, which could have been employed in raising a timber palisade, for example (*Bye-Jensen 2019.59, 261–272, Fig. 212*).

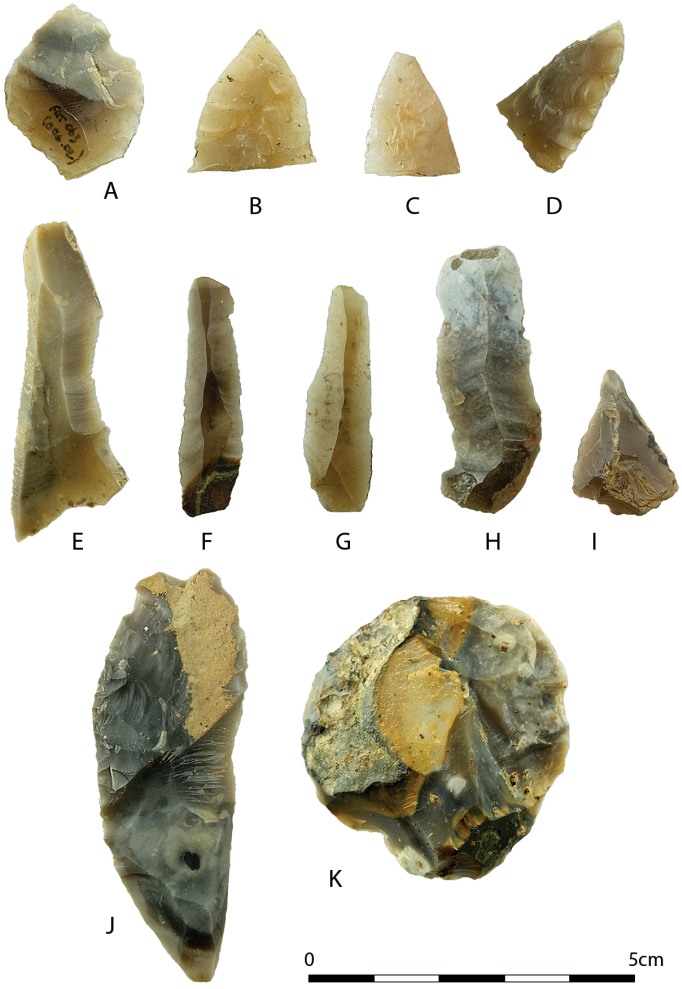


Fig. 8. Worked flint implements from F#001 and F#002:* A-D *leaf-shaped arrowheads;* E *barbed-and-tanged arrowhead;* F *serrated blade;* G-I *blades;* J *piercer;* K *retouched knife;* L *burnt scraper (Cotswold Archaeology).

Particularly distinctive are the four leaf-shaped arrowheads with covering bifacial retouch (Fig. 8.A-D), projectiles long associated with bow and arrow technology (*Clark 1963*). While these weapons were no doubt often employed to hunt wild animals such as deer, aurochs and boar (*Serjeantson 2011.37–47*), there is also good evidence for inter-personal violence in the British EN (*Smith 2013*), with skilled archery likely an emblem of status (*Edmonds 1995.46*), and good evidence for several causewayed enclosures having been attacked by archers. These include Carn Brea (Cornwall), Hembury (Devon), and Hambledon Hill (Dorset), with over 400 leaf-shaped arrowheads associated with the destruction of Crickley Hill (Gloucestershire), while projectiles have been found embedded in human bone at Hambledon Hill, Ascott-under-Wychwood (Oxfordshire), and Fengate (Cambridgeshire), amongst other sites (*Dixon 1979.188; Edmonds 1995.46; Smith 2013.115, 119*).

The Freston worked flint finds good comparanda from East Anglian causewayed enclosures, and pit cluster sites alike. The former includes Etton, Great Wilbraham and Haddenham in Cambridgeshire (*Evans* et al. *2006.130–134, Figs. 12–13; Middleton 1998; 2006*), plus St. Osyth and Orsett in Essex (*Hedges* et al. *1978.255–259; Martingell 2007*), the latter comprising Hurst Fen and Reydon Farm, Suffolk (*Clark* et al. *1960.214–224, Figs. 7–16; Harding* et al. *2017.9–11, Fig. 4*), Kilverstone, and Spong Hill Norfolk (*Beadsmoore 2006; Healy 1988*), and the Stumble, Essex (*Holgate 2012*). When one contrasts the average number of flaked flints per metre of excavated ditch from the 2019 excavations with the figures from Haddenham and the two Kingsborough causewayed enclosures (Tab. 5), we gain the impression – highly provisional – that the Freston termini are much richer, to the factor of at least six times.

While most of the flaked stone dates to the EN, the uppermost fill of F#001 (011.01) produced a complete barbed-and-tanged arrowhead (Fig. 8.E), a type associated with the Chalcolithic – Early Bronze Age in southern Britain (*Edmonds 1995.143–145; Green 1980.117–144*). This projectile most closely resembles earlier variants, being under 3cm long, and with short barbs (≤7mm long), arguably closest to Type 32 in the recent typo-chronology of Nicolas (*2017.257–259, Fig. 11, 257*), which are generally dated to Period 2 as defined by Needham (*2012*),

c. 2300–1950 cal BC. That said, one can also find slightly earlier (Period 1, *c.* 2450–2300 cal BC) parallels from the well-known Chalcolithic 'Amesbury Archer' burial near Stonehenge in Wiltshire (*Harding 2011.90–91, 99–101, Fig. 30* [*e.g., 6712*]). Closer to Freston, a comparable arrowhead is reported from West Row Fen (*Martin, Murphy 1988*), an Early Bronze Age settlement on Suffolk's fen-edge, a site that has produced both Beakers and later Collard Urns (E. Martin pers. comm.).

Tool	Total	%	Flake	Blade-Like Flake	Blade	Bladelet	Core	Unknown
Retouched piece	59	55	42	12	4	1		
Scraper	13	12	12				1	
Notched piece	12	11	9	2		1		
Denticulate	11	10	2	4	5			
Piercer	6	6	6					
Leaf-shaped point	5	5	1					4
Backed piece	1	1			1			
Totals	**107**	**100**						

Tab. 4. Flaked stone retouched tool types and blank choices from the 2019 Freston excavation.

Alongside the 42 flaked stone artefacts with traces of burning, the excavation also generated 1004 pieces of unworked burnt flint weighing 10.73kg, the bulk of which again came from the ditch termini, albeit with a significant bias towards F#001 (Tab. 1, Fig. 9). Such material is recurrently documented at EN sites in the region (*e.g., Evans* et al. *2006.Tab. 3; Harding* et al. *2017.9*), not least the pit cluster site of Kilverstone which produced 46.88kg of burnt flint (*Garrow* et al. *2005.145, Tabs. 1–2*). Flint may have been collected to be heated on fires for use as pot-boilers for cooking (*cf. Thoms 2008*), the material then being swept up with other burnt debris and dumped into the ditch termini or pits. One such example is F#005, which produced 49 pieces plus notable quantities of charcoal (Tabs. 1–2). Although the excavation produced no polished stone artefacts, axes made of both local and exotic raw materials have been recovered as surface finds from the site (J. Marriot and S. Plowman pers. comms.), and within the parish (*FRT 058 2020*).

Subsistence and environmental data

No animal or human remains were recovered from the 2019 excavations. While in theory the lack of bones might be due to differential depositional practices (*cf. Evans, Hodder 2006.325–329*), *i.e.* they were being buried elsewhere, it is more likely that such material simply did not survive due to the high soil acidity. Alas, this is an all too common problem for sites in this sandy region (*cf. Bethell, Carver 1986; Harding* et al. *2017.3*). Indeed, a recent survey of animal exploitation in Early-Middle Neolithic Britain included no faunal assemblages from east of the East Anglian Chalk ridge (*Serjeantson 2011.Fig. 1.1*). As such, we can currently say nothing about on-site meat consumption or the pastoral regimes of those visiting the monument. Ultimately, it might be necessary to analyse residues from the pottery (*Copley* et al. *2005; Reber* et al. *2019*) or try to extract ancient DNA from the soil (*Smith* et al. *2015*).

The archaeobotanical remains recovered from the 2019 season comprise four main categories, namely: (i) cereal grain material, (ii) *Corylus* sp. (hazelnut) shells, plus (iii-iv) the remains of several weed/wild taxa (Tab. 2). Overall, the densities of plant material were low with an average of 0.31 items/litre of soil. This is not unusual for British Neolithic sites (*Jones, Rowley-Conwy 2007.399–400*) and may be due to various taphonomic issues, not least the soil acidity. The identification of *Triticum* sp. (wheat) grains and *Corylus* sp. (hazelnut) remains are typical for a site of this period, with both clearly important components of human diet throughout EN Britain (*Treasure* et al. *2019; Wilkinson* et al. *2012*), with the latter being one of several wild resources that continued to have been exploited from the Mesolithic (*Ray, Thomas 2018.59–60*). Hazelnut shells dominate many British EN assemblages (*Stevens 2007.377; Treasure* et al. *2019.199*), likely due to their durability, especially when charred, which they often seem to have been either from intentional actions (cooking, kindling) or through accidental exposure to fire (*Jones, Rowley-Conwy 2007.400–401*).

It has long been debated as to why so few cereal remains have been recovered from these sites. Some suggest that to all intents and purposes the subsistence practices of the British EN were "*still formally Mesolithic*", with cereals initially having more of a symbolic significance than economic, being that they were consumed in primarily ritual contexts – such as causewayed enclosures – rather than domestic spaces (*Thomas 1993.388*). This view has since

Site	Ditch Length (m)	Worked Flint (n)	Richness (n/m)
Freston	6.3	720	114
Haddenham	230	474	2
Kingsborough (K1)	34	588	17
Kingsborough (K2)	29	144	5

Tab. 5. Contrasting relative abundance of worked flint from Freston (F#001–F#002) and other East Anglian causewayed enclosure ditches.

been challenged by Jones and Rowley-Conwy (*2007.399–407, Tab. 23.1*), who argue that (a) the rarity has been over-stated (see also *Treasure* et al. *2019.213*), (b) cereals will be underrepresented in EN assemblages because people would have avoided charring them thus decreasing their survival in the archaeological record, and (c) proxy isotopic data from human remains clearly indicates regular cereal consumption. Overall, the evidence suggests that while cereal cultivation and consumption were relatively widespread in Britain from the Earliest Neolithic, it was only in the Middle Bronze Age (mid-2nd millennium cal BC) that agriculture came to play a major subsistence role (*Stevens, Fuller 2012*).

While cereals are now attested from various EN domestic contexts, it remains the case that their consumption formed part of the activities taking place at causewayed enclosures, some of which may be more special or ritual in character (*Jones, Rowley-Conwy 2007.407–408*). At Freston the material thus far derives primarily from the two ditches (n=7/9 samples), with the palisade trench (F#011) producing the only other two cereal grain remains (Tab. 2). Concentrations of cereal remains – along with pottery, bone and lithics – from ditches at Windmill Hill are suggestive of deliberate deposition (*Fairbairn 1999.149, Fig. 107*), as are the notable quantities of charred cereal grains from pits dug into the enclosure ditches at Haddenham (*Jones 2006.314–315, Tab. 5.28*). Unfortunately, the meagre quantities of material documented in Table 2 do not allow us to currently put forward a similar hypothesis for the Freston charred plant assemblage. In turn, it is quite apparent that cereals can be recovered from a variety of contexts at these sites, with the character of assemblages attesting variously to bulk processing, food preparation and discard (*Jones, Rowley-Conwy 2007.407–408*). Hazelnut shells were also recovered from the ditch termini at Freston (Tab. 2), for which we have contextual parallels from Etton, Haddenham and Hambledon Hill, though notable concentrations of Corylus avellana are also recorded from hearth and pit contexts at the same sites (*Jones 2006.314, Tab. 5.28; Jones, Legge 2008; Nye, Scaife 1998.292–293, Tabs. 66–67*).

Focusing on the charred plant remains recovered from EN sites closest to Freston (Fig. 2), we again see clear evidence for mixed economies of cultivated and wild resources. The Kilverstone pit clusters produced *Triticum dicoccum* (emmer wheat) and *Hordeum* sp. (barley) alongside potential weeds of arable cultivation, and significant quantities of hazelnuts (*Ballantyne, Roberts 2006.71*). Meanwhile at The Stumble, identified crop remains are dominated by emmer wheat, with small quantities of *Triticum aestivum/durum* (free-threshing wheat) and *Triticum monococcum* (einkorn wheat), along with abundant hazelnut remains and smaller quantities of fruits, roots, rhizomes and tubers (*Wilkinson* et al. *2012.70–91*). At Spong Hill, impressions of grain and spikelet fragments of wheats, including emmer (*Triticum dicoccum*), plus a single example of barley, were documented on sherds of Mildenhall Ware, while flotation yielded wheat chaff and hazelnut shells (*Murphy 1988.103*). At Hurst Fen and Reydon Farm the archaeobotanical remains were almost exclusively composed of charred hazelnut shells, though

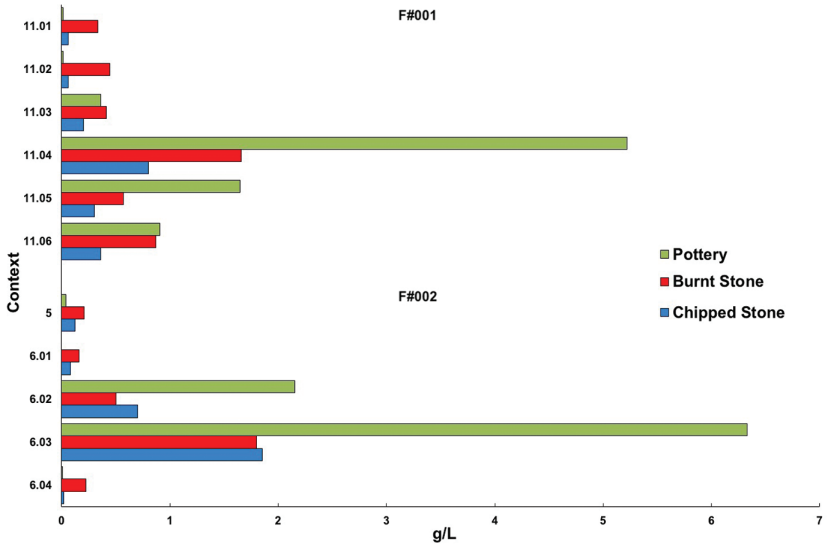


Fig. 9. Quantification of the main artefact types from the two Freston ditch termini (F#001, F#002) by stratigraphic layer (data from Table 1).

grain imprints on pottery attest to the presence of emmer and barley at the former site, while the latter produced evidence for emmer and/or *Triticum spelta* (spelt) (*Clark* et al. *1960.213, Pl. XXV; Wyles 2017.11–12*).

Whether the plant remains from the Freston causewayed enclosure are the result of ritual burning, the deliberate deposition of domestic waste, or aeolian transported material, remains an open question for now. Ideally, further work will produce greater quantities of archaeobotanical material allowing it to be more securely situated within the British Neolithic agricultural economy and the exploration of questions regarding 'ceremonial' vs. 'domestic' plant use.

Of the weed/wild taxa recovered, *Veronica* sp. (speedwell) and *Galium* sp. (bedstraw) are typical of cultivated or waste ground habitats (*Stace 2010*); the low numbers recovered, however, prevent species identification. Wood charcoal was also recovered from every Freston sample (Tab. 6) and was present in variable quantities, ranging from 0.1 to 1680ml (Tab. 3). Most of the charcoal was identified as *Quercus* sp. (oak), with additional identifications of *Alnus glutinosa* (alder), *Betula* sp. (birch), *Corylus avellana* (hazel), Maloideae (hawthorn, apple, whitebeams/rowan *etc*.) and a single fragment of *Ulmus* (elm) or *Cytisus/Ulex* (broom/gorse). The condition of the charcoal was generally poor, with strong occlusions of sediment and, in some cases, iron and vivianite staining, which is characteristic of deposition in seasonally waterlogged environments. These conditional elements hampered identification to species level and the determination of maturity in oak. Where possible, maturity was assessed by the presence of roundwood (evidence for bark, pith or strong ring curvature) and presence or absence of tyloses in oak, which indicates heartwood or sapwood, respectively. A suite of eight short-life samples – mainly *Quercus* (sapwood and roundwood) and *Corylus* – from the two ditch termini (F#001, F#002) and the palisade trench (F#011) have been selected for radiocarbon dating.

While some of the charcoal might represent windblown and waste material accumulated in the ditches during the monument's lifetime, the >1.5 litres from pit F#005 (Tab. 2) suggests the deliberate dumping of charred material, perhaps from a hearth. Oak provides a highly calorific fuelwood that is suitable for most activities, including cooking, pottery firing (*cf. Ali 2015; Campbell 2007; Murphy 2001*), and cremation (as at Etton [*Nye, Scaife 1998.298, Tab. 71*]). Oak-based fuelwood was also found to be the predominant taxon in the charcoal assemblages from the Kingsborough causewayed enclosure (*Gale 2008*).

Conclusion

In conclusion, the results of the 2019 excavation have clearly determined that the Freston interrupted ditch system is an EN causewayed enclosure, as evidenced by the chronologically diagnostic ceramic and lithic assemblages. While we await the radiocarbon determinations, a date for the site can be hypothesized with reference to established chronologies for the local EN pottery tradition, and the model for causewayed enclosure development across southern Britain. Mildenhall Ware, which is present in the basal layers of both ditch termini (almost a kilo in F#001), is estimated to have been produced in East Anglia from 3730–3665 cal BC to 3450–3355 cal BC, a range of 230–345 years (all dates expressed as 68% probability [*Healy 2013.14–16, Tabs. 11.1–11.2*]). The only two radiocarbon dates from an EN context in Suffolk derive from a pit containing Mildenhall Ware at Reydon Farm, which at 3710–3640 cal BC (at 95% probability) falls within the established range of this pottery tradition (*Harding* et al. *2017.13, Tab. 6*). Further chronological resolution is provided by Whittle, Healy and Bayliss (*2011.263–347, Fig. 6.1*) via their evaluation of radiocarbon dates from the causewayed enclosures of Eastern England closest to Freston (Fig. 2). Their findings suggest that these monuments may have all been constructed in the 37th century cal BC, including Etton, Haddenham and Northborough in Cambridgeshire, and St Osyth in Essex.

What is much less clear is how long the monument at Freston was maintained and used as a formal gathering place. The range of dates for causewayed enclosures elsewhere in Britain spans from 300 years to as short as a few decades (*Whittle* et al. *2011.xi*). Both inner ditch termini appear to contain significant amounts of material culture that relate to at least two depositional events prior to the site's abandonment. Neither of the ditches showed evidence of recutting, which suggests that they were left open throughout their use. However, the depth of the artefact-rich deposits varies between the ditches, with (F#001) being 2.43m deep and having close to a metre of material culture, while (F#002) is 2m deep and has about 50cm of anthropogenic fill. The pottery was concentrated within the lower strata of the ditch fill, with F#001 [011.04] and F#002 [006.03] having the richest assemblages (Tab. 1, Fig. 9), po-

tentially the refuse from group feasting (*cf. Smith 1965.19*). Conversely, the upper fills of the termini contained very few artefacts, perhaps due the site being abandoned at which point the ditches silted up naturally or were deliberately backfilled and the banks levelled (*cf. Smith 1965.15–18*). Alternatively, the lesser quantities of finds in these uppermost strata might be due to changes in depositional practice, with material culture being dumped somewhere else on the site. Ultimately, we hope that the integration of radiocarbon dates with the micromorphological studies will detail the temporal depth and character of these ditch infill sequences (*cf. French 2006*).

It is suggested tentatively that the Freston enclosure was abandoned *within* the EN, or more specifically the period we associate with the Mildenhall Ware tradition (before the 35th–34th centuries cal BC [*Healy 2013.15*]), as we have yet to recognize any examples of Peterborough or Grooved Ware vessels, *i.e.* products of the Middle and Late Neolithic, respectively (*Gibson 2011.78–87; Thomas 2010; Worley* et al. *2019.2*). This statement should however be tempered by an acknowledgement that the 2019 excavation exposed only a *tiny* area of the monument, a mere ~2.2% of its ditch system and the pottery has not yet been studied intensively. Indeed, there is a great deal that remains to be clarified concerning the site's establishment, development and abandonment more generally. For instance, it cannot be assumed that the two ditch systems and palisade were all built at the same time (*cf. Oswald* et al. *2001.75–77*), with the latter feature potentially relating to a later, more defensive reconfiguration of the site. This is something we see at other causewayed enclosures, such as Crickley Hill in Gloucestershire (*Dixon 1979*), and the Stepleton enclosure on Hambledon Hill (*Mercer, Healy 2008.760–761*).

Context	Description	Identifications
F#001 (011.03)	Ditch terminus	*Quercus* x 1 (cf. sw)
F#001 (011.04)	Ditch terminus	*Quercus* ++ (hw)
F#001 (011.06)	Ditch terminus	*Quercus* x 4 (hw); *Corylus* x 1
F#002 (006.01)	Ditch terminus	*Ulmus* or *Ulex/Cytisus* x 1, *Quercus* ++, *Alnus/Corylus*+
F#002 (006.02)	Ditch terminus	*Quercus* ++ (cf. sw), *Quercus* ++ (cf. sw, hw), *Betula* sp. +
F#002 (006.03)	Ditch terminus	*Quercus* +, *Alnus* +, Maloideae +
F#002 (006.04)	Ditch terminus	*Alnus/Corylus*++, *Quercus* + (hw), *Corylus* x 1
F#005 (007.01)	Pit	*Quercus* +++ (hw + burr), *Alnus/Corylus*+
F#011 (019.01)	Palisade trench	*Quercus* x 17 (hw), *Quercus* ++/+ (sw)

Tab. 6. Overview of the charcoal recovered from the 2019 Freston excavation.

Nor is the relative date of the pits clear; they could be associated with a pre-enclosure phase of settlement and/or pertain to activities that took place during or after the monument's life.

Another major question concerns the existence of any significant pre-enclosure activity, and the reasons as to why the site was originally established at this location. Starting with the latter issue, it is suggested above that the spring was the monument's central feature, both physically and spiritually. Planned excavation and palynological coring at the spring will hopefully provide us with more insight as to whether the site was established and cleared by incoming agro-pastoralists or if it represents the appropriation of a culturally significant place of an indigenous hunter-gatherer population. In turn, aerial photography and geophysical survey have revealed traces of two features at the site that *might* represent Neolithic activity that pre-dates the causewayed enclosure. These comprise the potential longhouse in the monument's northeast quadrant (Fig. 3), and a possible long barrow ditch that appears to be cut by the enclosure ditches of the southeast quadrant (*Schofield* et al. *2021.116, Fig. 7*). Aside from the potential stratigraphic relationship of the latter feature, both structures are associated primarily with the first centuries of the 4th millennium cal BC, *i.e.* the Earliest Neolithic phase that precedes the era of causewayed enclosures (*Bayliss* et al. *2011. 719–724; Ray, Thomas 2018.114–122*).

By the Late Chalcolithic/Early Bronze Age (later 3rd-earlier 2nd millennium cal BC), we believe that the enclosure had been long-abandoned and the ditches naturally infilled by silt, hence the fact that the barbed and tanged arrowhead was recovered from the uppermost fill of F#001. The nature of this later activity at the site remains unclear, although another projectile of the same type was found in 1985 on the ground above the ancient ditches (*HER FRT 005 2021*). We further note the traces of four ploughed-out round barrows of likely similar date *c.* 625m east of the monument suggest that there was a 'Beaker Culture' settlement nearby (*Historic England 2015*). With Beaker pottery having been recovered in the upper levels of ditches at several other causewayed enclosures

(including Etton, Hambledon Hill, Maiden Castle and Windmill Hill), this suggests that the Late Chalcolithic/Early Bronze Age human presence at Freston formed part of a larger cultural tradition of engaging with these ancient spaces (*Oswald* et al. *2001. 137–139; see also Kinnes 2006*).

Looking ahead, one of the key research interests concerns how many groups of people gathered here, and where they came from. With the monument notably larger than some of the East Anglian causewayed enclosures (8.55ha), such as Etton (>3ha) and Great Wilbraham (2.5ha) (*Evans* et al. *2006; Pryor 1998*), might it follow that Freston was constructed by a greater number of people who came together from a wider area? While isotopic studies of faunal and human remains have been used to help reconstruct the catchment areas for causewayed enclosures and later Neolithic henges (*Evans* et al. *2019; Madgwick* et al. *2019; Neil* et al. *2018*), at Freston it may be necessary to focus on sourcing the pottery and lithic assemblages to generate such information, given what appears to be the poor bone preservation at the site. The ceramic vessels may also provide evidence for the plants and animals consumed on site, by way of the organic residue analysis of the macroscopic encrustations recorded on the interior of several sherds on their interiors (*Copley* et al. *2005*), matter that can also be employed for short-life radiocarbon dating (*Berstan* et al. *2008; Casanova* et al. *2020*). In turn, use-wear studies of the worked flint can help reconstruct other activities performed at the site, with woodworking, textile manufacture, and food preparation all documented previously at such sites (*Bye-Jensen 2019*).

Ultimately, the project aims to take a long-term perspective on the Mesolithic-Neolithic transition in Suffolk, as a means of contributing to larger debates regarding the dynamics of 'Neolithisation.' Such investigations would engage with the emergence of new ontologies involved as much as shifts in subsistence bases and the organization of production (*cf. Thomas 1988.63–64*). While Mesolithic activity in the county is relatively well documented, including a few surface finds from the Shotley peninsula (*Wymer 1999b*), we have few absolute dates for this period. Furthermore, those sites that do have radiocarbon determinations are significantly earlier than the late 5th/early 4th millennium cal BC (*Jacobi 1984; Wymer* et al. *1975*), *i.e.* the period when we might have the interaction between indigenous hunter-gatherers and incoming farmers (*Brace* et al. *2019*). At Freston it is hypothesized that the causewayed enclosure's spring-based location *might* attest to an appropriation of indigenous landscape uses and cosmologies (*cf. Davis 2012; Jacques* et al. *2014; Tilley 1996.65*), while hazelnut consumption and pitting can also be suggested as practices that have their heritage in local Mesolithic traditions (*Milner 2009; Overton, Taylor 2018*). In turn, the longhouse *might* relate to the phase of Earliest Neolithic colonisation, prior to the construction of the causewayed enclosure. Overall, there remains much to be clarified, hopefully in the forthcoming excavation seasons.

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Radiocarbon dating of Holocene archaeological sites in the Far Northeast of Europe: scopes and limits of a supraregional database

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ABSTRACT – *The paper is devoted to the critical analysis of the radiocarbon dating results of Mesolithic, Neolithic and Chalcolithic complexes of the northeastern part of the East European Plain (Republic of Komi, Arkhangelsk and Vologda Regions and the Nenets Autonomous Area, Russian Federation). The comprehensive evaluation of all available geochronometric data in relation with the studied archaeological events highlighted the following three data sets: reliable, ambiguous and invalid dates. A new chronological model of Far Northeast of Europe colonization and dispersal of innovations over the Holocene is proposed based upon reliable radiocarbon dating results.*

KEY WORDS – *Mesolithic; Neolithic; Chalcolithic; Northeastern Europe; radiocarbon dating*

Radiokarbonsko datiranje holocenskih arheoloških najdišč na skrajnem severovzhodu Evrope: obseg in omejitve nadregionalne baze podatkov

IZVLEČEK – *Članek je posvečen kritični analizi rezultatov radiokarbonskega datiranja mezolitskih, neolitskih in halkolitskih kompleksov iz območja severovzhodnega dela Vzhodnoevropskega nižavja (Republika Komi, regiji Arkhangelsk in Vologda ter avtonomno okrožje Nenets, Ruska federacija). S celovito oceno vseh razpoložljivih geokronometričnih podatkov, v povezavi s preučenimi arheološkimi dogodki, izpostavljamo naslednje tri podatkovne zbire: zanesljive, dvoumne in neveljavne datume. Na podlagi zanesljivih rezultatov radiokarbonskih datumov predlagamo nov kronološki model kolonizacije raziskovalnega območja in razpršitve inovacij v holocenu.*

KLJUČNE BESEDE – *mezolitik; neolitik; halkolitik; severovzhodna Evropa; radiokarbonsko datiranje*

Introduction

The majority of researchers use instrumental methods of dating to determine the timing of archaeological events. However, the possibilities for applying them are far more comprehensive, and we suggest that they should become part of the critique of archaeological evidence and independent expertise for ideas relating to prehistory. Meanwhile, as users of external data, the archaeologists must have confidence in their reliability, which must be proven.

Many studies are devoted to this problem where researchers propose criteria for objective evaluation of radiocarbon age determinations of archaeological events. Since the problem was first raised in 1971 (*Waterbolk 1971*), researchers have attempted to improve the accuracy of such estimations and adapt the criteria for the study of materials of specific regions and periods (*Rick 1987; Spriggs 1989; Pettitt 2003; Graf 2009; Seitsonen* et al. *2012*). However, in Rus-

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sian archaeology, noteworthy studies in this direction are poorly represented (*i.e. Kuzmin, Tankerslay 1996; Kuzmin, Keates 2005; Kuzmin 2009; 2010; Seitsonen* et al. *2012; Zazovskaya 2016*), and for some regions and periods are completely absent. Although sequences of dates are published regularly, the primary reaction to them is blind faith in the numeric values obtained by scientific methods and an unfounded, often emotional conclusion about the correspondence or inconsistency of new data with archaeological concepts: 'good or bad', 'acceptable or unacceptable' dates. The dated material goes through a complicated path with obvious and uncertain influences from prehistoric individuals to the ^{14}C date, so the rationale for the result should be complex, considering all determinable factors (see below for details).

In this work, we have turned to identify opportunities and restrictions of radiocarbon dating of Holocene materials from the Mesolithic to the Chalcolithic in the Far Northeast of Europe (hereafter FNE). Archaeological periods are defined according to Russian (Soviet) research traditions and current regional data. The beginning of the Mesolithic is associated with the formation of modern postglacial landscapes (around 11.7 ka BP); the Mesolithic/Neolithic boundary is marked by the spread of pottery (early 6th millennium BC), and the Neolithic/Chalcolithic by the appearance of the early copper artefacts and their processing (around the 3rd millennium BC).

Our research aims to determine how reliable radiocarbon dating results are for improving the quality of our archaeological evidence and the amount of information it can provide. Such work that can lead to general conclusions is relevant, since it helps arrange the available data better. Moreover, it indicates directions in which we can conduct further studies regarding the use of geochronometric methods in archaeology and the interpretation of their results.

The objectives of this research are as follows: a review of the history and special features of the use of radiocarbon dating in regional studies; the collection and systematic organization of the available data and their evaluation. In order to determine specific regional variations regarding the use of radiocarbon dating for the Holocene archaeological sites, we have formulated answers to the following questions: (i) which materials are available for dating, and what has been dated?; (ii) what factors affect the reliability and accuracy of the data?; (iii) which results have been obtained, and how far do they correspond to archaeologists' ideas and data obtained using other natural sciences?; (iv) how do archaeologists interpret these dates?

Geographical and historical backgrounds

The territory under consideration includes the following regions of the Russian Federation: the Komi Republic, the eastern part of the Arkhangelsk Region, and the Nenets Autonomous Area. To extend the factual basis of our research, we also use data from the regions adjacent to the territory mentioned above, particularly the northeastern part of the Vologda Region (Fig. 1). The approximate area of the region under study is 700 000km^2.

The FNE is a territory between the Barents and White Seas, the Ural Mountains, the Northern Hills, and the Severnaya Dvina River's right bank. The northernmost part of the region is located in the tundra zone; the southern part is confined to the northern and middle taiga. Geomorphologically, most of the region is located in the northeast of East European Plain, while the foothills of the Ural Mountains represent its eastern edge.

The known archaeological assemblages are found exclusively in the taiga zone, occupied predominantly by primary forests (about 60%), bogs (about 14%) and a dense river network of three river basins: the Pechora, the Mezen and the Severnaya Dvina with the Vychegda, but very few lakes. The total area of the lakes is 450 000 hectares, which is 0.1% of the entire territory of the region.

According to the palaeogeographic data, during both Boreal and Atlantic periods the FNE was a part of the dark-coniferous taiga, and only the boundaries of landscape subzones – middle and southern taiga (*Nikiforova 1982.154–162*) – shifted, or the vegetation cover structure changed mainly due to quantitative redistribution within the coniferous species group (*Smirnova 1971*). For detailed information on the relationship between FNE Mesolithic colonization and the natural environment (see *Volokitin, Gribchenko 2017.75–104*).

In recent years, an interdisciplinary study has shown that the surfaces occupied by archaeological sites result from the impact of winds in the river valleys (*Karmanov* et al. *2013*). Aeolian ridges and fields cover the alluvial landscape and bedrocks, either flattening them or elevating the relief of floodplain ridges and levees while creating new dunes and deflation hollows.

The relief was formed in the Late Glacial and Early Holocene (*Zaretskaya* et al. *2014; Karmanov* et al. *2013*), but active geomorphological processes – erosion and alluvium accumulation – continue in the river valleys. As a result, the aeolian forms composed of loose sands are covered by poorly developed forest litter with reindeer lichen (*Cladonia rangiferina*) or green mosses (indefinite species) and occupied by pine forests. The choice of such landscapes as the most comfortable habitats and burial grounds is characteristic for the entire Holocene.

Archaeological evidence is confined to modern soil profiles, specifically to Albic Podzols (*World Reference Base Soil Resources 2006*). Back in the mid-1970s, soil scientists identified the features of their structure, properties and regimes (temperature, hydrological, redox, and nutritional) and gave their genetic characteristics (*Zaboeva 1975*). Later, researchers identified the mechanisms of the related physical, biochemical, and chemical processes; formation of soil structure; humus substances; organic-mineral complexes; mechanisms underlying the variability of soils in time and space (*Lapteva* et al. *2016. 26, 27*), and created the Atlas of Soils of the Komi Republic (*Atlas pochv Respubliki Komi 2010*). There is thus an exhaustive characterization of the initial natural state of deposits.

In our case, there are only five exceptions out of 200 sites, namely Vis 1 peat bog, Parch 1 and 2, Vylys-Tom 2, and Pezmog 4. Their cultural layers lay at different levels under alluvial deposits. Of course, there could have been more such sites, but the constant migration of river channels has left them with little chance of preservation. However, it undoubtedly affects our perceptions of the choice of habitat and habitation in prehistory.

At present, the known Mesolithic, Neolithic and Chalcolithic assemblages are represented mainly by campsites and settlements and only three burials (*Karmanov 2020*). The most informative sites including those discussed in this article are the remains of hunting campsites and subterranean dwellings, *i.e.* places where small and disparate population groups lived on a short-term basis (*Stokolos 1986; 1997; Volokitin 1997; 1999; 2003; 2004; 2006; Karmanov 2008; 2012*). This means that their impact on the sedimentary strata was insignificant and explains why the earthen structures and their components at such sites were temporary. In addition, the high mobility of small groups of people over a wide area gave rise to flexibility in diet and the use of materials for different needs. However, on the other hand, the short 'lifetime' of the studied sites and dwellings increases the likelihood that the dated materials are

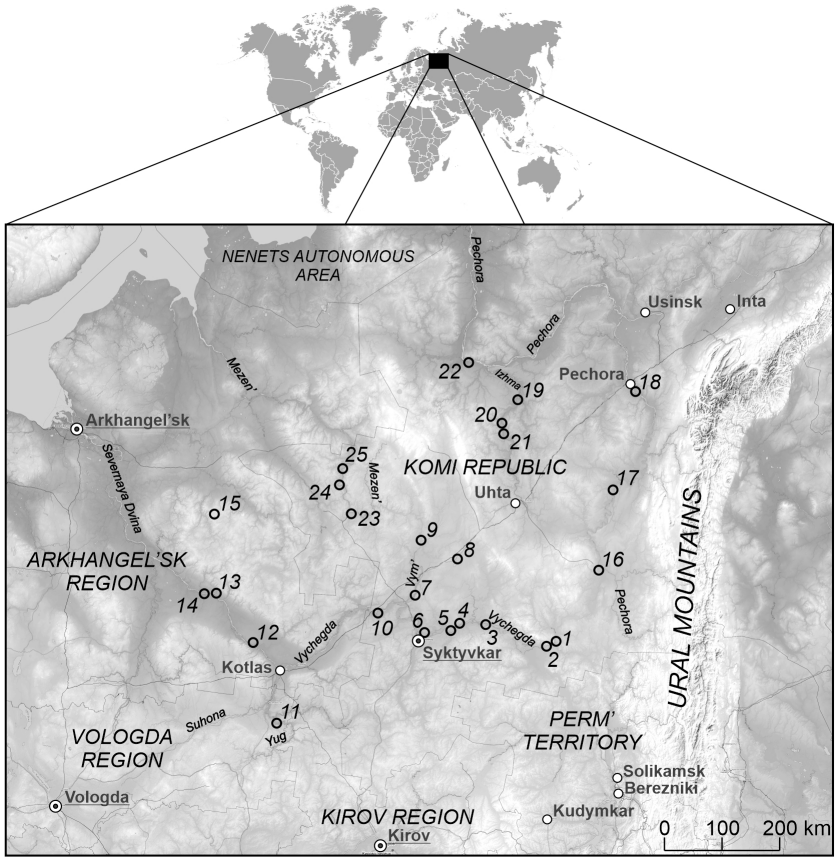


Fig. 1. European Far Northeast; distribution of sites mentioned in the text:* 1 *Cherdyb 1, Cherdyb 2;* 2 *Parch 1, Parch 2;* 3 *Podty 1;* 4 *Ugdym 1A, Ugdym 1D, Chertas 2;* 5 *Pezmog 4,* 6 *En'ty 1A, Vadnyur 1/5; Vadnyur 1/7A;* 7 *Niremka 1;* 8 *Vis 1 peatbog, Vis 2;* 9 *Yovdino 2/4;* 10 *Revyu 1;* 11 *Pavshino 2;* 12 *Prilulkskaya;* 13 *Chernaya Rechka 1;* 14 *Yumizh 1;* 15 *Yvron'ga 1;* 16 *Martyushevskoe 2/1, Martyushevskoe 8;* 17 *Dutovo 1;* 18 *Topyd-nyur 7a;* 19 *Lasta 8;* 20 *Lek-Lesa 1;* 21 *Vylys-Tom 2;* 22 *Shihovskoe 2/2;* 23 *Choynovty 2, Choynovty 1;* 24 *Oshchoy 5/3;* 25 *Muchkas. Based on OpenTopoMap available at https://opentopomap.org

associated with one phase of habitation and are not a mixture of remnants of asynchronous events.

The small number and low density of the mobile FNE population hampered the long existence of cultural traditions here. In addition, these traditions originated in adjacent territories. This allows us to apply the principle of synchronization of similar phenomena in prehistoric cultures for an approximate determination of their age. However, the regions of Northern Eurasia have been studied unevenly and the chronology of cultures has been developed to different degrees. In this way, ^{14}C dating is useful for verifying archaeological reconstructions.

The history of radiocarbon dating in the context of archaeological investigations

Radiocarbon dating began to be used in the FNE at the end of the 1960s. In particular, it was promoted by the field-research department of the Institute of Archaeology, affiliated with the USSR Academy of Sciences, which assessed a report by Grigoriy M. Burov on excavations carried out in 1961. The Commission responsible for field research departments 'decided to advise' him to send wooden artefacts found in the Vis 1 peat bog site "*for radiocarbon analysis to the laboratory of the Leningrad Branch of the Institute of Archaeology of the Academy of Sciences*" (*Burov 1962*). As early as 1972, Burov – together with the Leningrad Branch staff members mentioned above – published a series of radiocarbon dates from the Vis 1 and Marmugino peat bog sites (*Burov* et al. *1972; Semyontsov* et al. *1972.348*).

The next attempt to date the Mesolithic was in the 1980s. It was the Chertas 2 site located in the upper part of the Vychegda river valley. Unfortunately, the experiment turned out to be unsuccessful (Tab. 1.7, 8), and the archaeologist Ekaterina S. Loginova lost interest in radiocarbon dating. The initial dates for the Neolithic (Prilukskaya site) were only obtained at the beginning of the 1990s and published later in 1996 (*Timofeyev, Zaitseva 1996.52*). For Chalcolithic contexts, the first dates were obtained from charcoal samples taken from various dwellings at Oshchoy 5, Choinovty 1 (*Stokolos 1986.100–101*) and Niremka 1 (*Kosinskaya 1987*) – and not before the mid-1980s.

The abovementioned failures of archaeologists in the ^{14}C dating of regional complexes and the lack of contacts with radiocarbon laboratories can partly explain the relatively small number of samples examined in this way, and the lack of research interest. In the 1970–1990s, the FNE archaeological community did not appreciate radiocarbon analysis as much as it does today. We pointed out two periods in the history of radiocarbon dating of archaeological sites in the region under study: 1972–1999 and 2000–2020. The first period is characterized by episodic use of instrumental dating, while the second indicates the systematic use of ^{14}C for solving archaeological problems. Figure 2.a compares the number of radiocarbon determinations for the two periods. The positive dynamics show the increased interest of regional archaeologists in ^{14}C dating as an independent method for determining prehistoric events.

Data covering such an extensive territory (around 700 000km^2) and long time (*c.* 6 ka) is not yet representative: 97 radiocarbon dates has been obtained from 46 assemblages of 37 FNE sites. The quantitative distribution of dated materials is shown in Figure 3. Charcoal samples predominate among them due to their better preservation rate, and thus availability for the liquid scintillation dating, applied with most samples (Fig. 2.b). Other materials – wood and plant remains, food crust – were less often dated because of the scarce archaeological contexts for this kind of sample type (Fig. 3).

All the available data are included in Tables 1–3 and Figures 4–6. The calibration of radiocarbon dates was performed using the Calib 8.2 program (*Stuiver* et al. *2020; Reimer* et al. *2020*) and the OxCal v. 3.10 program for the graphic presentation of the dates (*Bronk Ramsey 1995; 2000*). These dates compose the database, which is the subject of the critical analysis in this paper.

FNE samples: from the prehistoric project to the chronological framework

Christopher Bronk Ramsey proposed radiocarbon dating sequence patterns as the major elements of radiocarbon dating. The 'history' of the sample includes everything relating to the sample prior to 'investigation'. The latter incorporates all of the physical actions carried out on the sample. The final stage of the dating process is 'interpretation', which aims to uncover the main elements of the sample's 'history' (*Bronk Ramsey 2008.267, Fig. 2*).

In our study, we add regional geographic characteristics and the impact of unpredictable human behaviour to the sample history. For example, uncertain-

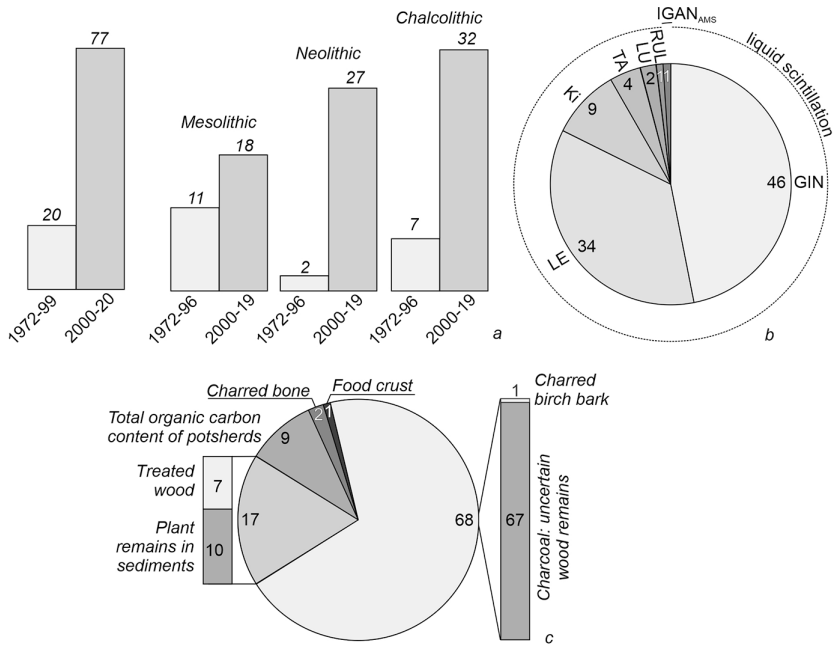


Fig. 2. History of investigations in EFN:* a *comparison of the number of ^{14}C dating for the periods 1972–96 and 2000–19;* b *distribution of the number of measurements in the ^{14}C laboratories of Soviet Union and modern Russia;* c *distribution of dated materials.

ties may arise in connection with the use of objects or substances older than the prehistoric events under study. These facts are not documented when archaeological assemblages are discovered or archived in museums.

Taphonomy and geomorphological effects

These are two related groups of factors that influence the quality of dating. Most sites with dated materials (32 out of 37) are open sites with subterranean dwellings. Therefore, we can assume that they were in 'open access' for a long time after their abandonment by ancient people. However, preservation of organic materials (above- and underground parts of dwelling structures, food remains) in the northern taiga could not be long term.

Many of the sites are located in pine forests growing on sandy fluvial terraces with an aeolian cap. Later forming of noncarbonated Albic Podzols (*Arkheologicheskaya karta Respubliki Komi 2014.7–13*) modified these sediments. Such soils form in a cold climate with seasonal ground freezing and a leaching regime. We can find the archaeological features and remains of structures in eluvial horizons at a depth from 0.05 to about 0.5m. Tree roots and periodic forest fires were thus constantly affecting the buried archaeological contexts.

In addition, fungal decomposition develops in the forest soils: fine mycelium fibres penetrate the pores of charcoal and cracks in organic materials (authors' observations). These unfavourable factors thus negatively affect the preservation of organic matter and contaminate the samples at the macro-level (for example, mixing of different-age and dissimilar materials) and micro-level (for example, mycelium).

Preserved dating materials from such FNE archaeological sites are charcoal, calcinated and charred bones, less often adhesives for repairing pots (bitumen, resin or tar), food crust, *i.e.* substances that have undergone significant thermal effects as a kind of conservation, and wet wood (Tab. 4).

The most common material is charcoal, which occurs in different states in the cultural layers of all sites. It represents the burnt structures of dwellings and fires and is scattered as small fragments throughout the deposits. There are remains of trees burned down during forest fires as a natural admixture in every archaeological context in the taiga. Their post-depositional transformation may produce structures that can be erroneously interpreted as artificially created. For this reason, when taiga sites are being dated, the origin of the samples can most probably explain the 'pitfalls' of radiocarbon dating. However, it should be pointed out that this is not

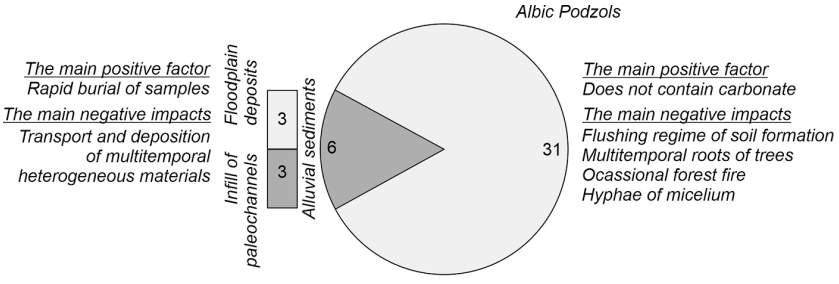


Fig. 3. Overview of culture-bearing deposits in two main geological contexts and their impacts upon them.

a problem of the method itself but the excavated archaeological assemblages, sample selection and the interpretation of certain situations by archaeologists. In 2004 the authors of this paper conducted an experiment and selected samples from charcoal clusters, including some found among the single pot fragments within the remains of a homogenous dwelling complex of the Middle Neolithic site Pezmogty 4 (Tab. 2.13–15; Fig. 5.b). All the dates obtained turned out to be outside the confines of the most likely age range for the context in question – the first half of the 5th millennium BC. This is proved by the sedimentary succession and dating results of similar complexes of the adjacent regions of European Russia. This thus meant that certain natural events had been dated, testifying that they had impacted the archaeological context.

Such situations may include ^{14}C dates, which do not correspond to the archaeological material since it is much younger. These are, for example, charcoal dates within 4250–3330 cal BC from the early Holo-

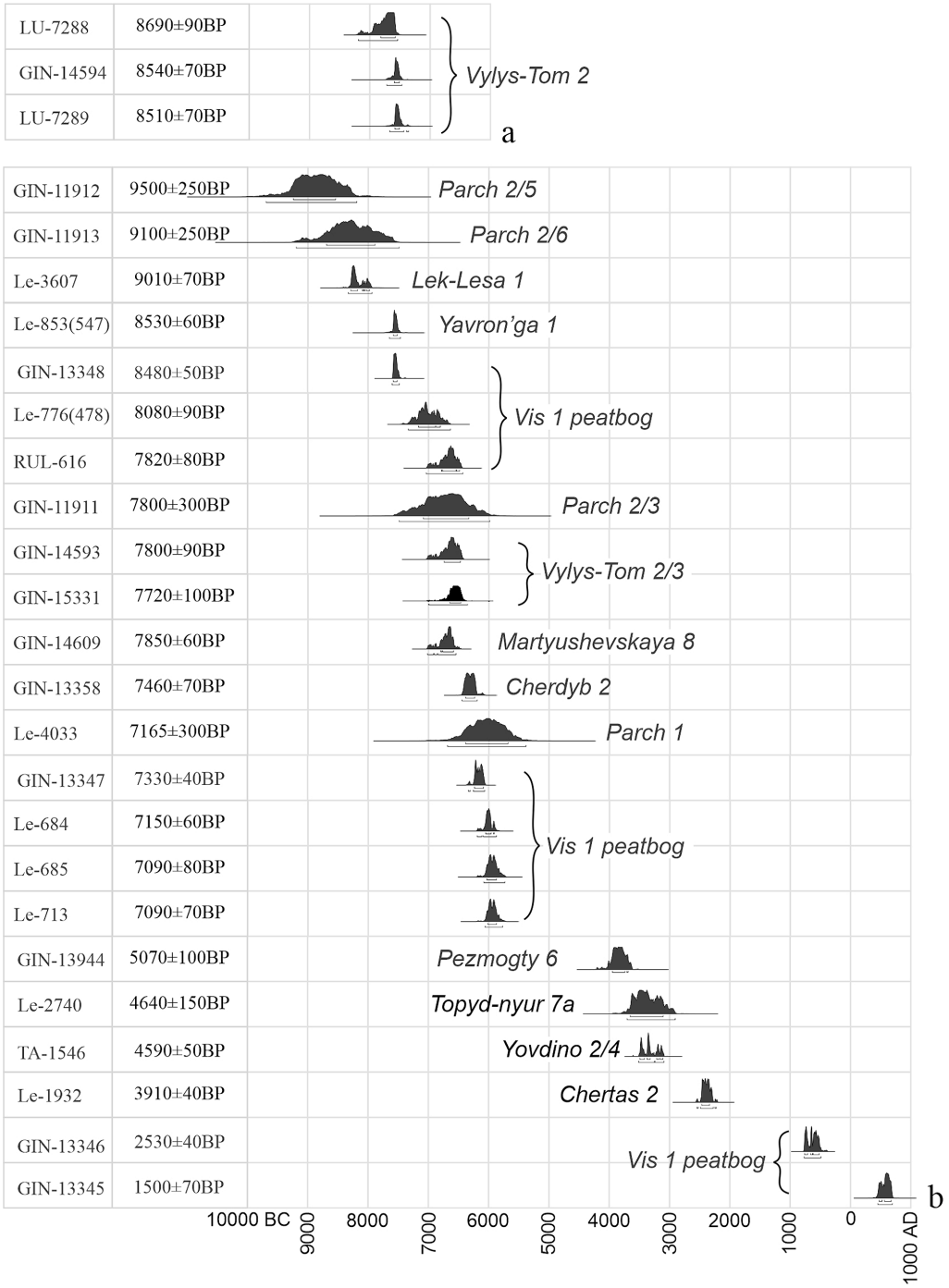


Fig. 4. Results of radiocarbon dating of Mesolithic assemblages:* a *reliable data;* b *ambiguous data.

cene sites of Pezmogty 6 (Tab. 1.9; Fig. 4.b), Yovdino II/4 (Tab. 1.19; Fig. 4.b) and Ugdym 1A (Tab. 2.16; Fig. 3.b).

Natural adverse impacts are most likely to explain different dates in groups of samples taken from the same archaeological assemblage and analysed in the same laboratory. Examples are the ^{14}C charcoal dates from the contexts of the Topydnyur 7a sites (Tab. 1.20, 21; Fig. 4.b), Prilukskaya (Tab. 2.26, 27; Fig. 5.b) and dwellings Shikhovskoye 2 (Tab. 3.11, 12; Fig. 6.b), Lasta 8 (Tab. 3.13, 14; Fig. 6.b), Choinovty 1 (Tab. 3.17–20; Fig. 6.b), Yumizh 1 (Tab. 3.28–30; Fig. 6.b) and Pavshino 2/2 (Tab. 3.32, 33; Fig. 6.b).

Bones have been found at most of the FNE Holocene sites (Tab. 4). They often occur as compact accumulations of a large number (up to 2500) of calcinated fragments confined to fireplaces, less often pits. In addition, they contain remains of various types, including species not living in pine forests (for example, beaver). All this points to their connection with human activities, and therefore it is a reliable material for dating, but only using the AMS technique, which was unavailable for the local archaeologists, and thus only two LSC dates were obtained (Tab. 2.22, 25; Fig. 5.a).

Wood and plant remains as available dating materials were found in the floodplains and paleochannel

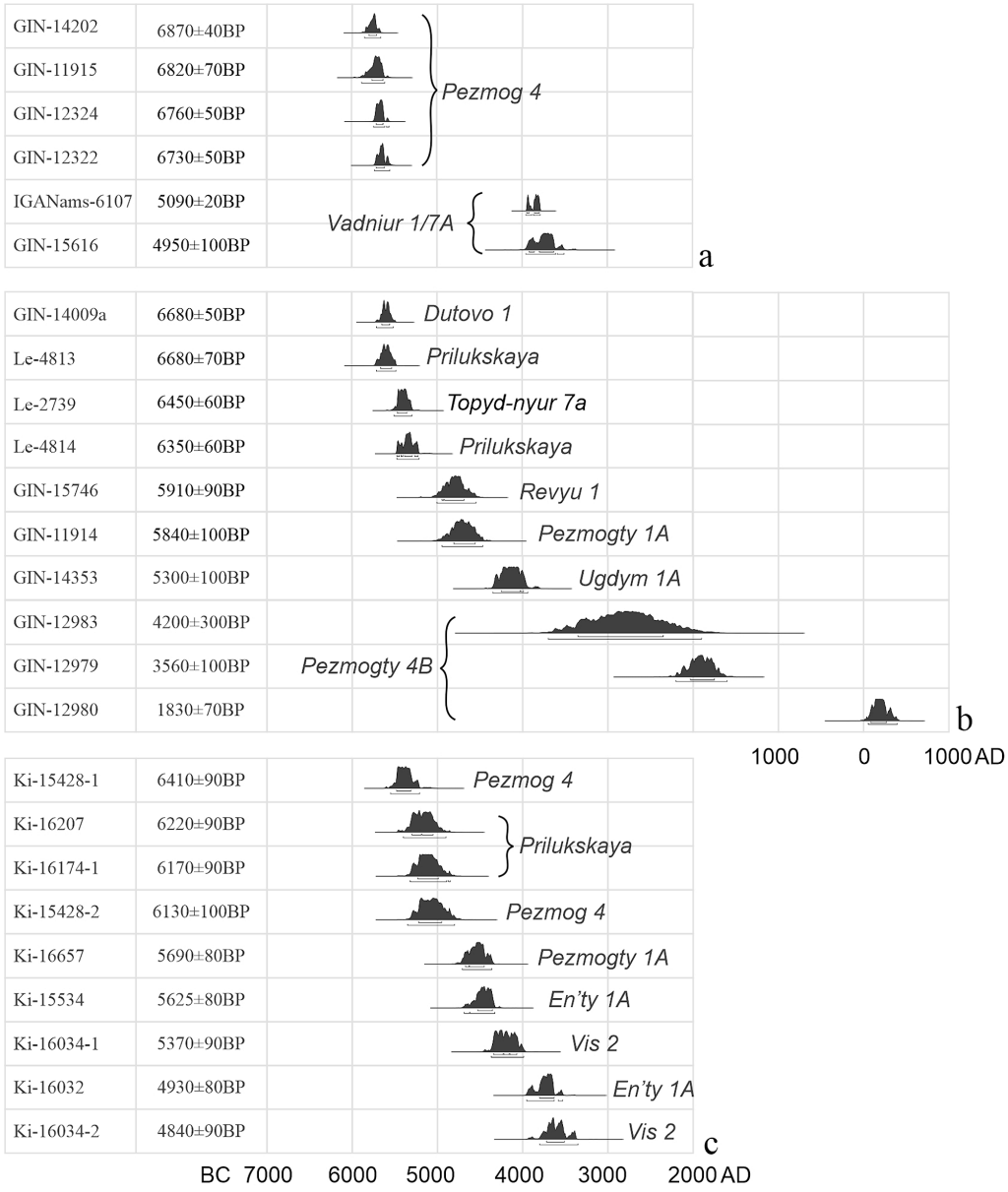


Fig. 5. Results of radiocarbon dating of Neolithic assemblages:* a *reliable data;* b *ambiguous data;* c *unreliable data.

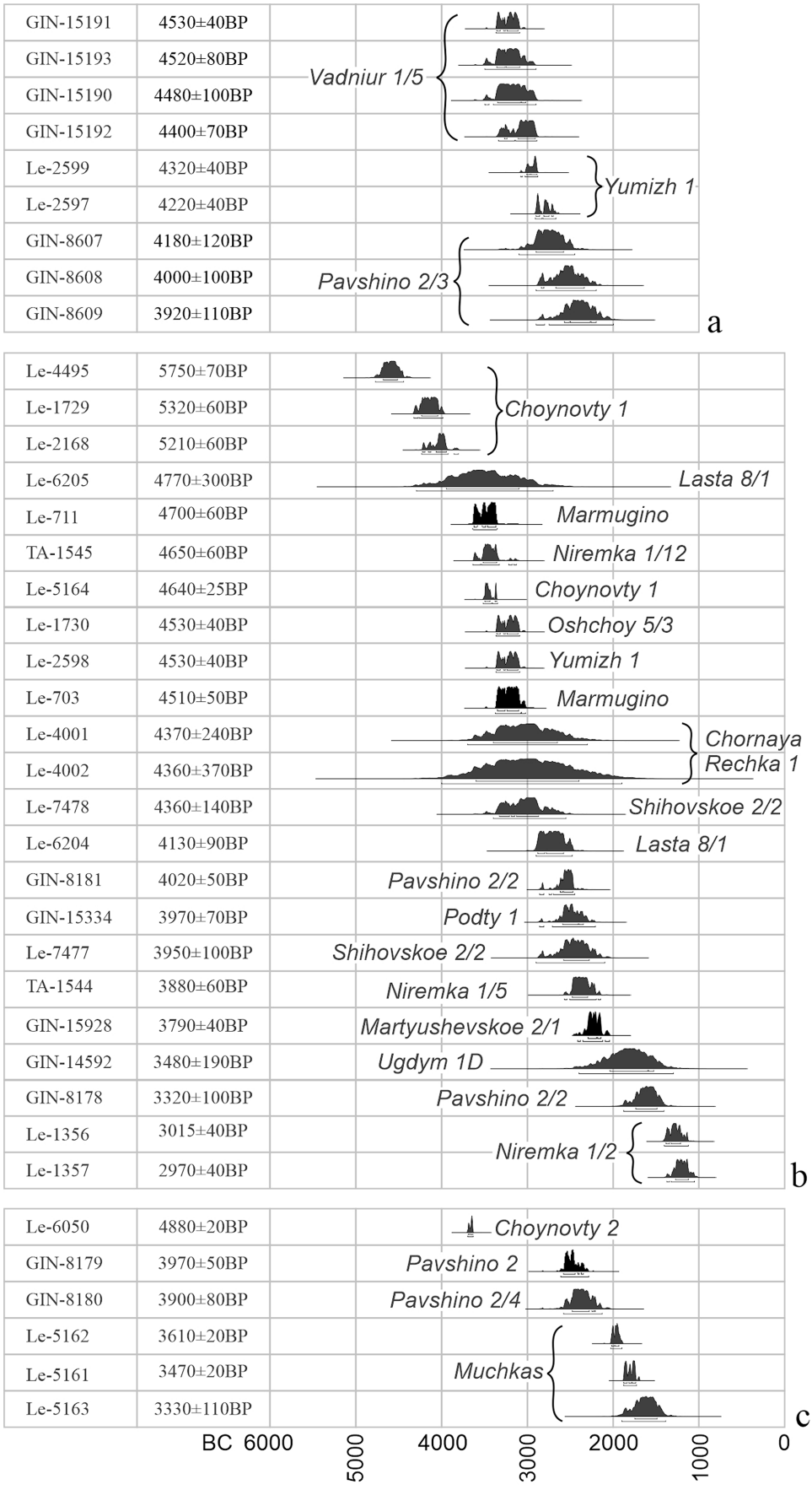


Fig. 6. Results of radiocarbon dating of Chalcolithic assemblages:* a *reliable data;* b *ambiguous data;* c *unreliable data.

infills at wetland sites. However, geoarchaeological archives of that kind are very few in the FNE and derive from following sites: Vis 1 peat bog site, Marmugino peat bog (*Burov 1967; 1969*), Parch 2 (*Volokitin 2006*), Vylys-Tom 2 (*Volokitin* et al. *2013*) and Pezmog 4 sites (*Karmanov* et al. *2014*). These localities have specific and different geomorphological features. The main negative factors are the transport and deposition of multitemporal heterogeneous materials and the activity of subterranean animals.

The examples of Parch 2 and Vylys-Tom 2 (Mesolithic) show that radiocarbon dating contexts enclosed within alluvial deposits can be ambiguous. The first example is the Parch 2 site (*Volokitin, Gribchenko 2017.97–101*). Here, the remains of eight dwellings were studied at a depth of 1.5m. Charcoals from three fireplaces of three dwellings have been dated (*Volokitin 2006.23–38*). Unfortunately, the obtained measurements have a large standard deviation range (Tab. 1.3–5; Fig. 4.b). Two dates are statistically close to each other, and the third is much younger. Such differences in occupation date among dwellings might be feasible if the site was located on the upper part of a fluvial terrace, but are implausible for the floodplain of Vychegda, one of the most active rivers in Europe. The most obvious explanation in this case is that the three dwellings might all date to 9000–8000 cal BC but bulk samples may include different amounts of younger carbon (due to *e.g.*, some local bioturbation) which would be difficult to remove during the pre-treatment stage.

Another example is the Vylys-Tom 2 multilayer site (*Volokitin* et al. *2013; 2014; Budzanivskiy, Volokitin 2014*), where two Mesolithic cultural horizons no. 3 and 4 (humified loam/sandy loam) were discovered at a depth of more than 2m separated by archaeologically sterile sandy bed of 0.1m thick (Fig. 7). In both horizons the remains of fireplaces were found above each other. The investigation of these has provided samples for a series of dates obtained in different laboratories. Three of the five published dates form a compact group (Tab. 1.26–28; Fig. 4), while the other two are far outside the group's boundaries (Tab. 1.24, 25; Fig. 4). However, geomorphological and paleochannel studies at the site and in its vicinity make it possible to state that the cultural horizons were separated by an interlayer of alluvial sand accumulated over a brief period, most probably 10–20 years (*Volokitin, Volokitina 2019. 396*). This shows that when seeking to establish the age of a site, it is essential to rely on stratigraphy and archaeological data, revealing that the materials in the two horizons are identical. Therefore, it is appropriate to link together the three similar dates from the two layers, acknowledging that the gap between the periods of Mesolithic habitation was tiny.

Several publications have been devoted to describing and analysing the Vis 1 peat bog site, both since it was first investigated in the 1960s (*Burov 1967; 1990*) and more recently (*Burov 2012; Zaretskaya* et al. *2014; Volokitin, Gribchenko 2017.93–96*). Burov based his conclusions on the dating of wooden artefacts from the site (Tab. 1.10–14), analysis of the small number of stone tools, and palaeographic reconstructions carried out in the 1960s by Sergey N. Tyuremnov. In 2005–2014, new radiocarbon dates were obtained on deposits from Vis peat bogs 1, 2 and 3 and on the palaeogeography of ancient river

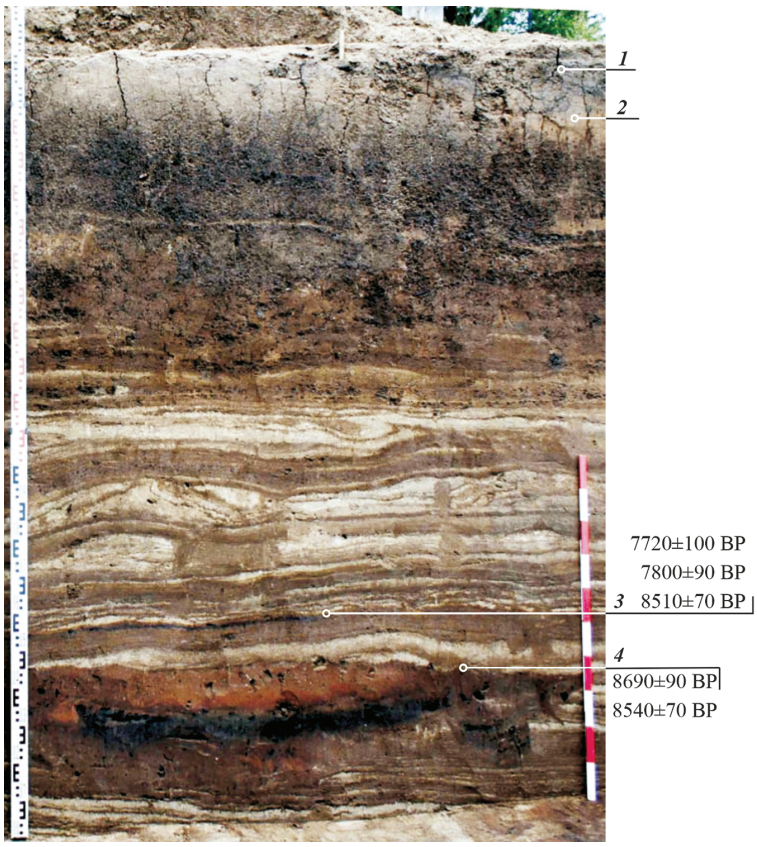


Fig. 7. Vylys-Tom 2: stratigraphy and radiocarbon dating results (after* Budzanivskiy, Volokitin 2014.Fig. 2*). 1–4 cultural horizons.

channels (*Karmanov* et al. *2013*). However, analysis of the results showed an inversion of the dates obtained from wood samples: this can be explained by the specific features of oxbow lake development, in which redeposition of formerly buried material can take place due to periodic renewal of watercourses along paleochannels (*Zaretskaya* et al. *2014. 94*). Moreover, neither bones nor pottery with food crust were preserved.

A successful example of dating archaeological context related to paleochannel infill is the Pezmog 4 site study (Tab. 2.1,2,5–10; Figs. 5.a, 8). Dating the food crust on the inner pot surface, culture-bearing deposits (silty peat), and charcoals from them coincided with the results. The subsequent age determination of the overlying deposits also demonstrated the reliability of the archaeological context and the absence of date inversions (Tab. 2.1,2,5–10). So far, this is the only example of dating food crust in the region using the LSC method. At the same time, a series of dates (Tab. 2.2, 5, 8) obtained from other materials shows that there is no significant freshwater reservoir effect.

Sampling during the excavations

At this stage of ^{14}C sample history, two main groups of problems can be identified in the regional aspect. The first is related to the historical background and geomorphological effects (see above). Due to the short duration of the habitation of small forager groups, there are few artefacts and ecofacts in the collections. Unfavourable conditions for preserving organic materials further reduce the informative value of contexts. The primary available material is charcoal (Fig. 3). For this reason, during excavations there is always the need to distinguish between wood deliberately burnt by prehistoric individuals and charcoal of natural origin – for example, in the wake of a forest fire. Nor is a guarantee of identifying prominent components of structures – fireplaces, for instance, in which there might have been admixtures of natural charcoals (see above). Sometimes archaeologists take every opportunity for instrumental dating and sample, for example, charcoal dispersed in the cultural layer. Such samples are highly unreliable subject for dating, as they may contain remains of diachronous forest fires (Tabs. 1.7,8; 2.13–16; 3.26,27,33). This is a problem not only of the studied region, but of other forest zone archaeological sites of boreal forests, *e.g.*, Karelian (*Seitsonen* et al. *2012.104*).

Erroneous conclusions from excavations can also lead to the archaeological perspective's production of 'inappropriate' data. For example, at the Mesolithic site Chertas 2 charcoal and enclosing sand were selected from the considerable depth of 1m. However, the two dates obtained did not correspond to the early Holocene (Tab. 1.7,8). This was not surprising because the spatial relationship between the artefacts and the studied structure makes us doubt its ancient age and the correctness of its interpretation as a prehistoric dwelling. A ditch of regular shape made in loose sand at such depth could not have been preserved from the Mesolithic under the constant effect of tree roots and ground processes. As the author of excavations testified, it is also appropriate to consider modern destruction (*Loginova 1985.19–22, Fig. 4b*). Probably in the 19th to early-20th centuries, a charcoal-burning pit had been dug up within the area of that site located on an aeolian dune. During the creation and usage of the pit, the Mesolithic cultural layer was distorted and re-deposited, and the charred timber of different age would have been moved together with soil and the artefacts enclosed in it. Later human impact on the site would eventually have destroyed it.

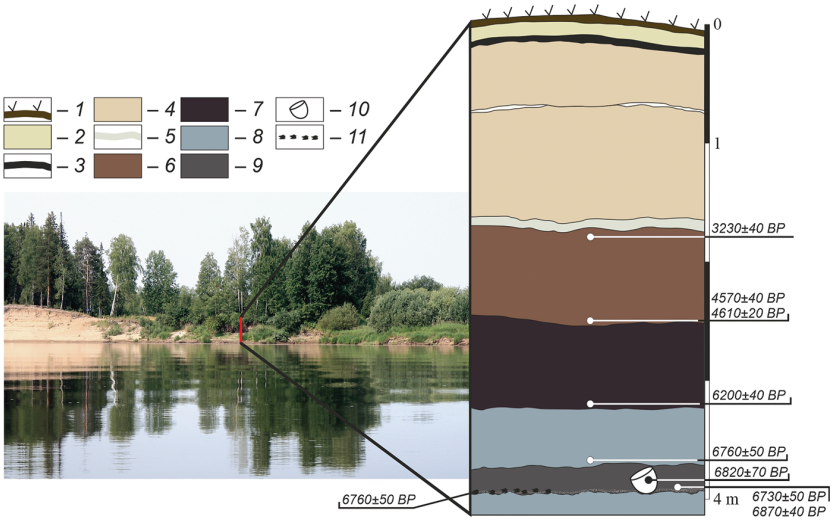


Fig. 8. Pezmog 4: outcrop of 1st terrace and floodplain (view from the river); stratigraphy and results of radiocarbon dating (after* Karmanov *et al.* 2013.Fig. 3*).* **1** *turf;* **2** *sand (result of flood);* **3** *buried soil;* **4** *sandy silt;* **5** *clay silt;* **6** *peat;* **7** *peaty silt;* **8** *clay;* **9** *silty peat with sand (culture-bearing deposits);* **10** *potsherds;* **11** *fragments of charcoal.

Some sampling strategies are not successful. For example, from the area of the Pavshino 2 settlement, fragments of charcoal were selected from Albic Podzol outside the archaeological context (Tab. 3.31) and the local remains of a damaged structure (lair?) in a depression (Tab. 3.37). The second example is the data from the Prilukskaya site. There, the radiocarbon age was determined for two charcoal samples taken from the fireplace remains identified by Irina V. Vereshchagina in excavation pit 2 in 1988: the fireplace had been found at a distance of approximately 4m from the central cluster of finds (Tab. 2.26,27; Fig. 5). However, no artefacts were found in the fireplace infill and its immediate vicinity (*Vereshchagina 1989*). Therefore, the connection between the dated fireplace and archaeological material is uncertain.

However, in some cases archaeologists have managed to identify archaeological objects or their parts without obvious negative impacts (for example, wooden roots and traces of ground deformation). For example, at Vadniur 1/5 and 1/7A we obtained two groups of dates (Tabs. 2.19,20; 3.3–6; Figs. 5.a, 6.a, 9) due to the discovery of horizontal chimney remains containing charcoal (*Karmanov* et al. *2017; Karmanov 2020*). The preservation rate of the deposits filling the investigated chimneys was relatively high. In addition, the intense ochre-like sand colour allowed us to avoid potentially problematic areas of deformation in the tubes and inclusions of the allochthonous material.

The second group of problems is the lack of accurate data on the sample location and the poor documentation accompanying their identification and transition to the laboratory. The archaeological situations revealed during excavations cannot be fully restored, and therefore the role of accurate 3D fixation and comprehensive photographic documentation is essential. However, in most studies of the 20th century charcoal and bone were considered as raw materials, and their field documentation is extremely rare. Nowadays, we often cannot determine where the samples were taken. The most striking example is the series of radiocarbon dates obtained from Muchkas settlement (Tab. 3.23–25; Fig. 6.c). They were valid for the Chalcolithic or the Bronze Age, but there is no proper information supplied on their context. Furthermore, four dwellings had been excavated (*Stokolos 1995*), and it is not possible to ascertain precisely the assemblage or assemblages the samples were taken from. The Choinovty 2 site context (Tab. 3.21) also has to be considered unreliable because it is not known which fireplace outside the dwelling area had been dated, and which archaeological material was concerned.

Laboratory stage

All samples of archaeological contexts in the region were analysed in the radiocarbon laboratories of the Soviet Union and Russia. Figure 2b shows the quantitative distribution according to this criterion: the laboratories GIN- (Geological Institute, Russian Academy of Sciences, Moscow, RF) and the Le- (Institute of History of material culture, Russian Academy of Sciences, Saint-Petersburg, RF) are leaders. All dates were obtained by the LSC method, except one (index $IGAN_{AMS}$) (Tab. 2.19). We shall not analyse here the peculiarities of different pre-treatment procedures of conventional radiocarbon dating in different Russian laboratories – they are shared over the area of the former Soviet Union (see details in *Zazovskaya 2016*), except the direct dating of pottery which became popular in the Neolithic archaeological community at the beginning of the 21st century (*e.g., Vybornov 2008*).

Nine dates have been obtained from the total organic carbon content or direct dating of pottery (Tab. 2.3,4,12,17,18,23,24,28,29) using the LSC method (*Kovaliukh, Skrypkin 2007*). Many publications have been devoted to the limitations and pitfalls of this approach (*e.g., O'Malley* et al. *1999; Gomes, Vega 1999; Kulkova 2014.116, 117; Meadows 2020. 54–56*). The authors of this paper have also touched on this subject earlier (*Karmanov* et al. *2014*), and for that reason we regard it as unnecessary to include the critical analysis here.

Data interpretation

The paradox of interpreting dating results lies in the fact that archaeologists often explain the validity of their dates, *i.e.* which of the dates correspond to the age of the prehistoric event or not. In other words, the results they expect are already presupposed before any dating, so the primary purpose would have been to confirm what they expected. Nevertheless, some of the interpretations provided are very interesting: Burov wrote concerning the dated artefacts from Vis 1 peat bog: "*The only exception is the Le-713 date, which is incorrect because it coincides with the Le-685 date. The samples had simply been mixed up in the laboratory*" (*Burov 2012.361, Tab. 1.13,14*). Thus, Burov tried to explain the inversion of these dates which have the same values but lie at different depths – 1.2 and 1.9m.

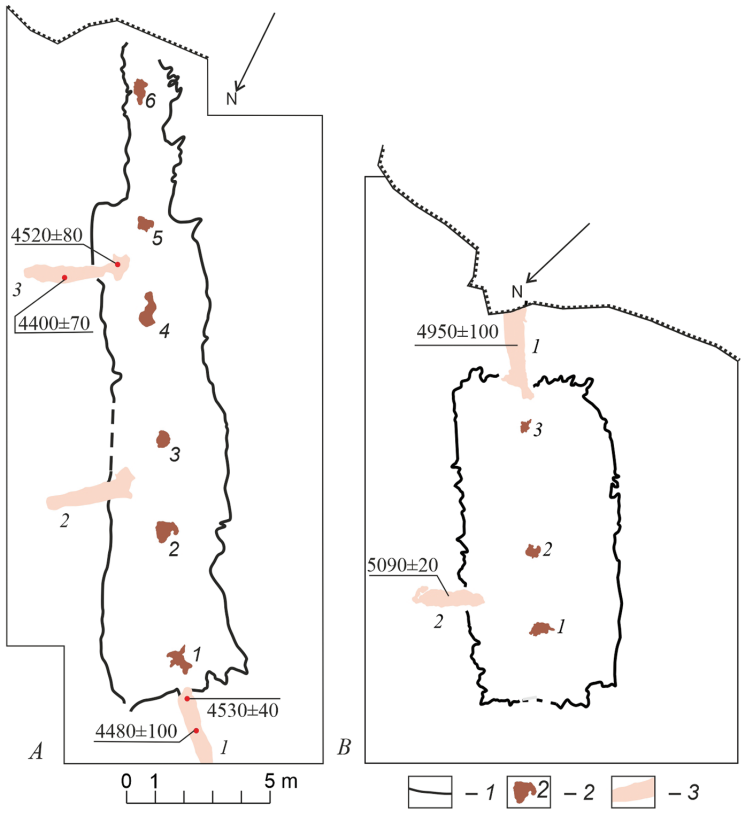


Fig. 9. Dwelling structure and results of ^{14}C dating.* A *Vadniur 1/5 (Chalcolithic);* B *Vadniur 1/7A (Neolithic).* 1 *dwelling limits;* 2 *fireplaces;* 3 *traces of horizontal chimney.

An explanation appears after the result has been obtained, although ideally the archaeologist himself should make a statement regarding the reliability of the sample during his fieldwork. However, based on our practice and analysis of available data, it can be stated that if the sample selection context is reliable, the radiocarbon dates are valid. These statements are based on our studies (Tab. 4).

Examples of speculations with single dates or invalid ideas are as follows. First is the Mesolithic campsite, Topydnyur 7a (Tab. 1.20,21). Aleksandr V. Volokitin makes the following comment about the data concerning its radiocarbon dates: "*Unfortunately the radiocarbon dating of the Topydnyur 7a site does not inspire complete confidence. One date is too young, and this leads to doubts regarding the second, 6450±60 (Le-2790)*" (*Volokitin 1997.116*). In addition to Volokitin's view, we offer another explanation: charcoal fragments scattered among the remains of a dwelling with an area of about 10m² have been dated. The first date (Tab. 1.21) is related to the Chalcolithic. However, the second, indicating the Early Neolithic, would require a more detailed analysis of the context, including the technical-typological characteristics of the stone tools found in the excavated dwelling. Inside it, 266 objects (including débitage) were found (*Volokitin 1987.6–9*), and the quantitative and qualitative composition of that assemblage meant that it was not possible to provide an unambiguous answer to the question of its cultural and chronological attribution. Nevertheless, it could be classified with an equal degree of probability as a site of the Chornaya Vadya type (*Kosinskaya 2002; Karmanov 2008.29–31*). Materials of this kind could occur in the 6th millennium BC, and the date 6450±60 (5480–5370 cal BC, Le-2790) could correspond to the time when the assemblage had been created.

The following example is from Niremka 1 settlement. The series of dates to define the age of dwellings from different cultures at this site (Tab. 3.7–10) was commented on by Lyubov' L. Kosinskaya, who investigated it. In the context of our research, it is important to consider the reasoning of different researchers, and therefore let us cite verbatim from the paper of Kosinskaya: "*Not one of those dates should be regarded as entirely satisfactory*". The date for dwelling no. 5 does not link in with the series for the Fatyanoid vessels found inside it.

The dates for dwelling 2 are acceptable, but they would seem to be on the relatively late side. In addition, the fact that fragments from the same pots were found in dwellings 2 and 5 shows that there was no significant chronological gap between them.

The date for dwelling 12 is acceptable. As for the pottery finds, the stone collection and the type of dwelling itself, it is closest to and forms a pair with dwelling no. 9, so it is inappropriate to have a significant temporal gap between them: furthermore, a Fatyanoid pot was found in dwelling no. 9 (*Kosinskaya 1987.119, 120*).

To a large extent, a commentary of that kind has ceased to be relevant. For example, the so-called Fatyanoid pots – represented in this particular region by the Chirkov-Seyminsky type – found near the top of the section both inside and outside the dwellings have been identified in other diachronous settle-

ments containing dwelling remains in the valleys of Severnaya Dvina (*Vereshchagina 1985*) and Pechora (*Stokolos 1988.95–101*) rivers. Those who maintained this pottery tradition probably used the depressions left behind from the dwellings of their predecessors as shelters. This means that the 'Fatyanoid pottery' bear witness to a later habitation and their presence cannot be interpreted as an indication that the radiocarbon dates are invalid. Far more important are data on fragments of a pot found in various dwellings but assigned to different dates. As the previous examples have shown, even samples from one fireplace are assigned to different ages, and for this reason the results from two dwellings of the same period with dates that do not match are hardly surprising. This could be explained as an example of the impact of tree roots mentioned earlier, or regarding the probability that the space in the depressions had been used on more than one occasion, bearing in mind their arrangement in a compact group.

The following example shows how archaeologists can be selective in publishing dates. In our practice, we know about one example – dating results from the dwelling of settlement Choinovty 1. Several dates were obtained from a reliable homogenous context, and two of them (Tab. 3.18,19; Fig. 6.b) were initially published (*Stokolos 1986.100*). Due to these results, the Final Neolithic age of the early period of the Chuzhyayolskaya culture was substantiated (*Stokolos 1997.219*). Later the whole series of dates obtained for that site was published (Tab. 3.17–20; Fig. 6.b; *Timofeev* et al. *2004.103*). The duration of the whole age range is with *c.* 1000 years considerable, and the rationale for the very early age of this archaeological phenomenon is no longer convincing.

Evaluation of the radiocarbon sequences

As a result of the evaluation of radiocarbon sampling and dating experience in our supraregion, we classify the chronological data based on the reliability of provided information: reference = reliable; ambiguous; unreliable.

The background for our further speculations is as follows:

- the system for evaluating the ^{14}C data in archaeology should depend on the peculiarities of the geography and historical context of the studied region, as well as the accumulated experience of instrumental dating in the region;
- this system should be based on the cooperation of an archaeologist and a geochronologist in order to adequately estimate the chronological information at all stages of its accumulation, from the prehistoric person to the chronometric data.
- the use of instrumental dating methods in archaeology, in particular radiocarbon dating, is part of a process in which the initial conditions are sometimes ambiguous and site-dependent: prehistoric individuals create samples, and various natural conditions constantly influence them. Therefore, the criteria for the reliability of ^{14}C dating results, like in any experiment, are simple and clear to everyone: repeatable accuracy and testability. Reliable age estimation of an archaeological event should ideally be obtained based on analysis of different materials and (or) different areas of archaeological objects and layers. These data can be recommended to the scientific community as trustworthy.

The main problem is that the experience of developing such a system for assessing regions that are identical to those we are studying in terms of geography, chronology and historical context is extremely small. We know the ^{14}C databases for the Neolithic and Chalcolithic of Northern Eurasia within Russia (*e.g., Timofeev* et al. *2004; Chernykh* et al. *2011; Dubovtseva, Kosinskaya 2021*), but only one study offers an integral system of their critical analysis. It is the study of the area closest to the FNE and the period of interest – Karelian Isthmus (northwest Russia), Mesolithic-Early Metal Age (*Seitsonen* et al. *2012.103, 104, Tab. 1*). To assess the reliability of the database, researchers use a rating system to determine the probability of matching radiocarbon ages with archaeological events. Paul Pettitt *et al.* (*2003*) proposed the basis of this system, while Graf and her followers then expanded it with new criteria and adapted the parameters to regional peculiarities (*i.e. Graf 2009. 699–701, Tab. 3; Seitsonen* et al. *2012.Tab. 1*).

The score (from 0 to 4) in the offered system increases with the researchers' confidence in the following conditions: "*(1) certainty of association of dated sample with human activity; (2) relevance of dated sample to the specific archaeological entity of concern; (3) quantity and reliability of dates for a specific archaeological horizon; (4) stratigraphic position; (5) sample type choice and the own age of the material; (6) standard deviation; (7) fittingness with the archaeological material and stratigraphy*" (*Seitsonen* et al. *2012.103, 104, Tab. 1*).

As Kelly Graf (*2009.699*) rightly points out, these criteria are only effective if we have complete information on all the items in this system. But we consider that the probability rankings proposed are artificial and the points awarded are the researchers' desire for a beautiful system that does not take into account that attributes may have different weights and hence different numbers of points (see detail critique of Graf' approach in *Kuzmin 2009*). Therefore, when assessing small databases, incomplete data, or apparent situations, such systems are excessive. For example, the argument that there is no information about a particular sampling location is sufficient to define the data as unreliable. Repeatedly proven erroneous dating of carbon in pottery makes redundant the further search for arguments why such dates are unreliable. Researchers have repeatedly been convinced of the validity of the 'one date is no date' principle, which allows such data to be defined as ambiguous. However, the estimation systems are of significant guidance for critically analysing databases and resolving disputed situations, resulting in determining the most significant probability of each date on a single basis.

Only a few definitions of FNE archaeological sites satisfy our requirements: Vylys-Tom 2 (Mesolithic) (Fig. 4.a), Pezmog 4 and Vadniur 1/7A (Neolithic) (Fig. 5.a), Vadniur 1/5, Yumizh 1 and Pavshino 2/3 (Chalcolithic) (Fig. 6.a).

Some of the ^{14}C data may not match for various reasons. Therefore, we characterize them as ambiguous dates. The criteria for their determination are as follows:

- the principle "*one date is no date*": to confirm/refute single dates, additional measurements are needed since the correspondence of the ^{14}C definition and the desired age of an archaeological event may be an accidental coincidence of numbers (Tabs. 1.1,6,9,19,22,23,29; 2.11,16,22,25; 3.1,2,7,8,22);
- significant difference in the series of dates, when it is impossible to determine which of the results corresponds to the time of the archaeological event, and which documents the negative impact on the sample based on other data (archaeological, paleogeographic or stratigraphic); the validation by additional data is required (Tabs. 1.3–5; 2.26,27; 3.11–14,17–20,32,33);
- measurements with a large standard deviation (Tab. 3.26,27);
- uncertainty between the archaeological material and event of interest allows us to offer different relative-chronological interpretations (Tabs. 1.20; 3.9,10).

If the sampling and dating were done in a methodologically correct manner, then we must not ignore the ambiguous dates. ^{14}C results that do not correspond to modern archaeological models should also not be excluded from the databases. Additional measurements may prove that some of them do indeed date archaeological events. Other determinations can possibly define temporally not well understood impacts on cultural remains and their geoarchaeological context. We thus propose a more flexible approach to the existing ambiguous data: after all, archaeological concepts are changing, and technologies for extracting dated substances are developing at a pace that was previously unthinkable (*Casanova* et al. *2020*).

Inaccurate or unreliable data are often obtained by incorrect methods, such as direct dating of pottery (Tab. 2.3,4,12,17,18,23,24,28,29). In addition, there are data with a lack of detailed sample information, and which cannot currently be correlated with specific archaeological contexts (Tab. 3.21,23–25,31,37). If nothing can be done with the first set of dates, then dates in the second set can become reliable if more information is found in the archives and subsequent dating episodes can substantiate them.

The evaluation of the reliable data and their significance for a supraregional chronological scheme in the FNE archaeology

The dating of the multilayered site Vylys-Tom 2 allowed us to obtain the first reliable sequence of the Mesolithic FNE layers. Previous datings were based on relative-chronological correlations of the materials from adjacent territories and on single ^{14}C dates or measurements with a broad standard deviation. It now can be securely stated that the older phase of that site dates to *c.* 7500 cal BC and the younger to *c.* 6500 cal BC or, alternatively, both phases belong to the 8th millennium BC (Figs. 4.a, 10.A).

Comprehensive analysis of the archaeological context of Pezmog 4 (*Karmanov* et al. *2013; 2014*) made it possible to move back in time the age of the early stage of the Kama Neolithic culture from the 4th millennium BC to second quarter of the 6th millennium BC, or to 5760–5615 cal BC. In addition, these data (Tabs. 2.1,2, 5.a, 8) allow us to reliably date the oldest pottery in the studied region and identify the earliest appearance of the combed tra-

dition in the ornamentation of early pottery in this part of Europe (Fig. 10.A,C). Unfortunately, another type of ancient pottery (Dutovo 1) is currently associated with only one date (Tab. 2.25; Figs. 5.b; 10.B).

The study of the Vadniur 1 assemblages more convincingly confirms the results of previous studies of settlements with multiple dwellings (*Stokolos 1986. 54–88, 113–166; 1988.27; Kosinskaya 1990; Semenov, Nesanelene 1997.19–60*). It was established that these sites existed not simultaneously as a settlement but sequentially due to multiple occupations of attractive places by small groups. For example, the dwellings no. 5 and no. 7 of Vadniur 1 settlement were located only 13m from each other, had the exact same orientation of the long axis, unique features of construction, and similar flint knapping technology, yet the most probable periods of their existence are separated by an interval of about 400–500 years (Tabs. 2.19,20; 3.3–6).

The dating of Vadniur 1/7A (Tab. 2.19,20) and Vadniur 1/5 (Tab. 3.19–21) assemblages presented the first series of reliable age determinations of the late Neolithic and Chalcolithic sites. As a result, archaeologists have the opportunity to revise the established views on the development of the Chuzhjajolskaya culture. In addition, it was determined that Vadniur 1/7A is the oldest forager's dwelling in Northern Eurasia with a complex heating and ventilation system (*Karmanov 2020*). Such a structure is similar to the *gresbakken* type in Norway (*Seitsonen 2006*) and on the Kola Peninsula (*Kolpakov* et al. *2020*).

The dating of the Chalcolithic complexes of the Garino culture (Yumizh 1 and Pavshino 2/3) are also significant. First, however, it is essential to clarify their age and some other dates of the complexes of this culture. So far, the age of sites with the oldest metal in northeastern Europe has been determined very roughly – within the 3rd millennium BC (Fig. 10.A,C).

In this regard, we pay attention to the problem of the different resolutions of methods. Every experienced archaeologist can assess how long a particular site was inhabited or frequented based on the collections' quantitative and qualitative characteristics, the nature of the deposits containing traces of cultural remains, planography and stratigraphy. For mobile foragers in the northern taiga, such places cannot be long term settlements: spending short periods in one place is the defining feature of such households with their appropriating economy. The creation of a burial pit, as a rule, is the work of a single day. Instrumental dating methods are inadequate for reliably assessing the precise age of such objects. According to calculations based on the sets of dates described here, the standard deviation intervals for uncalibrated dates are, on average, 140 radiocarbon years. Thus, even for simple conclusions regarding the chronological correlations between mobile foragers in various territories, age estimations based on these data are still only very roughly sketched.

Conclusions

The FNE chronological database consists of valid dates (22), ambiguous dates (60), and unreliable or

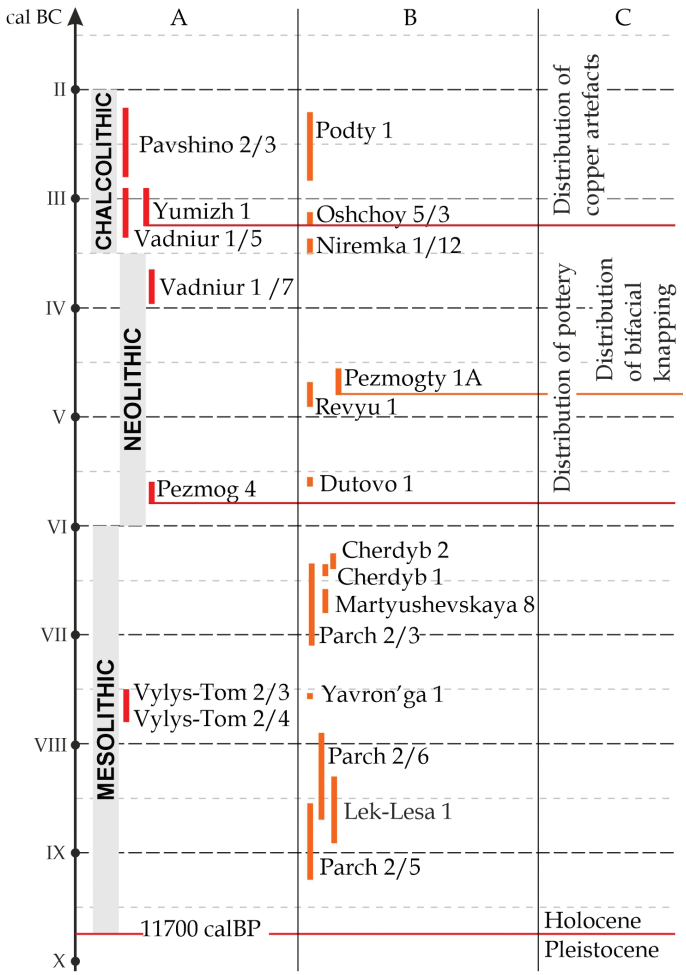


Fig. 10. Archaeological periodization of FNE: a model.* A *reliable dates;* B *single dates corresponding to periodization model, but requiring confirmation;* C *important events.

uncertain dates (15). Among the radiocarbon dates obtained for Holocene sites of the Stone Age and the Chalcolithic in the FNE, only 18 dates from the seven assemblages (Figs. 4.a; 5.a; 6.a; 10.A) can be defined as reliable and with the highest probability associated with prehistoric events. Therefore, they can be used in regional research. In addition, four other dates provide contextual reliability, illustrating the absence of stratigraphic inversion (Tab. 2.6, 7,9,10).

Sixty determinations are considered from an archaeological viewpoint as presenting ambiguous results (Figs. 2.b, 3.b, 4.b). There are 14 single dates that correspond to modern archaeological periodisation, but require confirmation (Fig. 10.B). At the very least, other measurements document the uncertain impacts on the materials or contexts in which the dated samples were found. We hope that future research can better determine their significance, which would require the dating of other materials from the assemblages they derived from or determining the age of similar complexes. Eventually, some of them may be confirmed, and we can identify them as reliable.

The next group of 15 dates (Figs. 5.c, 6.c) is here considered as unreliable and should not be used for the chronological determination of archaeological sites or events associated with this evidence.

The number of reliable age determinations of Mesolithic, Neolithic and Chalcolithic archaeological complexes is insufficient to elaborate even a tentative chronology of those periods. So far, they define only single events of mobile foragers' residence in the FNE in the Early and Middle Holocene. Nevertheless, they offer us the possibility to synchronize these events with those from adjacent territories, and thus they do provide some insights into the diversity of the ancient traditions of pottery making and building dwellings. They also point out possible directions for the search for the origins of these skills. In addition, they provide new arguments for the claim that the studied dwelling complexes were the result of multiple occupations of attractive places rather than the founding of large settlements. Further work will be concerned with the enrichment of the database and an increase in the responsibility for sample selection, in order to enhance the reliability and accuracy of dating. A first step could be a more detailed investigation of informative complexes, such as Vadniur 1, Pezmog 4 and Vylys-Tom 2.

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Tab. 1 Radiocarbon dating results. Mesolithic assemblages.

No.	Archaeological site	Dating materials	Laboratory index and number	^{14}C age, BP	Calibrated age, BC, 1σ	Reference
Vychegda river basin (Komi Republic)						
1	Cherdyb 1	Charcoal; unit 1	GIN-13357	7520±90	6460–6340	*Volokitin, Zaretskaya 2006*
2	Cherdyb 2	Charcoal; unit 2	GIN-13358	7460±70	6400–6250	
3	Parch 2/5	Charcoal, fireplace	GIN-11912	9500±250	9250–8550	*Volokitin 2006*
4	Parch 2/6	Charcoal, fireplace	GIN-11913	9100±250	8700–7900	
5	Parch 2/3	Charcoal, fireplace	GIN-11911	7800±300	7100–6350	
6	Parch 1	Charcoal cluster	Le-4033	7165±300	6400–5700	
7	Chertas 2	Charcoal, depth 1m	TA-1547	Modern	–	Slip card, E. S. Loginova archive (1981)
8		Charcoal with sand, depth 1m	Le-1932	3910±40	2470–2340	Slip card , E.S. Loginova archive (1985); *Timofeev* et al. *2004.100*
9	Pezmogty 6	Charcoal cluster	GIN-13944	5070±100	3970–3760	This paper
10	Vis 1 peat bog; river Vis	Wood, processed log, depth 1.7m	Le-776(478)	8080±90	7180–6900	*Burov* et al. *1972*
11		Wood, log, depth 1.75m	RUL-616	7820±80	6780–6560	
12		Wood, bow, depth 1.9m	Le-684	7150±60	6070–5980	
13		Wood, stick with ledge at the end, depth 1.2m	Le-685	7090±80	6050–5890	
14		Wood, processed plank, depth 1.9m	Le -713	7090±70	6030–5890	
15		Diatom gyttja; depth 0.4m	GIN-13345	1500±70	440–640 AD	*Zaretskaya* et al. *2014*
16		Gyttja; depth 0.7m	GIN-13346	2530±40	790–550	
17		Gyttja; depth 1.34m	GIN-13347	7330±40	6240–6090	
18		Gyttja; depth 2.3m	GIN-13348	8480±50	7580–7520	
19	Yovdino II/4; river Vym	Charcoal, fire pit in dwelling	TA-1546	4590±50	3500–3330	*Kosinskaya 1987.93*
Pechora river basin (Komi Republic)						
20	Topyd-nyur 7a	Charcoal	Le-2739	6450±60	5480–5370	*Volokitin 1997.116*
21		Charcoal	Le-2740	4640±150	3650–3100	
22	Matiushevskaya 8; river Severnaya Mylva	Charcoal	GIN-14609	7850±60	6780–6600	This paper
23	Lek-lesa 1; river Izhma	Charcoal	Le-3607	9010±70	8300–8190	*Volokitin 2005*
24	Vylys-Tom 2, cultural horizon no. 3 (humous loam/sandy loam); river Izhma	Charcoal, fireplace	GIN-15331	7720±100	6640–6465	*Volokitin, Volokitina 2019.396*
25		Charcoal, fireplace	GIN-14593	7800±90	6760–6490	*Volokitin* et al. *2014*
26		Charcoal, fireplace	LU-7289	8510±70	7595–7520	
27	Vylys-Tom 2, cultural horizon no. 4 (humous loam/sandy loam)	Charcoal, fireplace	LU-7288	8690±90	7830–7590	
28		Charcoal, fireplace	GIN-14594	8540±70	7605–7520	
Pinega river basin (Arkhangelsk region)						
29	Yavronga 1	Charcoal, bottom of fire pit	Le-853 (547)	8530±60	7595–7535	*Burov 1974.86*

Tab. 2. Radiocarbon dating results. Neolithic assemblages.

No.	Archaeological site	Dating materials	Laboratory index and number	^{14}C age, BP	Calibrated age, BC, 1σ	Reference
Vychegda river basin (Komi Republic)						
1	Pezmog 4, excavation of 1999	Food crust, inner part of the ceramic vessel; depth 3.66–3.75m	GIN–11915	6820±70	5760–5630	*Karmanov* et al. *2012*
2		Charcoal, cultural-bearing deposits; depth 3.6–3.7m	GIN–12324	6760±50	5710–5630	
3		Total organic carbon content (TOCC) of potsherds	Ki–15428-2	6130±100	5220–4950	
4		TOCC	Ki–15428-1	6410±90	5480–5310	
5	Pezmog 4, sampling of 2002	Silty peat (cultural-bearing deposits); depth 3.6-3.8 m	GIN–12322	6730±50	5710–5615	
6		Gyttja; depth 3.2m	GIN-12325	4570±40	3380–3120	
7		Peat; depth 1.8m	GIN-12326	3230±40	1530–1440	
8	Pezmog 4, sampling of 2009	Silty peat; depth 3.58–3.90m	GIN–14202	6870±40	5800–5710	
9		Silty peat; depth 3.25–3.28m	GIN–14201	6200±40	5180–5060	
10		Silty peat; depth 2.54–2.57m	GIN–14200	4610±20	3490–3360	
11	Pezmogty 1A	Charcoal, fireplace	GIN–11914	5840±100	4800–4550	
12		Potsherd, direct dating	Ki–16657	5690±80	4620–4450	
13	Pezmogty 4B	Charcoal, small fragments	GIN-12983	4200±300	3350–2350	This paper
14		Charcoal, small fragments among the sherds of broken pot	GIN-12979	3560±100	2030–1750	
15		Charcoal, small fragments	GIN-12980	1830±70	80–260 AD	
16	Ugdym 1A	Charcoal, small fragments, utility pit	GIN-14353	5300±100	4250–4030	
17	Enty 1A	TOCC	Ki–16032	4930±80	3800–3630	*Karmanov* et al. *2012*
18		TOCC	Ki–15534	5625±80	4530–4360	
19	Vadniur 1/7A	Charcoal, horizontal chimney no. 1 infill	IGANAMS–6107	5090±20	3870–3810	*Karmanov 2020*
20		Charcoal, horizontal chimney no. 2 infill	GIN-15616	4950±100	3810–3640	
21		Charcoal	GIN-15615	1690±30	256–416AD	
22	Revyu 1	Charred bones, pit no. 5	GIN–15746	5910±90	4910–4680	
23	Vis 2, river Vis	TOCC	Ki-16034-2	4840±90	3720–3510	*Karmanov* et al. *2012*
24		TOCC	Ki-16034-1	5370±90	4330–4220	
Pechora river basin (Komi Republic)						
25	Dutovo 1	Charred bones	GIN–14009a	6680±50	5645–5555	*Karmanov* et al. *2012*
Severnaya Dvina river valley (Arkhangelsk region)						
26	Prilukskaya; excavation pit 2, 1988	Charcoal, fireplace	Le–4814	6350±60	5380–5290	*Timofeev, Zaitseva 1996.52*
27		Charcoal, fireplace	Le–4813	6680±70	5660–5530	
28	Prilukskaya; excavation pit 1, 1974	TOCC	Ki–16207	6220±90	5300–5050	*Karmanov* et al. *2012*
29		TOCC	Ki–16174-1	6170±90	5230–4990	

Tab. 3. Radiocarbon dating results. Chalcolithic assemblages.

No.	Archaeological site	Dating materials	Laboratory index and number	^{14}C age, BP	Calibrated age, BC, 1σ	Reference
Vychegda river basin (Komi Republic)						
1	Podty 1, construction no. 1	Charcoal from the bottom of cultural layer	GIN-15334	3970±70	2839–2210	This paper
2	Ugdym 1D	Charred birch bark in the broken pot	GIN-14592	3480±190	2040–1600	
3	Vadniur 1/5	Charcoal, infill of horizontal chimney no. 1	GIN-15191	4530±40	3240–3110	*Karmanov* et al. *2017*
4		Charcoal, infill of horizontal chimney no. 3	GIN-15193	4520±80	3360–3090	
5		Charcoal, infill of horizontal chimney no. 1	GIN-15190	4480±100	3350–3080	
6		Charcoal, infill of horizontal chimney no. 3	GIN-15192	4400±70	3110–2910	
7	Niremka 1/12, river Vym	Charcoal, infill of exit ditch	TA-1545	4650±60	3520–3360	*Kosinskaya 1987.119*
8	Niremka 1/5	Charcoal, unknown context	TA-1544	3880±60	2559–2149	
9	Niremka 1/2	Charcoal, unknown context	Le-1356	3015±40	1395–1126	
10		Charcoal, unknown context	Le-1357	2970±40	1371–1051	
Pechora river basin (Komi Republic)						
11	Shihovskoe 2/2, river Pechora	Charcoal, remains of burnt roof	Le-7477	3950±100	2580–2280	*Vaskul 2011.5*
12		Charcoal, remains of burnt roof	Le-7478	4360±140	3130–2870	
13	Lasta 8/1, river Izhma	Charcoal; square 53-5G	Le-6204	4130±90	2780–2580	*Timofeev* et al. *2004.102*
14		Charcoal; square 4G	Le-6205	4770±300	3950–3100	
15	Martiushevskoe 2/1,	Charcoal; pit no. 2	GIN-15928	3790±40	2401-2046	This paper
16	river Severnaya Mylva	Charcoal; uprooted tree pit, under pit no. 2	GIN-15929	4680±60	3634-3358	This paper
Mezen river basin (Komi Republic)						
17	Choinovty 1	Charcoal; depth 0.4m	Le-4495	5750±70	4690–4520	*Timofeev* et al. *2004.45, 103*
18		Charcoal; depth 0.3m	Le-1729	5320±60	4240–4050	*Stokolos 1986.100;* *Timofeev* et al. *2004.45, 103*
19		Charcoal	Le-2168	5210±60	4070–3950	*Stokolos 1986.100*
20		Charcoal; depth 0.4m	Le-5164	4640±25	3500–3440	*Timofeev* et al. *2004.45, 103*
21	Choinovty 2	Charcoal, fireplace out of dwellings	Le-6050	4880±20	3665–3640	*Timofeev* et al. *2004.103*
22	Oshchoy 5/3	Charcoal; depth 0.8m	Le-1730	4530±40	3240–3110	*Stokolos 1986.101;* *Timofeev* et al. *2004.102*
23	Muchkas	Charcoal, dwelling ?; depth 0.3m	Le-5162	3610±20	1980–1935	*Timofeev* et al. *2004.43, 102*
24		Charcoal, dwelling ?; depth 0.12m	Le-5161	3470±20	1780–1740	*Timofeev* et al. *2004.102*
25		Charcoal, dwelling ?; depth 0.4m	Le-5163	3330±110	1750–1490	
Severnaya Dvina river valley (Arkhangelsk region)						
26	Chornaya Rechka 1	Charcoal, the cultural layer	Le-4001	4370±240	3400–2650	*Vereshagina 2008.128*
27		Charcoal, the cultural layer	Le-4002	4360±370	3600–2400	
28	Yumizh 1	Charcoal; square 25	Le-2597	4220±40	2900–2750	
29		Charcoal, the fireplace 1; depth 0.45m	Le-2599	4320±40	2960–2890	
30		Charcoal, the fireplace 1; depth 0.2-0.4m	Le-2598	4530±40	3240–3110	

No.	Archaeological site	Dating materials	Laboratory index and number	^{14}C age, BP	Calibrated age, BC, 1σ	Reference
Yug river valley (Vologda region)						
31	Pavshino 2	Charcoal buried with podzol dump; 10m from the destroyed dwelling no. 1	GIN-8179	3970±50	2573–2457	*Vasiliev, Suvorov 2000.21*
32	Pavshino 2/2	Charcoal, passage between two chambers	GIN-8181	4020±50	2580–2470	
33		Scattered charcoal fragments, cultural layer in the pit-house	GIN-8178	3320±100	1740–1490	
34	Pavshino 2/3	Charcoal, fireplace (?)	GIN-8607	4180±120	2900–2580	
35		Charcoal, fireplace (?)	GIN-8608	4000±100	2670–2340	
36		Charcoal, fireplace (?)	GIN-8609	3920±110	2500–2270	
37	Pavshino 2/4	Charcoal fragments from the dwelling pit, sampled from the area destroyed by a lair	GIN-8180	3900±80	2480–2280	
38	Marmugino peat bog	Wood, fishing trap no. 1	Le-711	4700±60	3470–3370	*Timofeev* et al. *2004.99*
39		Wood, fishing trap no. 2	Le-703	4510±50	3240–3100	*Timofeev* et al. *2004.98*

Tab. 4. Synopsis of dated materials and availability of results.

Materials available for dating	Frequency	Number of dates available for publication
Charcoal	Common	68 (Tabs. 1.1–9,19–29; 2.2,11,13–16,19–21, 26,27; 3.1,3–37)
Calcinated or charred bones	67 of 158 reference assemblages	2 (Tab. 2.22,45)
Total organic carbon content in sherds	765 pots	9 (Tab. 2.3,4,12,17,18,23,24,28,29)
Undefined glue (bitumen, resin or tar) for pots repairing	46 of 765 pots	0
Food crust	1 of 765 pots	1 (Tab. 2.1)
Wood	2 sites	7 (Tabs. 1.10–14; 3.38,39)
Charred bark	2 cases	1 (Tab. 3.2)
Total organic carbon content in the sediments, containing archaeological materials	3 sites	4 (Tabs.1.17,18; 2.5,8)
Total organic carbon content in the sediments, overlying the cultural layers	6 sites	6 (Tabs. 1.15,16; 2.6,7,9,10)

Revising the chronology of Stanovoye 4 in the Upper Volga Region (Western Russia)

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ABSTRACT – *This paper examines the Stanovoye 4 site-chronology, which was developed through several radiocarbon dating efforts throughout the last two decades. Today, the dates indicate long-term cultural traditions at the site, lasting over 3000 years. The goal of this paper is to understand the site chronology holistically, which is done through a critical review of all available dates and sample characteristics. Additionally, the choice of sample materials, dating methods and preservation practices will be discussed. Furthermore, the dating of PVA-consolidated samples is discussed from an archaeological standpoint.*

KEY WORDS – *radiocarbon dating; Mesolithic; Neolithic; chronology; the Upper Volga region*

Revizija kronologije najdišča Stanovoye 4 iz območja zgornjega toka reke Volge (zahodna Rusija)

IZVLEČEK – *V članku predstavljamo kronologijo najdišča Stanovoye 4, ki je bila oblikovana v zadnjih dveh desetletjih na podlagi številnih radiokarbonskih datumov. Trenutni podatki kažejo, da je poselitev na najdišču del dolgotrajne, več kot 3000-letne kulturne tradicije. V članku poskušamo razumeti kronologijo najdišča na holistični način, in sicer s pomočjo kritične recenzije vseh dostopnih datumov in značilnosti vzorcev. Poleg tega razpravljamo tudi o izboru materiala vzorcev, metodah datiranja in zaščitnih praksah. Ob tem iz arheološkega vidika obravnavamo tudi datiranje vzorcev, ki so bili utrjeni s PVA lepili.*

KLJUČNE BESEDE – *radiokarbonsko datiranje; mezolitik; neolitik; kronologija; območje zgornjega toka reke Volge*

Introduction

The site Stanovoye 4, located in the Ivanovo area of the Upper Volga region, in western Russia, was excavated by Mikhail Zhilin, between the years 1992 and 2002. The site consists of four Mesolithic archaeological layers, a layer dating to the early phase of the so-called 'Forest Neolithic' (characterized by the presence of ceramic but without farming or pastoralism) as well as a Middle Neolithic layer. Because of the site's distinct and radiocarbon-dated stratigraphy, as well as good organic preservation conditions, its chronology and technological development can be explored in detail. Furthermore, the site's location in the centre of the Upper Volga region makes it relevant for studies of regional and transregional contacts and communications from the very beginning of the Mesolithic until the Middle Neolithic (*Zhilin 2002; 2009*).

The Upper Volga region is likely a relevant area for the spread of several technological concepts into Fennoscandia and northern Continental Europe during the Mesolithic (*cf. Rankama, Kankaanpää 2007; 2008; Hartz* et al. *2010; Sørensen* et al. *2013; Kankaanpää, Rankama 2014; Damlien 2016; Manninen* et al. *2021*). The chronological bases for these technological dispersions rest on more than 150

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radiocarbon dates from around 30 sites, several of which are stratified peat bog sites (*Zhilin 2009*).

The Stanovoye 4 site has already been dated on several occasions: Nataliya Zaretskaya *et al.* (*2005*), Sönke Hartz *et al.* (*2010*), Bente Philippsen (*2019*) and most recently by the authors of this paper. In this article, we calibrate and evaluate all previously dated samples, along with the newly acquired dates. The large number of radiocarbon-dated samples, done during the last two decades, come with various source critical aspects. Here, we review the use of certain sample materials, varying dating methods and problematic preservation practices in order to explore and map the many source critical factors that play into the chronology of the Stanovoye 4 site, in an effort to better understand it.

This will be done by detangling various fractions of radiocarbon samples that are characterized by different source critical issues and instead use these fractions to create individual chronologies. After this (divide-and-conquer-like) procedure, the chronologies will be compared and evaluated to reach a general chronology for the site. This chronology, along with the stratigraphic and archaeological evidence from the site, will provide a more comprehensive understanding of human activities during the early Holocene.

The site and stratigraphic sequences

The Stanovoye 4 site is located on a sloping promontory stretching into the Podozerskoye peat bog, formed in the terrace of a previous glacial lake (Fig. 1). The Lahost River runs from the bog and through the site. The stratigraphy at the site is complex with highly dynamic sedimentation processes, which also differ slightly across the site's two main trenches, *i.e.* trenches 2 and 3 (Fig. 2) (*Zhilin 2002; 2009; Zhilin, Matiskainen 2003*). A smaller trench (1) is situated *c.* 50 meters west of trench 2 (*Zhilin 2002*) but will not be dealt with here due to its small assemblage and lack of dates. The stratigraphies from trench 2 and 3 have been subject to sediment analysis and substantial plant microfossil analysis, which provided insights on the local sedimentation processes (*Zaretskaya* et al. *2005*). Pollen analysis has also been useful for reconstructing the prehistoric environments surrounding the site (*Aleshinskaya 2001*).

Environmental processes of sedimentation at the site

The sediment layers that make up the site are numbered 1–9 and the archaeological layers are referenced by Roman numerals I-IV. The following sedimentation process at the site is based on the previous investigations by Anna S. Aleshinskaya (*2001*) and Nataliya E. Zaretskaya *et al.* (*2005*).

The stratigraphy and chronology of the site starts at the Early Mesolithic ground level, which consists of washed moraine. The artefacts found on top of this moraine are related to archaeological layer IV. At the time the site was situated on, and in the near vicinity of, the ancient shoreline. Due to rising water levels the site was later submerged and artefacts from archaeological layer IV became covered by sediment layer 8. The analysed sedimentary samples

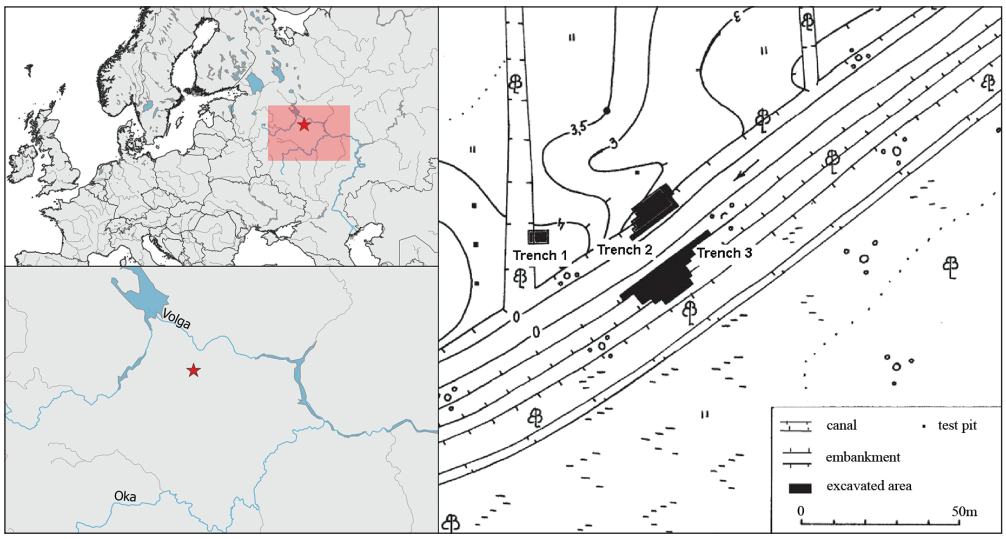


Fig. 1. On the left, a red star marks the location of Stanovoye 4 in Russia. On the right, plan of the site (©EuroGeographics for the administrative boundaries).

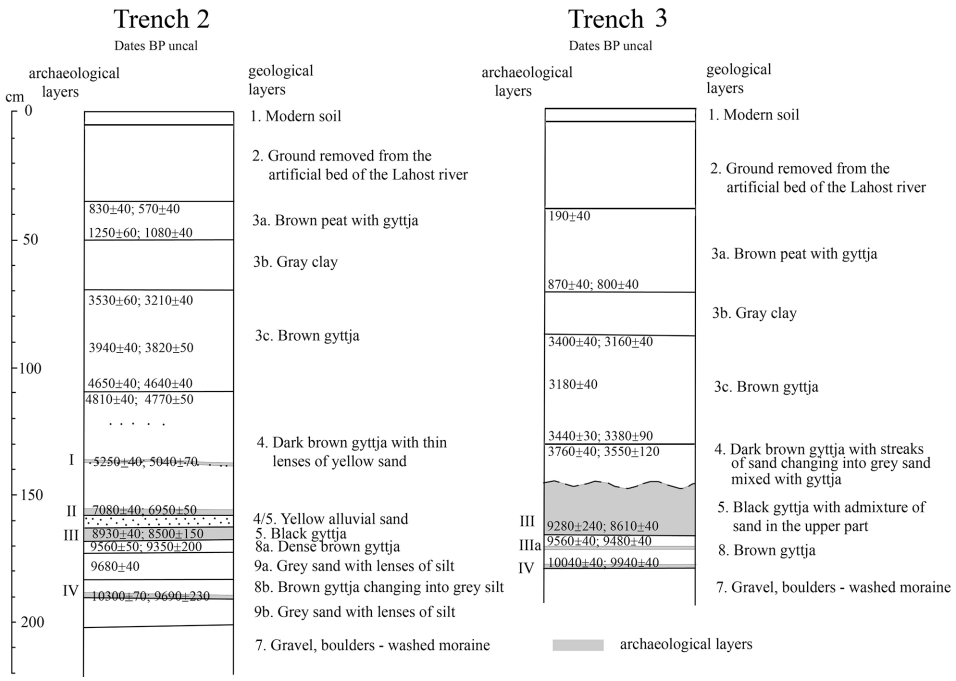


Fig. 2. Stratigraphies from trenches 2 and 3. Geological layers are numbered 1–9, and archaeological layers using roman numerals I-IV. ^{14}C ages are in uncal BP (see Table 1, available at http://dx.doi.org/10.4312/dp.48.13).

from layer 8 consist of organomineral silt and gyttja, which along with the plant compositions indicate that sedimentation took place in an environment characterized by cooler water temperatures (in trench 2) and shallow littoral sediments in the form of gyttja (in trench 3). The pollen and microfossil analyses, along with the acquired dates, thus suggest that sediment layer 8 and archaeological layer IV were deposited at the very end of the Younger Dryas and at the beginning of the Preboreal (*Aleshinskaya 2001; Zaretskaya* et al. *2005*).

Gyttja (related to layer 8) continued to accumulate on top of layer IV in the following centuries. This is due to rising water levels of the nearby lake during the warmer temperatures at the beginning of the Preboreal. This is also supported by pollen and microfossil data (*Aleshinskaya 2001; Zaretskaya* et al. *2005*).

Subsequent sediments, from the upper part of sediment layer 8, in trench 3, show that the water level of the nearby lake was reduced again in the context of a Preboreal landscape, as based on plant microfossils and pollen (*Zhilin, Matiskainen 2003; Zaretskaya* et al. *2005*). During this regression, archaeological layer IIIa was accumulated. About 100 years later, another transgression is visible in the sediments together with changes in river activity (*Zaretskaya* et al. *2005*). In the same stratigraphic horizon, but in trench 2, two thin wooden stakes were found between the two archaeological layers IV and III (*Zhilin 2002*). This area of the stratigraphy will henceforth be referred to as sediment layer IV/III.

The obtained radiocarbon dates show a start of sedimentation of layer 8 in trench 3 in the first half of the 10th millennium cal BC and it continues until the first half of the 9th millennium. In trench 2, the sedimentation of layer 8 is dated from the second half of the 10th millennium to the second half of the 9th millennium (*Zaretskaya* et al. *2005*).

Archaeological layer III is embedded within sediment layer 5 in both trenches. In trench 3, pollens from this layer indicate that sedimentation took place during the second half of the Preboreal. Meanwhile, pollens from the same layer in trench 2 are characteristic of a landscape during the first half of the Boreal (*Aleshinskaya 2001*). The radiocarbon dates obtained from trench 3 show a start of sedimentation of archaeological layer III around the middle of the 9th millennium, continuing into the first half of the 8th millennium cal BC. In trench 2, the sedimentation of layer 5 is instead dated to the end of the 9th millennium and continuing into the second half of the 8th millennium cal BC (*Zaretskaya* et al. *2005*).

The sediment layer 4/5 in trench 2 consists of yellow sand, which contains redeposited artefacts that

probably come from layer III. This layer is interpreted as relating to a series of flooding events, in which finds were washed out from the slopes of the promontory (situated north of trench 2), moved downstream and subsequently redeposited in the riverbanks. Pollen analysis of related sediments in trench 2 indicates that this occurred during the second half of the Boreal. Later on, the lake level again rose, covering layer 4/5 (in trench 3) with gyttja. The bottom part of this gyttja layer contains archaeological layer II, preserved in situ. Pollen data from this layer indicate sedimentation during the Early Atlantic period (*Aleshinskaya 2001; Zhilin, Matiskainen 2003*). Radiocarbon dates from the bottom part of the gyttja layer (layer 4 in trench 2) indicate that this sedimentation started in the first half of the 6th millennium cal BC and continued throughout the following centuries (*cf. Zaretskaya* et al. *2005*). The Middle Neolithic layer I in trench 2 is embedded in gyttja, which was deposited during the Atlantic period (*Aleshinskaya 2001*).

Cultural and technological traditions at the site

The earliest settlement phase on the Stanovoye 4 site is represented by archaeological layer IV, in both trenches. The archaeological materials consist of 154 lithic artefacts and *c.* 54 bone and antler tools. The typology and technology of these finds indicate that they belonged to the Early Mesolithic Butovo technocomplex (*cf. Zhilin, Matiskainen 2003; Zhilin 2007; 2009*).

Artefacts from this layer showcase a variety of technological concepts and techniques. The production of larger blades was done by means of indirect (punch) techniques while smaller blades were produced using pressure techniques from a variety of core types (*Zhilin 2009; Hartz* et al. *2010*). Bone and antler artefacts were made from a variety of animal species, including elk and beaver (*Zhilin 2003; 2007; 2009; Zhilin, Matiskainen 2003*).

The subsequent archaeological layer is found solely in trench 3 and is represented by layer IIIa. The related lithic assemblage is scarce but includes a few chert flakes, a flint knife, an asymmetric trapeze and an oblique one-edged arrowhead, the latter characteristic of the Ienevo technocomplex, although the round scrapers from this layer are typical for the Butovo technocomplex. The bone and antler assemblage includes artefacts such as a large arrowhead with an irregular sub-biconical head, a gouge, a fragment of a knife and a grooved long bone. Other organic finds include the remains of a wooden fish trap found with a large stone sinker adjacent to it (*Zhilin, Matiskainen 2003*).

The following settlement period is represented by archaeological layer III, found in both main trenches. This assemblage shows typological and technological features related to the Middle Mesolithic period, and the Butovo technocomplex, as described above (*Zhilin 2003; 2007; 2009; Zhilin, Matiskainen 2003*). The bone and antler assemblages from this layer are extensive, including a variety of tools and artefacts, along with many wooden stakes which have been interpreted as fishing weirs (*cf. Zhilin, Matiskainen 2003*).

Archaeological layer II was recovered only in trench 2. Its assemblage includes a small number of flint and bone finds as well as thick-walled ceramic fragments. This suggests the presence of an economy based on hunting, gathering and fishing as well as the use of pottery, which is characteristic of the earliest stage of the Early Neolithic Upper Volga cultural complex (*Zhilin, Matiskainen 2003*).

Archaeological layer I was excavated in trench 2. It yielded several Middle Neolithic flint artefacts and small bone fragments (*Zhilin 2002*).

Materials and methods

A total of 49 radiocarbon samples are currently available from the Stanovoye 4 site (Tab. 1; available at http://dx.doi.org/10.4312/dp.48.13). These include four artefact samples (see Fig. 3) that have not been published previously. In an effort to understand the characteristics of the samples, aspects of storage and sampling will be described. The methods involved in the sample subgrouping will also be explained.

During and after excavation

During excavation, finds and samples were stored in plastic bags. After the excavations the organic remains were cleaned with water and subsequently dated or stored. Some of the wooden and organic samples were dated shortly after excavation (and published by *Zaretskaya* et al. *2005*), while other samples were consolidated using one layer of a (10%) PVA solution made up of water and carpenter's glue (bought in the late 1990s). After the consolidation samples were stored in plastic bags.

Two fragments of wooden handles (KIA-35153 and KIA-35157) that were found inside antler mattocks

(sleeves) were put in plastic bags, while still wet, and kept there for a decade before being dated. According to Leopold D. Sulerzhitsky (personal communication) such a situation can lead to modern carbon being introduced into samples from surrounding air as a result of fungal activity inside the wood. There is therefore a possibility of modern contamination in these samples.

Sampling and dating of artefacts

The sampling of artefacts from the site has mainly been done by Mihail Zhilin who followed a procedure that starts by mechanically removing the surface of the bone artefacts in the area of sampling, in an active effort to avoid any surface contaminators. For some artefacts, such as larger antler sockets, a layer of up to 3mm of the surface was removed. Subsequently, a hole was drilled into the interior of the bone, creating the bone powder used for dating. For other artefacts, such as smaller and more delicate beaver mandibles, the surfaces were more lightly scraped off before drilling. Some artefacts were, however, sent to the lab for cleaning and sampling (and subsequently published by *Hartz* et al. *2010*).

Samples have been dated at different times and by various labs, including the Geological Institute at the Russian Academy of Sciences (RAS) (lab-code GIN), Leibniz Laboratory for Radiometric Dating and Stable Isotope Research in Kiel (lab-code KIA), Aarhus AMS centre (lab-code AAR) and the Groningen AMS lab (lab-code GrA). The newly dated radiocarbon samples were also dated at the lab in Kiel. The different labs follow similar protocols for preparing/cleaning the samples and collagen extraction (for individual lab procedures, see Appendix below).

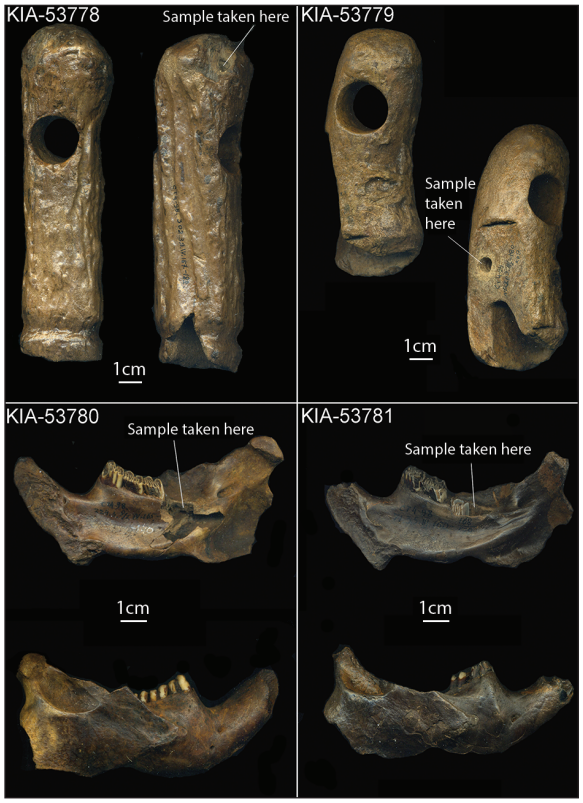


Fig. 3. The newly dated artefacts.

The samples were calibrated using the most recent r:5 Atmospheric IntCal20 dataset (*Reimer* et al. *2020*) in Oxcal v 4.4.2 (*Bronk Ramsey 2021*).

Subgrouping the samples

In an effort to exclude certain source critical issues, relating to various sample materials, dating methods and consolidation efforts, the samples will be subgrouped into different datasets. Each dataset will subsequently undergo calibration and individual chronologies will be presented, before a more general chronology for the site is discussed.

The attribution of samples in different datasets (Tab. 2) needs to be addressed. All samples are attributed to one of the following datasets: 1 (sediments), 2 (artefacts) or 3 (ecofacts). Each sample can be clearly attributed to one of these groups. However, for datasets 4–7, it is possible to find individual samples in several datasets, since one sample can be both AMS-dated (dataset 4) and consolidated (dataset 7).

Excluded samples

Some of the previously dated sediment samples underwent both cold and warm extractions, resulting in two dates for each sample (as noted in Table 1; available at http://dx.doi.org/10.4312/dp.48.13). These were sometimes not in agreement. In this study, we decided to use the dates from the warm extraction whenever the two fractions did not agree (see Appendix below).

Reviewing and calibrating the datasets

Dataset 1 – Sediments

Sediment samples and source critique

The dataset includes samples of silt and gyttja. These samples were 2–4cm thick and were extracted from the trench wall. In general, the use of sediments such as gyttja, silt and peat for radiocarbon dating has been criticized for several reasons, mainly due to the complexity of sedimentation processes and different potential origins of the accumulated carbon in

a small sample (*Zaretskaya* et al. *2001; Taylor, Bar-Yosef 2014.91–92*).

An issue relating to the sediment samples from Stanovoye 4 is the small representation of samples, with only a few samples from each layer. Moreover, despite the sediment layers containing archaeological materials/layers, the sediments themselves are not anthropogenic remains. Therefore, they don't directly date the occupational phases or human activities on the site.

Calibrated sediment dates

Based on the sediment dates from Stanovoye 4 (Fig. 4), the acquired site chronology seems to reflect 4–5 phases in a longer continuous sedimentation process. The samples from layer IV date to the final stages of the Younger Dryas and first half of the Preboreal, spanning 10 500–9300 cal BC. The two oldest dates have extensive standard deviations, amounting to 500–600 years, making an exact starting point for habitation difficult to interpret.

The samples from sediment layer IV/III date to the Preboreal, specifically between 9300 and 8700 cal BC. Samples from layer III seem to divide into two clusters, one at around 8300–7900 cal BC and another at 7800–7500 cal BC. However, there are too few samples to confidently argue for two separate occupational phases. Lastly, samples from layer II date to the Atlantic period, to *c.* 6600–5800 cal BC.

Dataset 2 – Artefacts

Artefact samples and source critique

The artefacts from the site include bone and antler artefacts as well as worked wooden handles and stakes. In general, bone and antler samples come with a number of source critical aspects. For instance, aquatic animals and marine-feeding animals can store higher amounts of aquatic carbon in their bones, resulting in an apparently older date, known as the marine/freshwater reservoir effect (*Philippsen 2013; Taylor, Bar-Yosef 2014.71–74*).

The dated bone samples from Stanovoye 4 do not include any aquatic fauna that can be subject to the marine/freshwater reservoir effect. Nevertheless, many of the dated bones and antler samples come from elk (*Alces alces*), which is a species that has been argued to be at risk of the freshwater reservoir effect due to their high consumption of aquatic plants (*Philippsen 2019*). Further research on this topic, which also included some finds from Stanovoye 4, has indicated little evidence for this relationship in general, although the finds from the site did suggest some temporal differences between an elk antler socket and its wooden handle (*cf. Philippsen 2019*). However, other reasons than the freshwater reservoir effect have been proposed for this (*ibid.*). These finds will also be discussed later in this article. Other dated bones from Stanovoye 4 include beaver (*Castor fiber*), which is a semi-aquatic animal with a terrestrial diet that can be excluded from the risk of the freshwater reservoir effect.

Dataset	Contents	Included samples
1. Sediment samples	Silt and gyttja samples.	GIN-8379, GIN-10111 II, GIN-10126 II, GIN-10106 II, GIN-10112 II, GIN-10127 I, GIN-10108 II, GIN-10122 II, GIN-10127 II, GIN-10109 II, GIN-10125 II, GIN-10110 II, GIN-10126 I
2. Artefact/ anthropogenic samples	Bone/antler artefacts and one unworked human bone. Worked wooden finds.	AAR-22231, GIN-8854, KIA-35157, AAR-22232, GIN-8856, KIA-35158, GIN-8374, GrA-34084, KIA-39316, GIN-8375, KIA-35152, KIA-39317, GIN-8376, KIA-35153, KIA-53778, GIN-8377, KIA-35154, KIA-53779, GIN-8378, KIA-35155, KIA-53780, GIN-8853, KIA-35156, KIA-53781
3. Ecofact samples	Unworked bone/wood	GIN-10113, GIN-10128, GIN-11093a
4. AMS-dated samples	Artefacts dated using AMS.	AAR-22231, KIA-35155, KIA-53778, AAR-22232, KIA-35156, KIA-53779, GrA-34084, KIA-35157, KIA-53780, KIA-35152, KIA-35158, KIA-53781, KIA-35153, KIA-39316, KIA-35154, KIA-39317
5. Conventional dated samples	Artefacts and ecofacts dated using conventional dating methods.	GIN-8374, GIN-8378, GIN-10113, GIN-8375, GIN-8853, GIN-10128, GIN-8376, GIN-8854, GIN-11093a, GIN-8377, GIN-8856
6. Non-consolidated samples	Artefacts and ecofacts that were not consolidated.	GIN-8374, GIN-8853, GIN-11093a, GIN-8375, GIN-8854, GrA-34084, GIN-8376, GIN-8856, KIA-35153, GIN-8377, GIN-10113, KIA-35157, GIN-8378, GIN-10128, KIA-39317
7. Consolidated samples (PVA)	Artefacts that were consolidated.	AAR-22231, KIA-35155, KIA-53778, AAR-22232, KIA-35156, KIA-53779, KIA-35152, KIA-35158, KIA-53780, KIA-35154, KIA-39316, KIA-53781

Tab. 2. The dated samples from Stanovoye 4 are attributed to seven different datasets, characterized by sample material, dating method and consolidation efforts. Note that each sample can be attributed to several datasets.

A human bone (GrA-34084) was also included into the group due to its direct connection with human activity at the site. Since Stanovoye 4 is located far away from any marine environment, the marine reservoir effect can be excluded from the human bone. However, due to the site's location on the shore of the nearby lake, a risk of a freshwater reservoir effect in the human bone could be considered (*Philippsen 2013; Meadows* et al. *2020*).

However, we assume that the dated human bone from Stanovoye 4 was not affected by the freshwater reservoir effect as suggested by the isotope value ($\delta^{13}C$= –21.08‰) (*cf. Alexandrovskiy* et al. *2009*). Additionally, the large amounts of mammal bones and smaller amounts of fish bones found in the same layer as the human bone (layer III, trench 3) has led to the interpretation that fish played only a minor part in the diet of the site inhabitants at that time (*Zhilin 2004*).

Generally, wooden artefacts can show an old-wood effect. This means that an artefact can appear older than its actual age since it is made up of several years' worth of tree growth and corresponding ages (*Taylor, Bar-Yosef 2014.67–68*). The dated wooden artefacts from Stanovoye 4 include several worked stakes (often made of birch), which vary between 6 and 10cm in diameter. Additional finds include a plank which is 1.2m long and 2cm thick and several handles (for antler sockets) which are 2–3cm in diameter. The wooden artefacts from Stanovoye 4 were probably not affected by the old wood effect due to their smaller sizes and fast-growing wood species.

Wooden stakes in general come with some additional contextual ambiguity as they tend to pierce several stratigraphic layers and archaeological contexts. This can make their exact contextual information difficult to assume, which decreases their contextual reliability compared to other artefacts. The stratigraphic positions of dated stakes from Stanovoye 4 are clearly defined, and their relationships with archaeological layer III (in both trenches) are reliable (*Zhilin 2003*). The dated wooden handles are at risk of modern contamination due to the way they were stored prior to dating (as previously mentioned).

Calibrated artefact dates

The calibrated artefact samples from Stanovoye 4 (Fig. 5) suggest a more or less continuous chronology at the site. Samples from layer IV span a time between 10 000 and 8700 cal BC. The oldest date displays a very large standard deviation, making the start of this phase imprecise. Some samples from layer IV match the age of two wooden stakes found in layer IV/III (GIN-8374 and GIN-8376) as well as a wooden stake, lying horizontally, in layer IIIa (GIN-8377). This is likely a result of the calibration curve

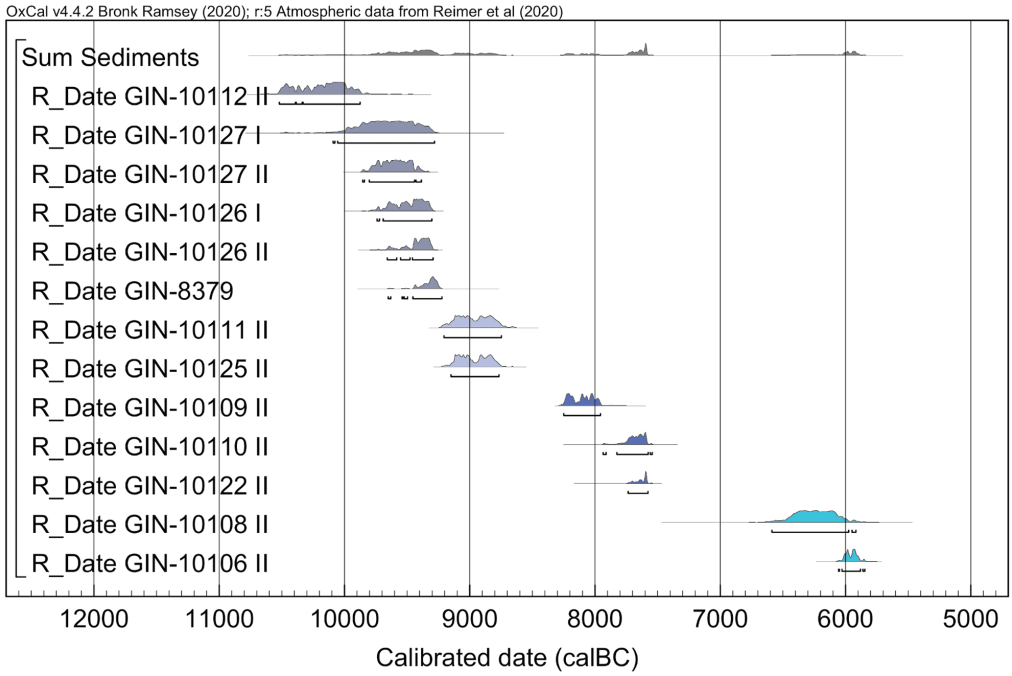


Fig. 4. Calibrated sediment samples from the site. The colours indicate their find contexts:* grey *archaeological layer IV;* light blue *layer IV/III;* dark blue *archaeological layer IIIa;* blue *archaeological layer III, and* turquoise *archaeological layer II.

plateaus at this time, and would indicate that the age of several of the artefacts from layer IV are not significantly older than the stakes from layer IV/III.

One other sample (KIA-53780) from layer IV is much younger than the remaining samples from that layer. In fact, it instead coincides perfectly with the samples from layer III. Perhaps the sample's contextual information was incorrectly documented, and should instead place the find in layer III. Another possibility is that the find represents a younger intrusion in older layers.

The samples from layer III suggest a long chronology, between 8800 and 7200 cal BC. The samples cluster in several groups throughout the time period, likely due to the character of the calibration curve.

One artefact sample from layer II (GIN-8378) provides a date at around 6100–5700 cal BC, placing it in the Neolithic period.

Dataset 3 – Ecofacts

Ecofact samples and source critique

Only three samples are included in this group, all of which are unworked (*i.e.* not altered by humans). The sample GIN-10128 come from a piece of birch trunk (diameter 12cm), the sample GIN-10113 is a wooden branch with a 6cm diameter and sample GIN-11093a was taken from an elk bone. Since the ecofacts are unworked they do not necessarily reflect human activities on the site. Additionally, the latter sample is the sole ecofact sample found within a clear archaeological layer (III, in trench 3). The sample GIN-10128 was found in a sterile interlayer between archaeological layers IV and III in trench 2, while the sample GIN-10113 pierced several layers, probably as a result of a tree fall (*Zaretskaya* et al. *2001*).

Wooden samples are, as always, at risk for old wood effect. Though, the samples ages of the ecofact samples at Stanovoye 4 are probably not high enough to significantly alter the chronology of the site. The same can be said about the unworked elk bone which also has an unknown age, but should not be older than 25 years (maximum average age of European elk).

Calibrated ecofact dates

The ecofact samples suggest a very limited chronology (Fig. 6), based on the few available samples. The sample GIN-10128, from layer IV/III, dates to around 9300–8800 cal BC. From the same layer, sample GIN-10113 instead dates to *c.* 8200–7600 cal BC, which more closely matches the final ecofact date from sample GIN-11093a. This sample comes from layer III and matches the sediment samples from the same context, dating to 8200–7600 cal BC. Sample GIN-10113 possibly represents a younger intrusion into older layers.

Dataset 4 – AMS dates

AMS-dated samples and source critique

AMS-dated samples are generally more precise than conventionally dated samples (*Bronk Ramsey* et al. *2004*), which makes this dataset support a more detailed chronology in general. Additionally, the finds from the site that were prioritized for AMS-dating are all artefacts and, thus, directly related to anthropogenic activities. The samples within dataset 4 are therefore characterized by both a strong contextual integrity and archaeological reliability.

A critical aspect of this dataset is the lack of samples from archaeological layers IIIa and II. Additionally, most of the AMS-dated samples have been consolidated using PVA-glue which increases the risk of contamination (more on this in Dataset 6).

Calibrations of AMS-dated samples

The AMS-based chronology (Fig. 7) is almost identical to the previously described artefact chronology (see Dataset 2). To summarize, archaeological layer IV dates to between 10 000 cal BC and 8700 cal BC, while layer III starts around 8800 cal BC and ends sometime between 8300 and 7200 cal BC.

Dataset 5 – Conventional dates

Conventionally dated samples and source critique

The samples that were dated conventionally are all ecofacts or wooden stakes. As already mentioned, unworked ecofacts do not necessarily date anthropogenic activities on the site.

Calibrations of conventionally dated samples

The chronology, based on conventionally dated samples (Fig. 8), suggests that the oldest dates from the site come from layers IV/III and IIIa. These together span 9300–8800 cal BC. Although these dates do not represent the oldest settlement of the site, it appears that way since all dates from older layers were AMS-dated.

One sample from layer IV/III groups with samples from layer III, as was observed in dataset 3. The samples from layer III span 8600–7500 cal BC. A sample from layer II is much younger than the remaining samples and dates to 6100–5700 cal BC.

Dataset 6 – Non-consolidated samples

Non-consolidated samples and source critique

The non-consolidated samples can be excluded from the risk of PVA contamination (see Dataset 7). However, other source critical aspects relate to these samples. For instance, samples consist of both ecofacts and artefacts, which vary in the level of anthropogenic relation. Additionally, the non-consolidated samples were dated using either AMS or conventional dates, resulting in mixed levels of precision.

Calibrations of non-consolidated samples

The non-consolidated samples (Fig. 9) group in several clusters. The first cluster of dates includes samples from layers IIIa and IV/III, which together span 9300–8800 cal BC. The two samples from layer IV, falling within the same cluster, are discussed later on. The samples from layer III group into several clusters, although this is probably a result of the calibration curve plateaus. It is likely that the samples from layer III represent a continuous settlement on the site from around 8700 until 7500 cal BC, as seen in the other datasets. The one sample from layer II dates the layer to *c.* 6100–5700 cal BC.

Dataset 7 – Consolidated samples

Consolidated samples and source critique

The consolidated samples are all AMS-dated, making them more precise than conventional dates. The AMS dates based on artefacts are also directly related to anthropogenic activities on the site. Unfortunately, all these samples come from only two of the archaeological layers, IV and III, while the remaining layers lack representation.

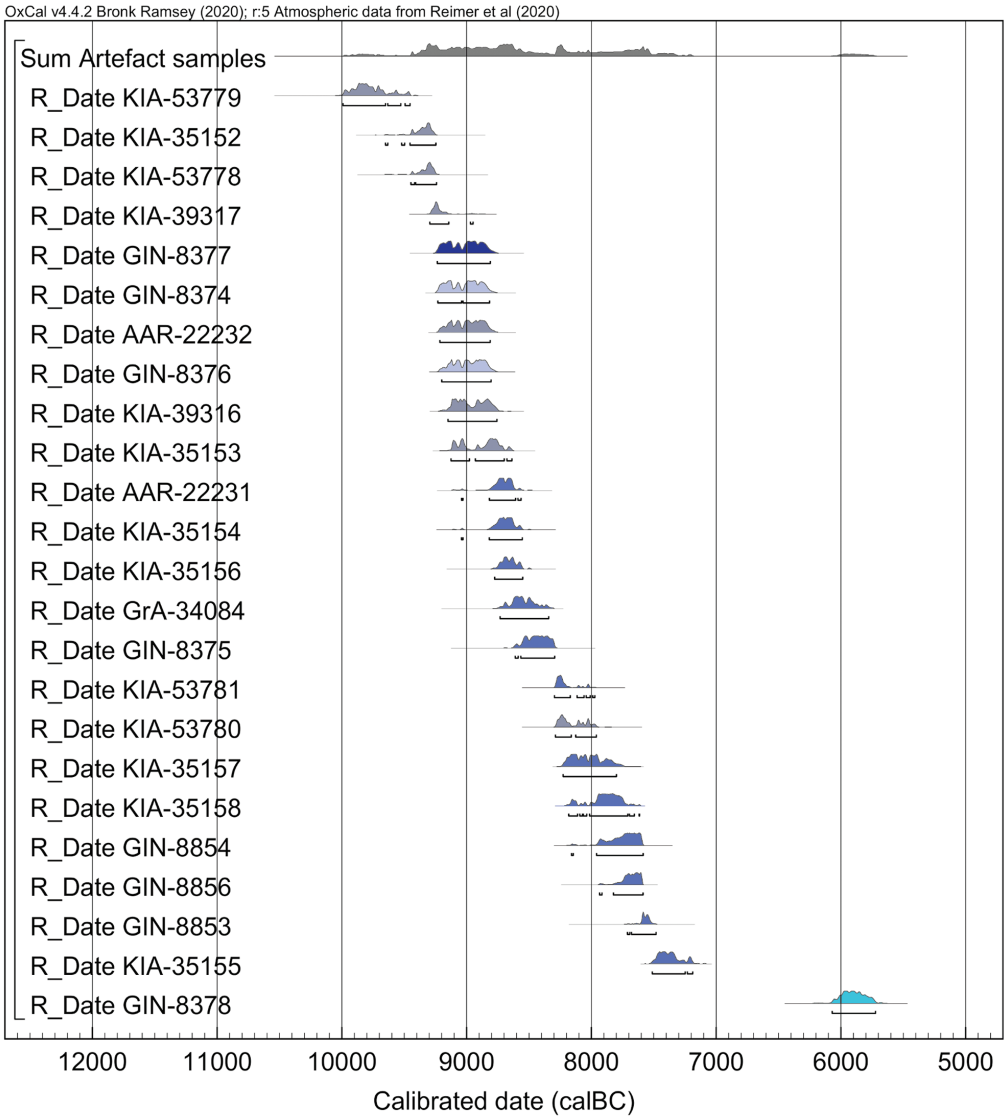


Fig. 5. Calibrated artefact samples from the site. The colours indicate their find contexts: **grey** ***archaeological layer IV;*** **light blue** ***layer IV/III;*** **dark blue** ***archaeological layer IIIa;*** **blue** ***archaeological layer III, and*** **turquoise** ***archaeological layer II.***

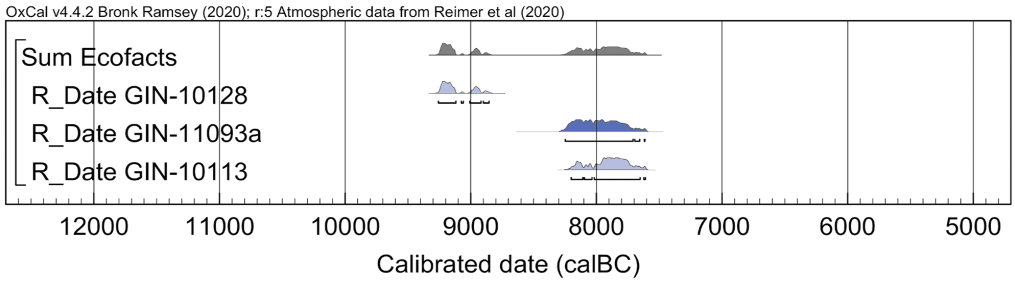


Fig. 6. Calibrated ecofact samples from the site. The colours indicate their find contexts: **grey** ***archaeological layer IV;*** **light blue** ***layer IV/III;*** **dark blue** ***archaeological layer IIIa.***

Several organic samples from the site were preserved using PVA-glue. This practice has been common since the 1950s, especially for finds from waterlogged sites. Many PVA-based consolidants exist, including PVA, PVAc and PVAL, but the most commonly used variety is known as 'Elmer's carpenter's glue'. Early studies showed that the glue could be easily removed in the lab prior to dating. However, in more recent years, studies have indicated that it might be harder to remove than initially thought. The reason is that PVA will form cross-linking of polymers which, over time, reduces its solubility (*Johnson 1994*).

An additional issue is that the details surrounding consolidation efforts are rarely documented. Often, it is not known which PVA-variety was used or how the treatment was carried out. This is an issue, since the details of these procedures play a role in the successful removal of the consolidant. Furthermore, the porosity of the artefact may also affect the solubility of the PVA (*cf. Brock* et al. *2018*).

The reliability of the samples, and the related dates, depends on the successful removal of PVA, since remains can result in dates appearing older than they actually are. There are various strategies for removal of PVA-contaminants in the lab, most of which include the use of repeated washes of distilled water, acetone and methanol (as suggested by *Stevens, Hedges 2004*). The samples from Stanovoye have undergone similar treatments (see Appendix below).

However, several standard pre-treatments involving acetone, chloroform and methanol have in some stu-

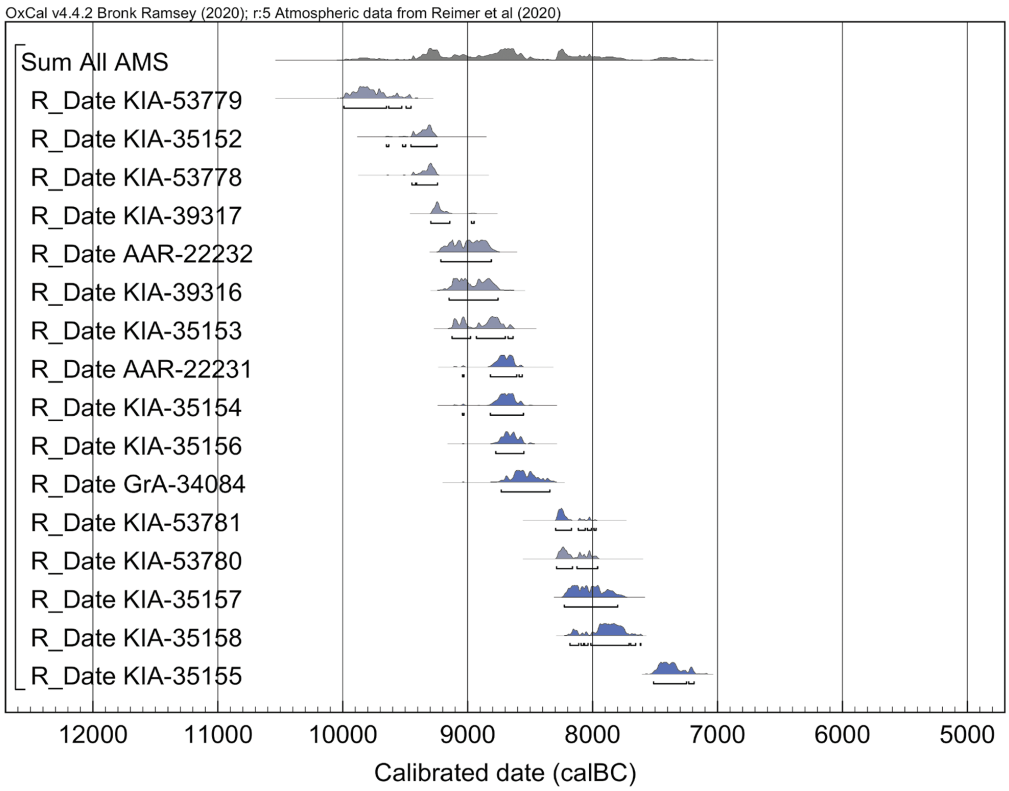


Fig. 7. Calibrated AMS-dated samples from the site. The colours indicate their find contexts: **grey** ***archaeological layer IV;*** **dark blue** ***archaeological layer IIIa.***

dies proven ineffective for removing common consolidants (*Dee* et al. *2011; Brock* et al. *2018*). Therefore, the dating of PVA-treated finds is not recommended unless alternative methods can be applied or the consolidated areas can be avoided (*ibid.*). The results by Fiona Brock *et al.* (*2018*) have been criticized due to their use of modern PVA-glue (often containing plastics and other additives), which may not be relevant for consolidation efforts in the past (*Meadows* et al. *2019*). Additionally, the use of the silica-polymer *Chromosorb*™ (as a base for contamination experiments) might not correctly map the potential chemical cross-linking between the consolidant and the sample itself, due to the material's highly absorbent properties (*Dee* et al. *2011*).

The use and removal of older consolidants on actual (Mesolithic) bone artefacts has recently been investigated (*Meadows* et al. *2019*). Although the investigated bones turned out to not be consolidated using PVA, the other preservation mediums were found to have penetrated into the bone, while the highest concentrations were found on the surface (*ibid.*). If this is true also for PVA-consolidants, it could mean that the Stanovoye samples from further within the bone contain lower amounts of remaining PVA-contamination compared to samples from just beneath the surface.

The issues relating to the treatment and removal of PVA-glue from artefacts are clearly complicated. The PVA-treated artefacts from Stanovoye must be considered somewhat less reliable, since lab pre-pre-treatments may not be as reliable for PVA-removal as previously indicated. If the consolidated samples from the site are affected by any remaining PVA, they could appear older than non-consolidated samples from the same contexts.

Calibrations of consolidated samples

The PVA-consolidated samples from Stanovoye 4 (Fig. 10) provide a very similar chronology to the AMS-dated samples, mainly due to the fact that the two chronologies largely consist of the same selection of samples. Nonetheless, the consolidated samples also follow the chronology suggested by the non-consolidated samples. The consolidated samples from layer IV span the time 10 000–8700 cal BC, although with few overlapping dates. Samples from layer III follow the already described pattern, which likely represents a long-term occupation on the site between 8800 and 7200 cal BC.

The samples AAR-22232 and KIA-53778 come from the same artefact, an elk antler socket, which was consolidated using PVA. The AAR-sample was the first to be extracted and the KIA-date was taken from the same area but from further within the artefact. The wooden handle that belongs to the same artefact was not consolidated, but also dated (KIA-35153). However, this sample instead poses a risk of modern contamination due to incorrect storage after excavation. A comparison of the samples can be found in Table 3.

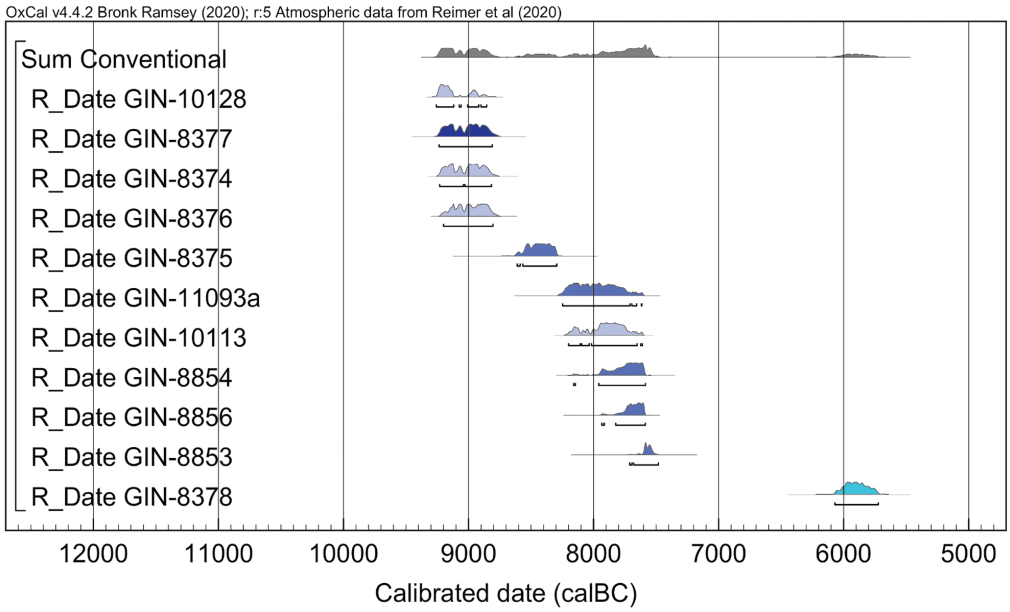


Fig. 8. Calibrated conventionally dated samples from the site. The colours indicate their find contexts:* grey *archaeological layer IV;* light blue *layer IV/III;* dark blue *archaeological layer IIIa;* blue *archaeological layer III, and* turquoise *archaeological layer II.

As is clear from the table the two samples from the same antler artefact gave differing results, by 258 ^{14}C years, with the AAR-sample being younger and more closely correlating to the related wooden handle (although with a difference of 92 ^{14}C years, *cf. Philippsen 2019*). Although, if the handle is contaminated with modern carbon, perhaps the older KIA-53778 date is more reliable. The processes at play here, and reasons for the differing dates from the one tool, are not yet completely understood. Theoretically, reasons related to PVA-contamination, slight differences in lab procedures or other unknown factors could play a role. Further investigations are necessary to understand the processes behind these results.

A detailed discussion of the samples and site chronology

Here, the multiple chronologies will be compared to each other, and discussed in relation to the sedimentation sequence and archaeological finds from the contexts, in an effort to understand a more general chronology of the site.

Archaeological layer IV

The first occupation phase in the site's history relates to layer IV in both trenches. Archaeological finds from the context have been typologically and technologically interpreted as belonging to the early Butovo technocomplex. At the early stage of this habitation phase, people had settled on the shoreline of the ancient lake.

The sediment samples from layer IV generally suggest an older and shorter chronology (*c.* 10 500 to 9200 cal BC) compared to the artefact samples (*c.* 10 000–8700 cal BC). Ecofacts from layer IV have not been dated and can thus not be compared. A closer look at the individual samples shows that the start and end of these chronologies are rather imprecise, mainly due to the many plateaus on the calibration curve in the early Holocene.

One sediment sample (GIN-10112 II) sets the start of the sediment chronology to 10 500–9800 cal BC. If this lone sample is considered an outlier, the sediment chronology more closely matches the starting point of the artefact-based chronology. However, the oldest artefact sample (KIA-53779) also falls within a plateau on the calibration curve, making it less precise. Nevertheless, the early sediment samples could be viewed as support for such an early start to the phase. If the early artefact and sediment samples are considered reliable, the site was first settled already during the end of the Younger Dryas.

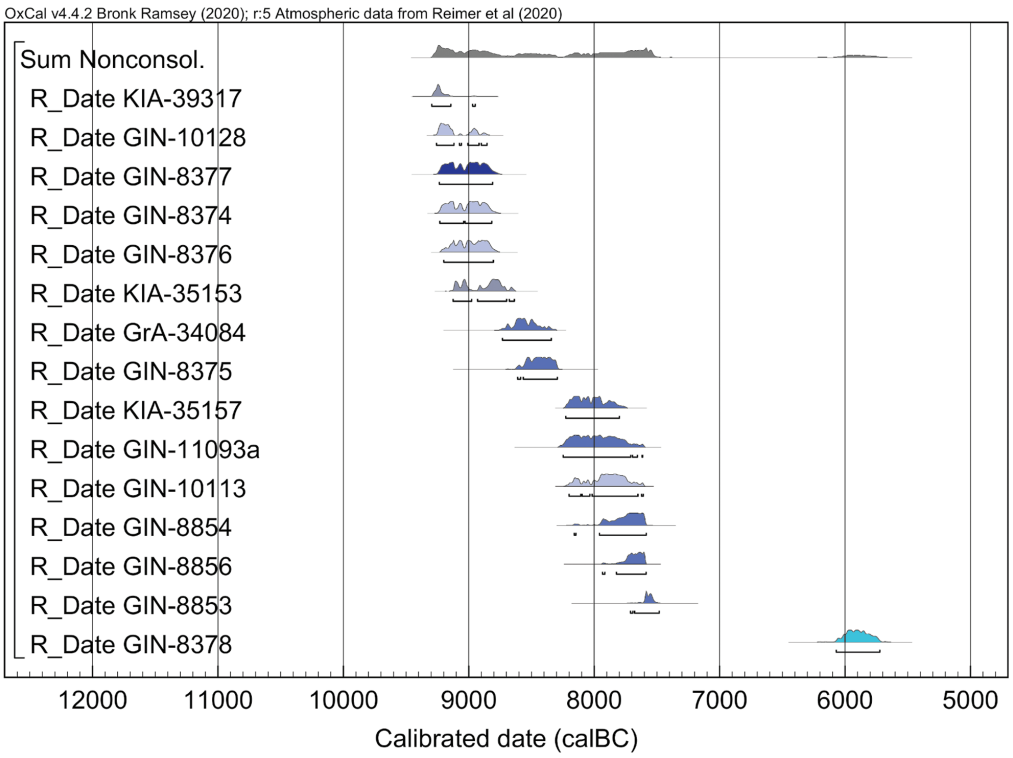


Fig. 9. Calibrated non-consolidated samples from the site. The colours indicate their find contexts: **grey** ***archaeological layer IV;*** **light blue** ***layer IV/III;*** **dark blue** ***archaeological layer IIIa;*** **blue** ***archaeological layer III, and*** **turquoise** ***archaeological layer II.***

If we assume that these samples are not reliable, the occupation should instead have started in the early Preboreal, around 9400–9200 cal BC, as suggested by three rather precisely dated artefact samples; KIA-39317 (trench 2), KIA-35152 and KIA-53778 (trench 3).

The remaining artefact samples from layer IV (AAR-22232, KIA-39316 and KIA-35153) date to 9200–8600 cal BC, a time which is also characterized by a calibration curve plateau, again making the end of the occupation phase imprecise. While these samples are all AMS-dated, the latter is at risk of modern contamination. All the AMS-dated samples, except for the one just mentioned, were also consolidated using PVA. The dates AAR-22232, KIA-39316 and KIA-35153 also date to the same time as sediments and artefacts from the overlaying layers IIIa and IV/III (see below), which could indicate that they are unreliable. It could also be an indicator that the temporal difference between the two layers is small.

Due to rising water levels, people had to move away from the shoreline and the artefacts and sediments relating to archaeological layer IV were subsequently submerged in gyttja deposits.

Archaeological layer IIIa and sediment layer between IV/III

During a temporary water regression during the Preboreal, the site was again inhabited, this time by people related to the Ienovo technocomplex (*Zhilin, Matiskainen 2003*). It is likely that a small difference in age is not observable in this part of the chronology due to the long calibration curve plateau at this time. This is assumed because of the stratigraphic sequence as well as a difference in typology between the archaeological layers. Dating more (typo-chronological characteristic) samples from layer IIIa could help determine the age of the layer in relation to adjacent contexts.

The same can be argued about the wooden stakes from trench 2, sediment layer IV/III. The samples (GIN-8374, GIN-8376) were found in horizontal positions, stratigraphically located above the level of layer IV and in the same level as the finds from layer IIIa. Their calibrated dates fall within the same plateau as the sample from layer IIIa. Nonetheless, it cannot be excluded that these samples are related to the habitation mentioned above, by people related to the Ienovo technocomplex.

One ecofact sample from trench 3 (GIN-10113, a thick branch) pierced several layers, perhaps as a result of a tree fall. It is younger than the sediment and rest of the finds, which indicates that it represents a younger intrusion into older layers.

Archaeological layer III

After another period of rising water levels, by the nearby lake, continuous habitation in the area around the lake and artefacts related to archaeological layer III are accumulated in the water. Pollen indicates

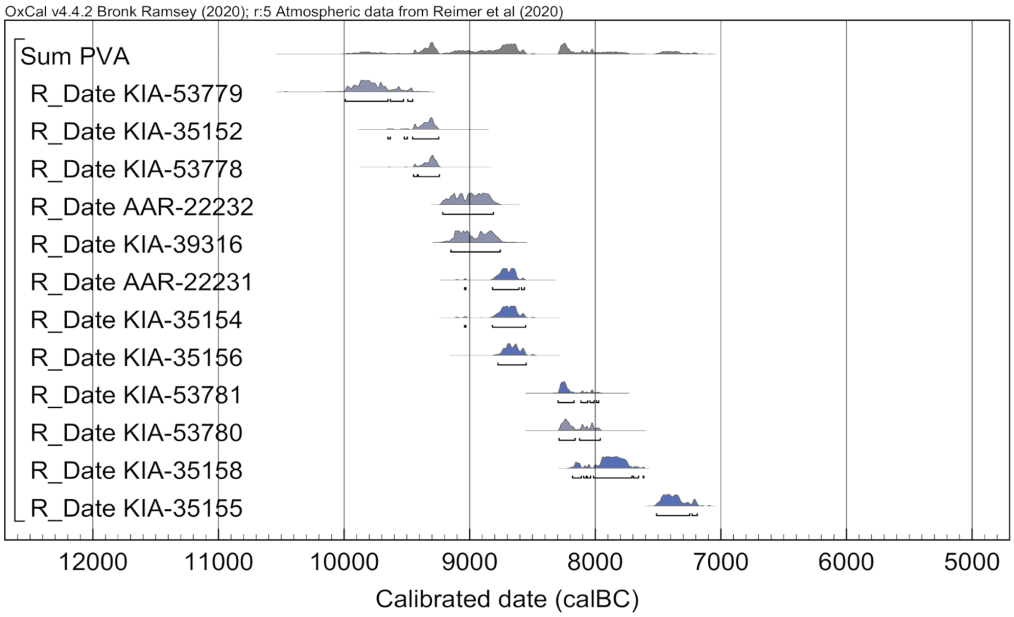


Fig. 10. Calibrated consolidated samples from the site. The colours indicate their find contexts: **grey** ***archaeological layer IV;*** **light blue** ***layer IV/III;*** **blue** ***archaeological layer III.***

Lab no.	Part of artefact	Trench	Position	Satrat.	Uncal. BP	Cal BC (95.4%) Start	Cal BC (95.4%) End	PVA-treated
KIA-35153	handle	3	square 302	Cult. lay. IV	9505±47	9126	8638	no
AAR-22232	antler (further outside)	3	square 157	Cult. lay. IV	9597±43	9215	8812	yes
KIA-53778	antler (further inside)	3	square 157	Cult. lay. IV	9855±50	9447	9242	yes

Tab. 3. Three samples from the same elk antler socket and related wooden handle.

that this occurred in the second half of the Preboreal (according to samples from trench 3) and in the early Boreal (according to samples from trench 2) (*Aleshinskaya 2001*).

The technology and typology of the artefacts from layer III indicate that they are related to the Middle Butovo technocomplex (*Zhilin, Matiskainen 2003*). The artefact dates from this layer, in trench 2, suggest a chronology spanning 7900–7500 cal BC. A similar pattern is observable in the sediment dates from the same context, which span the time between 8300 and 7600 cal BC.

The artefact samples from the layer in trench 3 instead propose a slightly longer chronology than in trench 2, here stretching from 8800 to 7600 cal BC. One sample (KIA-35155) with a younger date is discussed below. Interestingly, the samples appear to cluster into several sub-phases. However, this is probably an effect of the many calibration curve plateaus during this time span, although the presence of some temporary hiatus within this long time period is probable. Nonetheless, it is likely that the site was more or less continuously or repeatedly settled from the second half of the Preboreal up to the middle of the Boreal period. This is also confirmed by pollen data.

A closer look at some of the artefact samples indicates that habitation at the site may also have taken place during harsher climate conditions. The first five artefact dates fall within a plateau located in the curve around 8800–8300 cal BC. Another couple of dates (KIA-53781 and KIA-53780) fall within the global cold spell around the 7th Bond-event (*Bond* et al. *1997*) around 8300–8100 cal BC. After the Bond-event, another four dates cluster within a plateau in the calibration curve, between 8200–7600 cal BC, followed by another steeper part of the curve where we also find activity on the site (samples GIN-8853) at 7700–7500 cal BC.

The youngest sample from layer III (KIA-35155) dates to sometime around 7500–7200 cal BC, and is also located within a calibration curve plateau. It is significantly younger than the other samples in trench 3, which could indicate that it is a later intrusion. An archaeological layer dated to the second half of the Boreal period was excavated in trench 1 (*Zhilin 2002*), and perhaps this sample relates to that occupation.

Archaeological layer II

The Neolithic layer II is dated via two sediment dates and one artefact date, all from trench 2, to a time span around 6600–5700 cal BC. Typologically distinct finds relating to the Upper Volga culture were found in the same context. One of the samples (GIN-10108 II) also falls within an extensive calibration curve plateau, making it imprecise. More dates from this archaeological layer would provide a better chronological base for this Neolithic occupation phase.

Even though many of the dates fall within plateaus in the calibration curve, which inherently lead to less reliability, there are nonetheless clear signs of long-lasting or repeated visits and activities in the area of the site throughout the Early Holocene.

The role of AMS-dated and non-consolidated samples from Stanovoye 4

After calibration, there is no significant difference in the precision of the AMS-dated samples compared to the conventionally dated samples, mainly due to the character of the calibration curve for the early Holocene.

However, the comparison between AMS-dated samples and conventionally dated samples showed that certain contexts and sample materials have been prioritized during dating. This creates a skewed general chronology for the site, since the more reliable (AMS-dated) samples all come from layers IV and III. Meanwhile, layers IIIa and II are not represented at all, and therefore do not contribute to the understanding of the site chronology as reliably as samples from other contexts. Although it should be noted that the conventionally dated samples, from layers

IIIa, IV/III and II, tend to generally follow the chronologies suggested by the AMS-dates, which indicates that their slightly less reliable nature (due to their dating method) plays a smaller role in this instance. Nonetheless, a more detailed chronology of Stanovoye 4 can only be possible with further AMS-dating of reliable samples along with the further development of the calibration curve for this time period.

Two samples (KIA-39317, GrA-34084) are AMS-dated but not consolidated, which would make them the most reliable samples from the site. They were also not affected by modern or ancient processes like improper storage and reservoir effects. This puts them in a unique position for comparison with the other samples. Nonetheless, these samples do not appear to stand out from the chronology created by the rest of the samples. On the contrary, they fit well into the chronologies suggested by the artefact samples/AMS-dated samples. This would indicate that the consolidated samples, which underwent cleaning procedures in the labs before dating, seem to be unaffected by the PVA. However, any small differences in age due to PVA-contamination would perhaps go unnoticed due to the multitude of calibration curve plateaus. Needless to say, further testing for PVA-contamination on relevant samples would be useful in order to resolve this issue.

Conclusion

In this contribution we discussed the many types and common characteristics, of ^{14}C-dated samples that are readily available from sites excavated only a few decades ago. It has become clear that the use of slightly older assemblages can be a challenge, due to the constant development of methods and techniques within the field of conservation and radiocarbon dating. Samples taken under current best practices should, and can, still be useful for furthering the understanding of prehistory. Therefore, it is of little gain to simply consider them 'bad' by modern standards and discard them from use. This includes samples that were consolidated using PVA or samples of certain sample materials. It is our opinion that it is better to work with what we have rather than discarding information, in order to better understand the site under the given circumstances. This is of special interest for studies of legacy materials.

In this article, we also set out to investigate the possible effect of PVA-contamination on a selection of the samples from the site, from a strictly archaeological perspective. Although recent studies have shown that PVA is more difficult to remove in the lab than was previously understood, the samples from Stanovoye 4 do not appear to be affected by any remaining PVA contamination, as based on their close correlation to the non-consolidated samples. However, extensive plateaus in the calibration curve for this time make detailed comparisons complicated. Furthermore, these are only initial indications based on a small number of comparable samples. More studies focused on the effects of PVA-contamination should thus be done to confirm or refute these results. The further dating of non-consolidated bone and antler samples from the Stanovoye 4 site, as well as other organic materials such as resin, would also be beneficial for understanding the chronology of the site in general.

The chronologies suggested by various fractions of radiocarbon samples from the site Stanovoye 4 support a joint timeline which includes long standing traditions and a continuous site history that lasts almost 3000 years. The oldest archaeological layer IV on the site relates to the settlement by people related to the Early Butovo technocomplex, and took place between *c.* 10 000–9500 cal BC. After some hiatus, and shorter visits on the site by people linked to the Ienovo technocomplex, the site is again more continuously in use by people in relation to the Middle Butovo technocomplex. Artefacts made and implemented by these people are found in layer III and date to between 8800 and (definitely) 7600 cal BC, possibly even until *c.* 7200 cal BC. Although a broad chronology for the site has been constructed, many details remain unclear, due to the complex calibration curve during the early Holocene.

Furthermore, it has been highlighted that certain contexts of the site have been prioritized for AMS-dating and consolidation, while others are hardly represented at all. More dating efforts are needed from layers IIIa and II in order to reach a more holistic chronological understanding of the site.

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Appendix – Sample treatment at different labs

The organic samples from Stanovoye 4 reported in our paper were radiocarbon dated at different times in various labs. The pre-treatments involved in the dating procedure can be found below along with relevant sources.

Leibniz Laboratory for Radiometric Dating and Stable Isotope Research in Kiel (lab-code KIA):

Pre-treatment of the bones and collagen extraction was done in several steps. Firstly, the pieces of crushed, solid bone material (0,5–2mm) were defatted using acetone, rinsed with demineralized water and subsequently demineralized in HCl (*c.* 1%). Mobile humic acids were removed by taking the previously demineralized bone material and treating it with 1% NaOH (20°C, 1h) and once again with 1% HCl (20°C, 1h). The bone collagen, to be used for dating, was dissolved overnight as gelatine in demineralized water at 85°C and pH = 3. Insoluble particles were removed using filtration through a 0.45µm pore silver filter. The gelatine solution was then freeze-dried, which is an adaption of the method described by Longin (*1971*).

Combustion to CO_2 was performed in an evacuated quartz tube with CuO and silver wool at 900°C. The obtained CO_2 was subsequently reduced at 600°C, using H_2 and iron powder as the catalyst. The resulting graphite mixture was pressed into a target holder for AMS measurement.

Geological Institute at the Russian Academy of Sciences (RAS) (lab-code GIN):

The sediment samples dated in 2005 were subdivided into two fractions, one of which underwent a hot alkaline extraction and the other a cold alkaline extraction. This procedure was designed to separate and recover organic matter that relate to different stages of preservation (details in *Zaretskaya* et al. *2001*). This also resulted in two dates for each sample (I and II). Nataliya E. Zaretskaya *et al.* (*2001*) use the age difference between the two measurements as a reflection of the age variation within the

sediment layer. The warm-extractions were mainly used in the current study.[1]

Wood and bone samples were pre-treated and dated using routine procedures used at GIN. Wood samples underwent a standard A-A-A pre-treatment; the samples were first cleaned by standing in hot 5% HCl, washed with distilled water and subsequently boiled for 20 min in a 2% NaOH solution. Alkali insoluble wood fragments were then digested in hot 5% HCl and finally washed with distilled water (*Zaretskaya* et al. *2001*).

Aarhus AMS centre (lab-code AAR):
Bone and antler samples were demineralized using 1M HCl for several days, until the end of effervescence (complete dissolution of calcium carbonate) and no observed density gradient (calcium phosphate completely dissolved). Humates were then removed using 0.1M NaOH, with renewed NaOH until the solution remained colourless, with each base step lasting several hours at 4°C. After each base/acid step, samples were rinsed three times with demineralized H_2O. Finally, the samples were rinsed three times with a weak HCl-solution (pH=2), covered with that solution, and heated to 58–80°C for 48 hours, until collagen was dissolved. Samples were centrifuged (15 minutes at 2000rpm) and filtered through 0.45µm syringe filters, before being freeze dried (*Philippsen 2019*).

Groningen AMS lab (lab-code GrA):
Collagen from the bones was extracted using a modernized version of the Longin method (*Longin 1970*). The collagen was then combusted, purified and transferred into graphite (*Aerts-Bijma* et al. *2001*). This graphite was pressed into target holders for the AMS ion source. The AMS measured the isotope ratios $^{14}C/^{12}C$ and $^{13}C/^{12}C$ of the graphite, from which the conventional ^{14}C age is determined (*van der Plicht* et al. *2000*). The stable isotope ratios $^{13}C/^{12}C$ and $^{15}N/^{14}N$ were measured for the same collagen dated by AMS. These stable isotope ratios were measured by an elemental analyser, combined with a mass spectrometer (*Aerts-Bijma* et al. *2001; Alexandrovskiy* et al. *2009*).

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1 A similar approach as described by Zaretskaya *et al.* (*2005*) has been presented as a manner of removing mobile secondary organics from the bulk sediment (Beta Analytical n.d., sections 'Acid/alkali/acid' and 'Acid/alkali/acid – solubles'). These mobile organics have been shown to often reflect younger fractions of the soil (*Nilsson* et al. *2001*, and sources therein) which, if not removed can result in a modern contamination. Due to the higher risk of more modern carbon in the mobile organics, the cold-extraction samples from Stanovoye were considered less reliable than warm-extraction samples, and thus excluded when the two fractions were non-consistent. I the case that samples correspond to the same age, samples from both extraction methods remain in the study.

Elateia 1 in northeastern Thessaly 8000 years ago: relative and absolute chronology of a flat extended settlement

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ABSTRACT – *Intensive and systematic surveys in the area south of Mount Olympos and west of Mount Ossa revealed not only tell settlements, but also several flat sites from different prehistoric periods. For one of the settlements, namely Elateia 1, a detailed relative chronological assessment was made with the help of statistical evaluations of pottery assemblages. In addition, short-lived bone samples confirmed and more precisely defined the exact chronological position of this 10-hectare site within the Middle Neolithic period. The present study underlines the importance of statistical evaluations of complete pottery assemblages, even those obtained through survey investigations, and their significance for a better understanding of chronological, chorological and post-depositional processes.*

KEY WORDS – *Thessaly; flat sites; Early Neolithic; Middle Neolithic; absolute and relative chronology; pottery analysis*

Elateia 1 v severovzhodni Tesaliji pred 8000 leti: relativna in absolutna kronologija plane razširjene naselbine

IZVLEČEK – *Intenzivni in sistematični terenski pregledi na območju južno od gore Olimp in zahodno od gore Ossa so odkrili ne le naselbine tipa tell, ampak tudi številna plana najdišča iz različnih prazgodovinskih obdobij. S pomočjo statističnega vrednotenja zbirov lončenine smo za eno izmed teh najdišč, tj. Elateio 1, izdelali natančno oceno relativne kronologije. Najdišče, ki je veliko 10 hektarjev, smo tako lahko s pomočjo kratkoživih vzorcev kosti potrdili in bolj podrobno opredelili natančno kronološko pozicijo v obdobju srednjega neolitika. S pričujočo študijo poudarjamo pomen statističnega vrednotenja celotnih lončeninskih zbirov, tudi tistih, ki so bili pridobljeni s površinskimi preiskavami, in njihov pomen pri razumevanju kronoloških, horoloških in podepozicijskih procesov.*

KLJUČNE BESEDE – *Tesalija; plana najdišča; zgodnji neolitik; srednji neolitik; absolutna in relativna kronologija; analiza lončenine*

Introduction

Thessaly in central Greece is internationally renowned for the many multi-layered settlement mounds or magoules located not only in the vast plain, but also in hilly areas. A chain of mountains comprising the Lower Mt. Olympos in the north, followed by Mt. Ossa, Mavrovouni, and ending with Mt. Pilion and its adjacent hilltops in the south, separates the Thessalian Plain from the Aegean Sea. Especially the western flanks of this chain of mountains provided basic resources, such as flowing bodies of water, some of them feeding lakes, or different kinds of precious rocks like marble, gabbro and serpentinite.

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As such, they offered prehistoric peoples perfect living conditions with abundant water resources, fertile alluvial fans and soils, and direct access to raw materials.

One hundred and twenty years ago the famous sites of Sesklo and Dimini in the south-eastern part of Thessaly were extensively excavated, and 60 years ago two sites in the northeastern reaches, Nessonis I and Gediki (Fig. 1), were investigated with small trenches. Today, 60 years later, in an ongoing German-Greek cooperation project under the auspices of the Ephorate of Antiquities in Larissa and supported by the German Research Foundation, special attention has turned towards systematic and intensive surveys and non-invasive investigation methods. During this research we discovered several flat sites that had escaped attention in previous times.

Flat sites are much more difficult to locate, due to their comparatively thin cultural layer subjected to erosion or, in contrast, due to their coverage with thick alluvial deposits. They are extremely endangered, especially since today's agricultural machinery with rotating deep ploughs not only destroys clods of earth, but also (pre)historic finds and artefacts. The few flat sites known so far were either discovered during extensive surveys or rescue excavations, or brought to the attention of the Ephorate by local people (*Gallis 1992; Toufexis 2017. 28–30, 345–350; Anetakis* et al. *2020*). This was the case at Elateia 1 in the area called 'Bigmeni Petra' (Μπηγμένη Πέτρα) because of a 2.26m long 'standing stone' erected at the highest point of the site.

The Basin of Elateia

In the spring of 2017, we started systematic research in the north-easternmost area of Thessaly, south of Mt. Olympos and west of Mt. Ossa (Fig. 1). There, over time, two basins had formed, those of Sykourio and Elateia. The southerly Basin of Sykourio had already been investigated in the late 1950s to early 1960s by Dimitrios Theocharis (*1962*). He was able to identify several sites, all of which he classified as *magoules*. Six of them were presumably related to a lake, the 'Bara Toibasi', today desiccated (*Reingruber* et al. *2021*). A seventh site was identified later in the very south of the Sykourio Basin (*Gallis 1992*). In the very north, near the opening leading to the Basin of Elateia, a *magoula* was founded upon a natural hill during the Neolithic period, which was inhabited mainly in the Bronze Age: Bounarbasi (*Kilian 1976*).

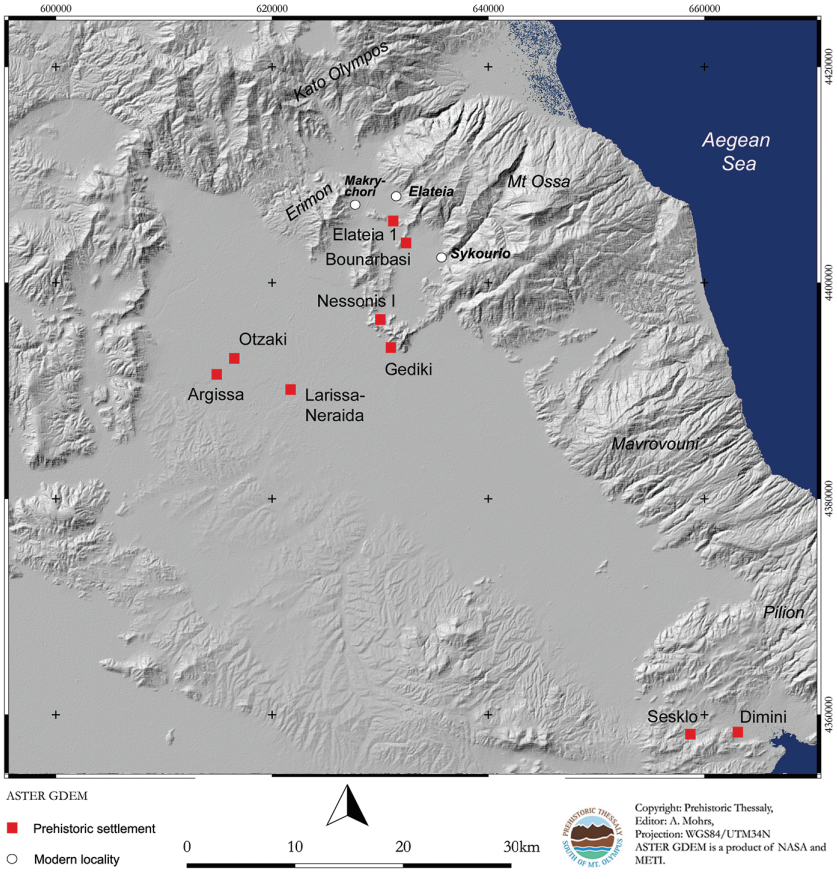


Fig. 1. Eastern Thessaly with the basins of Sykourio and Elateia and some of the Neolithic sites mentioned in the text.

Less attention was given to the Basin of Elateia, north of Bounarbasi. It is crossed by the River Pinios in the north, whose course defines the northern limit of the investigated area. From the confluence of the Kalamitsa and Pinios rivers in the north down to the modern village of Kypselochori the distance is *c.* 9km. In east-west direction, from modern Elateia to Makrychori, the distance is only 4.8km. On both of its lateral sides the Basin of Elateia is bordered by either a steep mountain or by a chain of hills: Mt. Ossa in the east se-

parates it from the Aegean Sea, and the Erimon and the Drachmani (Patoma) hills separate the basin from the Thessalian Plain. From the latter, only a few and short rivulets empty into the River Kalamitsa, which enters the basin through an opening from the south. This river collects the water from both sides of the basin and finally flows into the Pinios – or rather, formerly flowed into it, as the Kalamitsa has dried up, just like its tributaries from the hills.

Until 2017 only the western part of the Basin of Elateia had been investigated through rescue excavations carried out by Giorgos Toufexis at the foot of the *magoula* Makrychori 1. This site is known for its ditch system, the oldest of which is dated back to the transition Early Neolithic (EN) to Middle Neolithic (MN) (*Toufexis 2017.167–172; Reingruber* et al. *2017*).

Transects of our systematic survey were laid out both east and west of the Kalamitsa River, but especially in its eastern part we encountered several flat sites from different periods, the largest among them being Elateia 1 ('Bigmeni Petra').

Location of the flat site Elateia 1

The flat settlement south-west of the modern village of Elateia lies on the Late Pleistocene–Early Holocene alluvial fan west of Mt. Ossa. The western confinement of the site is determined by a natural scarp up to 12m in height (between 63 and 75 masl). It was formed by the alluvial fan ending there, cut by the waters of the Kalamitsa River, which has migrated up to 300m farther west over the millennia (Fig. 2). Another natural boundary is given in the north by the course of the Tsantarli streamlet ('rema') that has also dried up in modern days. To the south, the settlement area was probably bounded by a standing body of water, but this needs to be clarified through targeted drillings. To the east, a field path separates this spur in a N-S direction from the rest of the terrain, which rises continuously to the flanks of Mt. Ossa. The settlement area thus delimited is considerable: 400x260m (about 10 hectares).

The rather small fields in this settlement area not only belong to different field owners, but are also cultivated in very different ways: three areas have been lying fallow for years, so that a dense weed growth prevents a systematic inspection (Fig. 2). Generally, our return twice a year was worthwhile, as very good field inspection was achieved in two different campaigns per year, one in early spring and the other in later autumn. Thus, of the 10 hectares 81% has been investigated, the coverage of the site being as complete and the finds collected as representative as possible.

With the exception of the relatively empty areas in the northeast, the rectangular walking units ('fields') were comparable in size (approx. 900m^2, depending on the topography of the site). These units were surveyed at a regular and constant pace, and the mass finds (sherds, daub and at first sight unidentifiable objects) were collected with their respective field numbers in separate bags. All decorated sherds, like the small finds, were measured three-dimensionally with help of GPS-devices and bagged separately. However, since sometimes decorations could only be recognized after washing, some such sherds were not measured with GPS, but they do contain the information about the field in which they were collected.

The pottery from Elateia 1

The complete inventory and its distribution in the area of the flat site

From 72 field units (designated with the letter F and a three-digit number, *e.g.*, F023), 11 489 sherds were collected, of which only a very small proportion (1.3%) had to be sorted out because they belonged to younger periods. Thus, the total sum of 11 337 prehistoric sherds (182.73kg) was available for processing. The area remains – with the exception of modern agricultural use – only slightly overimpacted, and therefore the settlement of Elateia 1 ('Bigmeni Petra') can be considered one of the best preserved flat settlements of the early MN period. The state of preservation of some of the sherds is very good, considering that they are surface material. However, 3741 sherds, one-third of the total, are heavily worn, as if rolled by water. These sherds appeared in certain areas, so that we were also able to draw conclusions about post-depositional processes from the time after the settlement was abandoned.

The 11 337 Neolithic sherds were not scattered evenly over the area. At least four clearly recognizable focal points could be identified according to both number and weight (Fig. 3): one is in the northwestern area with fields F049/F051, another in the central-western area with fields F201 and F203, while the most numerous sherds were found in the southern areas (F148–F149 and F143–F145). A concentration of domestic activity in these areas is con-

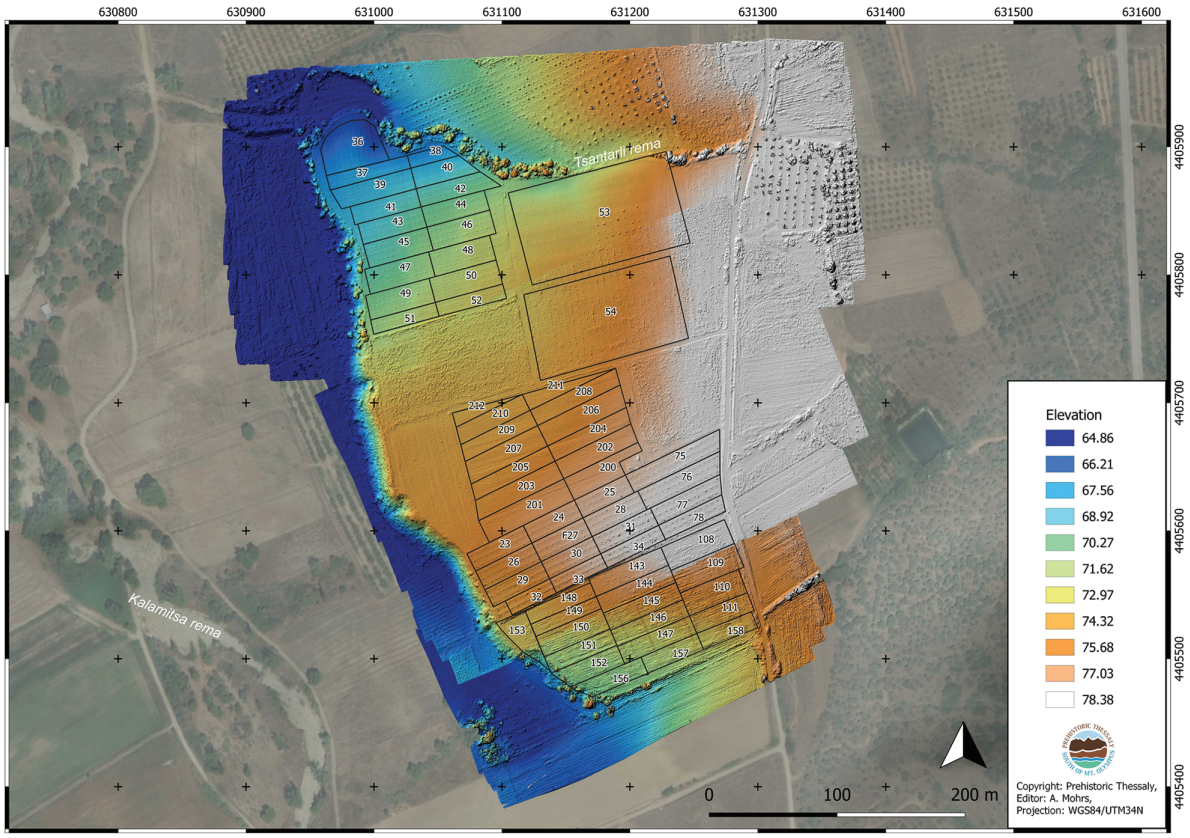


Fig. 2. A high resolution Digital Elevation Model (DEM) of the flat extended site of Elateia 1 with intensively surveyed field units (DEM by Vaggelis Kremastas).

firmed by the decorated sherds found there, probably not in a random scattering. Not only according to their number, but also when calculated in percentage-per-total, the previously established focal points can be validated and others proposed: the highest percentage of decorated sherds appeared in the almond grove, in F033 and F031 (Fig. 4). However, due to poorer visibility, fewer sherds (and finds in general) have been collected here.

Both in number and decoration only a few sherds were recorded in the northeastern part, in F053–F054, although the visibility there was excellent. We assume that this area was not part of the domestic space and as such was not used for dwellings. Instead, in this open area gardening or animal keeping may have been carried out (this is in line with the occurrence of other finds categories, *e.g.*, stone tools).

The individual field units form the basis for the evaluation of all find categories. Due to the aforementioned differences in the distribution and frequency of finds, it seemed appropriate to group neighbouring fields with similar characteristics into areas. Thus, in the course of the evaluation of the finds eight areas were defined starting from the northwest (area NW) and ending in the southeast (area SE). For the ceramic analysis, this meant that the comparison of features was based on the number of sherds-per-area, each of which accounted for 100% within its area. This puts the unevenly high numbers of finds from, for example, the SW area with 2994 sherds and the NW area with 679 sherds into perspective. Only the area NE with a sparse 77 sherds falls through this grid. Thus a uniform and consistent type of presentation is maintained.

Pottery categories

The total of 11 337 sherds could be assigned to seven pottery categories, which were determined on the basis of aesthetic (colour) and technological criteria, such as clay composition, temper, application of a slip and surface treatment (Fig. 5). Two categories are relevant only when discussing secondary changes: 81 sherds burnt in conflagrations, and 3741 sherds were heavily worn and rolled. These 3822 sherds (33%) were withdrawn from evaluation, as the surfaces were too greatly altered and thus no unambiguous assignment to a specific category was possible. Without them, 7515 sherds remain for examination (Fig. 6), which do not occur uniformly

in all areas. The reasons for these differences will play a determining role in the future analysis.

The seven ceramic categories represented are all monochrome. Monochrome surfaces occur in all phases and subphases of the Neolithic and Chalcolithic, and therefore this term cannot be used in a chronological sense. The term 'monochrome' is used here not in opposition to painted styles, but in opposition to bichrome burnt pottery styles. To the latter would belong the black-topped pottery of the EN II and of the LN I with different colours on the inner and outer surfaces (grey/black and light brown, respectively), additionally with a black rim, and no such sherds occurred in Elateia 1. Another bichrome burnt category refers to reddish oxidized surfaces contrasting with black reduced ones – mostly the interior is black and the exterior red, or, more rarely, the other way around. Such sherds are represented in Elateia 1 with one piece each and are statistically irrelevant, as is the black polished type with only two specimens. These four sherds were added to the category closest to them. With these few exceptions, vessels were fired in an oxidizing atmosphere resulting in reddish/brownish surfaces both in- and outside.

Well over one-third of the sherds (43%) have red surfaces with or without coating. Brown surfaces, mostly light-brown, slightly less often dark-brown and only very rarely grey-brown, make up 21%. Very light surfaces were achieved by the application of a slip (1%) or were made of a very light clay: kaolin. This category is represented by only 69 pieces in Elateia 1, and thus is far less numerous (0.6%), just as it is generally rare, yet at the same time widespread during the EN/MN in Thessaly.

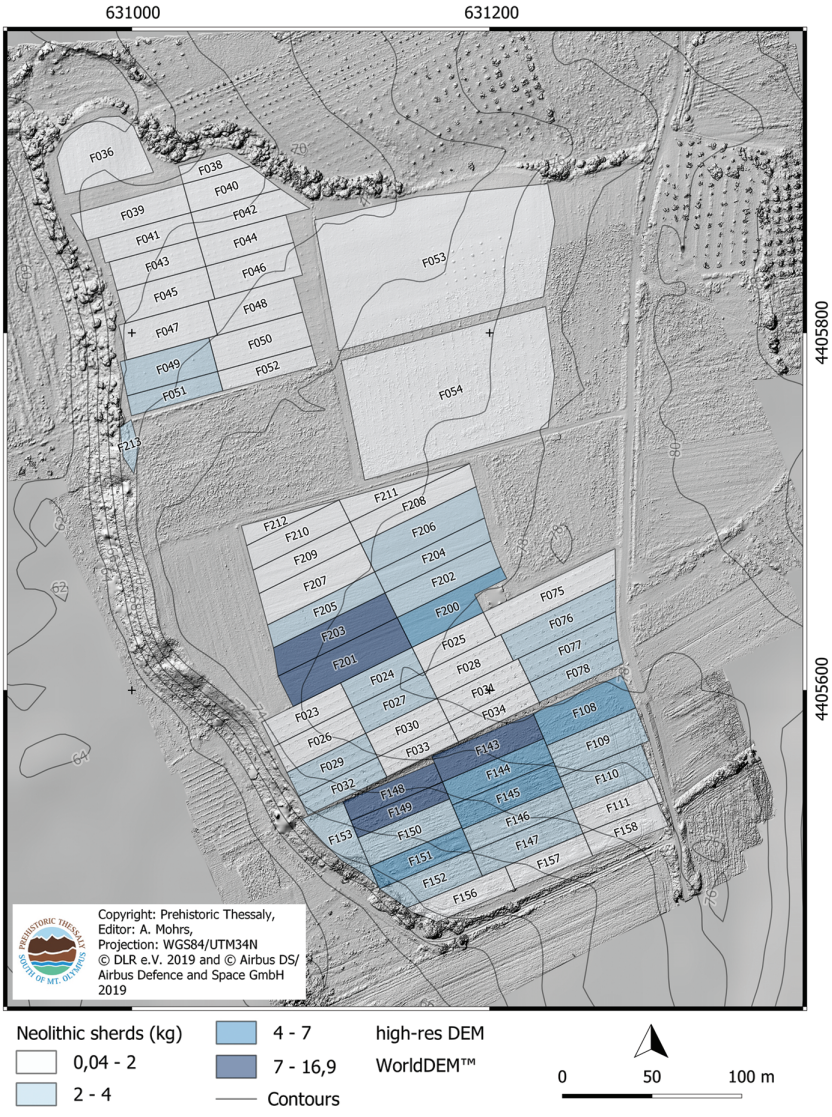


Fig. 3. Elateia 1, field units and frequency of Neolithic pottery (in kg).

It is quite a coincidence that the three main categories 'red burnt', 'red slip' and 'light-brown burnt' appear with the same number of decorated pieces (133–135 sherds – *cf.* Tab. 1). In relation to the number of decorated sherds with intact surfaces (540 sherds), they account for 75% of the total, and can thus be regarded as standards for the application of a decoration. Within the respective category, however, only 5–6% of the red and dark-brown, but about 11% of the light-brown and grey-brown vessels were decorated. Even more popular as decorative backgrounds were the light-coloured coatings: more than one-half of all sherds of this type, almost 55%, were decorated, mostly painted (60 out of 69). The very light, kaolin-like surfaces are also relatively frequently decorated, at about 7%.

However, when looking at the frequencies of decorations on intact surfaces (7515 sherds), the proportions are different: the three main types are represented with almost 2% each,

whereas the decorations on a light coating represented just under 1%. They are thus much rarer and not evenly distributed throughout the settlement (see below). The darkish surfaces are also rather rarely decorated, with well under 1%, mostly with impresso. A special position can be attributed to the kaolin type: such vessels may have been considered particularly aesthetic on the basis of their appearance alone (similar to black-topped in EN II). Nevertheless, five out of 69 sherds were provided with impresso and plastic decoration, but at less than 0.1% of the total they must be regarded as exceptions.

Looking at the categories by area, some aspects stand out: most rolled/worn sherds occurred in the area NE, but they are also common in the areas CNE and CNW. In a representation without the rolled/worn sherds (Fig. 6), it can be seen that in these two areas red and light slipped sherds are also fewer, as the coatings may have also been worn off. In the areas with little rolled/worn material, the coatings are also more frequent, especially in CSW. In the two southernmost areas, the percentages of the single categories are very similar: the ratio of red fired to red coated is relatively balanced, but in the case of the browns the light surfaces predominate. In the NW and CSW areas, however, the dark-brown surfaces are much more frequent. In the NW area, the kaolin-like variety is absent and the light coatings are rarer. In all areas, the grey-browns are constantly represented with about 1% of the total, while the light-browns tend to be more frequent in the south rather than in the north of the settlement.

Whether these quite significant differences might be of chorological and thus relative-chronological importance remains to be discussed based on the evaluation of further factors, such as shapes and ornamentations. For the moment we can summarize that the SW and SE areas show very great similarities, which also exist with CSE area. The two areas CNW and CNE also show very similar combinations. With minor differences (absence of kaolin in NW), the NW and CSW areas are also comparable.

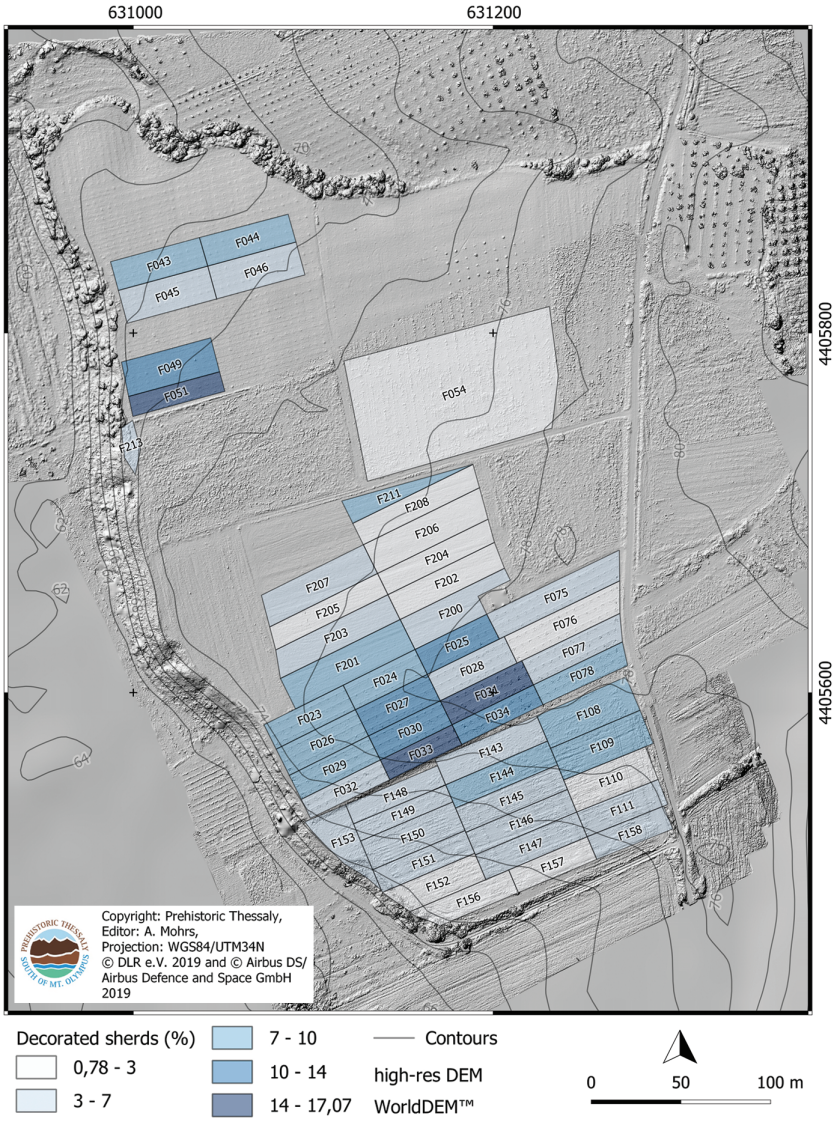


Fig. 4. Elateia 1, field units and frequency of decorated sherds (in %).

Vessel shapes

Since in a surface survey many different kinds of shapes from all possible prehistoric and historical periods can appear, a recording system was designed that could deal with this. In a first step the diagnostic rims were sorted according to the angle of inclination of the vessel wall (Tab. 2): closed with less than 90° (T10–T17) or open with more than 90° (T20-T26). In the case of bases three main types were distinguished: those with a ring (T41), simple flat bases (T42), and inward raised bases (T44 and T43). Special shapes were given the code T50 (*e.g.*, sieves), and jointed features (lugs, handles) were given

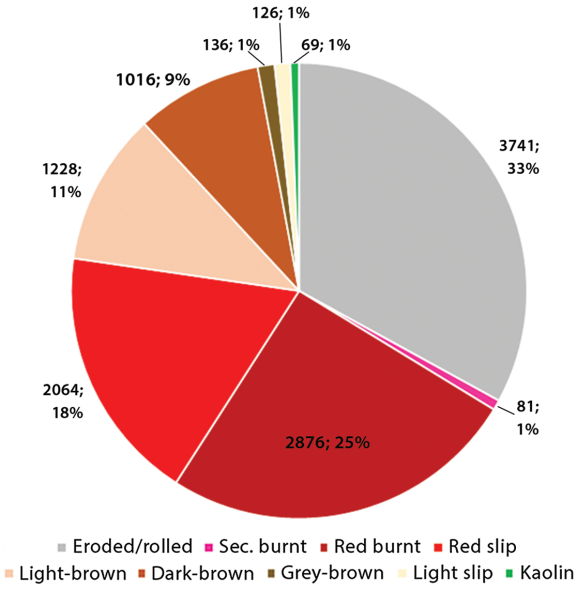


Fig. 5. Nine pottery categories as determined at the flat site Elateia 1.

the codes T60–T65. As many of the rims ended in different kinds of lips, and also bases displayed different traits in detail, these were distinguished by an additional code from a to z. With this combination of numeric and alphabetic codes all 3140 diagnostic sherds were systematically classified.

From a relative-chronological perspective, some types are ubiquitous, while others are chronologically sensitive. Shapes running throughout from the EN to the MN are well-known in the inventories published from sites in the Thessalian plain (*e.g.*, Argissa and Otzaki: *Reingruber 2008; Milojčić-v. Zumbusch J. 1971*). To these belong simple convex shapes with rounded (T11a) or beaded lips (T11b) and with a simple ring base (T41a) – they were present in Elateia 1 in all eight areas. Conversely, others, *e.g.*, collared necks of closed pots (T16) or hole-mouthed jars (T17), are not as frequent. However, it is not the individual vessel type that is of particular significance here, but rather the combination of types. In order to understand which types are or are not relevant, it was first necessary to carefully process the entire inventory (as will be described in more detail in the final publication). Their various possible combinations result in a 'set of dishes' that can differ in composition from area to area (see below).

Decorative styles and ceramic categories

A total of 635 decorated sherds from Elateia 1 represent 5.6% of the full inventory (when excluding the rolled/worn sherds the number is even higher, at 7.18%). Five main decoration styles have been distinguished: two in combination with negative decoration (impresso and incision), two in combination with colour application (painted and scraped) and one as positive decoration (plastic decoration). Within each decorative style slight variations can be identified, depending on what kind of implements were used to apply the negative decoration, or which colours were used on what kinds of slips.

There is a very clear preference for the impresso decoration in 442 examples (Fig. 7), followed by painting (91 examples with red and only four with white paint). Scraped decoration is comparatively rare, with 30 examples, and of an early style: sometimes the distinction between painted and scraped is not clear-cut. Incised decoration, with 10 examples, was seldom used and cannot be considered as representative. Plastic decorative elements were applied more often (43), but some of them may have been functional (15). On only a few pieces are these styles combined, resulting in the 'fusion style' of impresso and painted decoration.

Impresso decoration, *i.e.* the intervention with an instrument or even just the thumbnail on the still moist surface of a vessel, clearly predominates. Contrary to what is usually proposed (*Milojčić-v. Zumbusch J. 1971*), impresso is not confined to the final

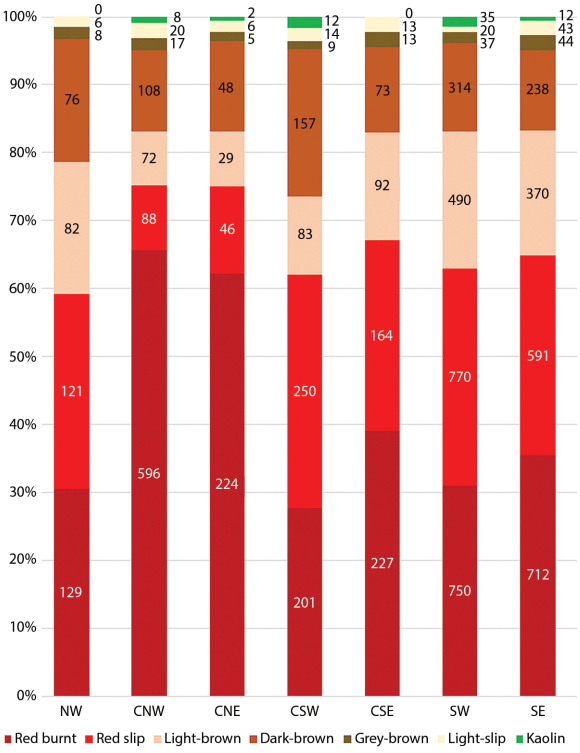


Fig. 6. Elateia 1, seven pottery categories (excluding the two secondary altered ones) in seven areas (excluding area NE).

stage of the EN, but occurs throughout the MN in different variations (*Mottier 1981. Typentafel D.25–46*). Either the pricked impressions were executed with a tool (more seldom, with the fingernail), and are in these cases rather randomly displayed over the whole surface (Fig. 8.7–8). Or the pointed impressions were made with the help of a comb: This kind of decoration was initially referred to by Milojčić-v. Zumbusch as 'Cardium decoration', since it was thought to have been executed with a cockle shell (*Cardium edule*). In Elateia 1 a comb-like instrument was used in 138 cases, and it can have up to nine teeth. The arrangement of the ornaments is linear, and the overwhelming majority are displayed horizontally on the vessel, often in parallel rows (Fig. 8.1–2,13).

Category	no. of sherds	% from 7515	no. of dec. sherds	% dec. from 540	% dec. per category	% dec. from 7515
Red burnt	2876	38.3%	134	24.9%	4.7	1.78%
Red slip	2064	27.5%	135	25.0%	6.5	1.80%
Light-brown	1228	16.3%	133	24.5%	10.7	1.77%
Dark-brown	1016	13.5%	49	9.1%	4.8	0.64%
Grey-brown	136	1.8%	15	2.8%	11.0	0.20%
Light slip	126	1.7%	69	12.9%	54.8	0.92%
Kaolin(type)	69	0.9%	5	0.9%	7.2	0.07%
Total intact	***7515***	***100%***	***540***	***100%***	***100%***	***7.18%***
Rolled/worn	3822		95			
Total	***11337***		***635***			***5.60%***

Tab. 1. Frequencies of decorated fragments per category and in the total material.

In Elateia 1 the varied methods of applying the impresso style (either with an implement, fingernail or comb) are abundant in number and rich in different arrangements, indeed unmatched at any other site so far. Impresso occurs on all categories of surfaces without exception, and can be regarded as 'standard'. However, the red surfaces, with or without coating, were preferred. According to the instrument used, up to five different kinds could be identified, which will be analysed in more detail in the final publication.

Within the other decorations, a preference for certain styles for certain categories is more discernible, since red-on-buff painting was primarily executed on light-brown slip (57 examples) and only 24 times on plain surfaces, but never on grey-brown and kaolin surfaces. Ornaments are usually arranged linearly (13 parallel stripes, eight unidentifiable), running horizontally or diagonally over the vessel surface. Usually, the shapes are of the closed type (13 out of 20).

Well-known from the MN is the red-on-white painting, while less so the white-on-red painting: in Elateia 1 the former outnumbers the latter by 67 to four. In addition to linear patterns, single or repetitive (*e.g.*, chevrons), more complex patterns occur, *e.g.*, rhomboid (Fig. 8.3) and slightly curved lines, creating entirely new overall motifs, *e.g.*, the flame pattern (eight times). The vast majority of these vessels were also painted on the inside (28 times, *e.g.*, Fig. 8.3–6), or they at least had a coating (20 times), or the inner surface was burnished. The preserved rims and bases show that in particular the bowl of type T22d+T42a was painted (six examples).

White colour was already used as a coating in the EN II: in Argissa it was initially used to cover thick-walled vessels (*Reingruber 2008.169, 214*). Throughout Thessaly it was comparatively rarely applied for painted designs prior to the LN I. In the early MN the parallel white and thin lines were usually applied diagonally, probably on the shoulders of closed vessels (Fig. 8.11), similar to the necked jars from the 'pottery workshop', building with rooms 11–12, in Sesklo (*Theocharis 1973.Fig. 5, 183–184, 281, Pl. II.13, 16*). In Elateia 1 the white-on-red is restricted to the central-western and southern areas. This also applies to the T16 vessel shape (see above), so that there would be a good spatial correlation between shape and decoration.

Scraped decoration is present on all unslipped categories, because the colour is basically the streaky scraped-out light or red coating. In a few cases, in which no polish had been applied after scraping, a distinction between linear painted and scraped ware is sometimes difficult to make. In most of the cases (30) the effect of blurred and even serrated boundaries between paint and background are obvious, as if polished over (*Vitelli 1984*). Both combinations occur: either darker brown and red surfaces are provided with light (scraped) coatings (light-on-dark: 13 times) or, the other way around, light-brown surfaces with darker scraped coatings (dark-on-light: 17 times). In Otzaki, both styles occur on the same vessel, which is why Mottier suspected that they were the result of irregular firing processes and not of intentional colour contrasts. While in the lower levels of that site the patterns are still very straight,

in the upper ones they are often blurred (*Mottier 1981.33, Typentafel F*).

Shape (description)	Shape (types)		Shape (description)	Shape (type)
Simple bowls, closed	T11–T12	vs.	simple bowls, open	T21–T23
Structured dishes, closed	T14–T15	vs.	structured dishes, open	T24–T25
Jars (with neck)	T13, T16	vs.	hole-mouth jar	T17
Simple base with ring	T41	vs.	simple flat base	T42
Inward curved base with ring	T44	vs.	curved without ring	T43
Pierced lugs	T62–T63	vs.	handles	T64–T65

Tab. 2. Closed (T11–T17) and open (T21–T25) shapes of vessels, bases (T41–T44) and attached elements (T62–T65) as determined for the site Elateia 1.

With this decorative technique, thin lines, much less complex geometric ornaments, cannot be created, and at most chevrons might result (two cases). Shapes with scraped decoration are thin-walled and show sharp breaks (seven out of 10). If rims and bases are preserved, they belong to open shapes, occasionally to closed ones, both with flat bottoms (Fig. 8.9–10,16). Strap handles (T65b) were also scraped.

Plastic decoration is one of the oldest ornaments in Thessaly (*e.g., Reingruber 2008.Taf. 1.14*). Here a distinction must be made between individually applied decorative pellets, knobs or thin strips (43) and pierced lugs (15). The former were found mainly on body-sherds (39) and only four in connection with a rim (never with a base) that belonged to an open shape (T21, T22). The chevron pattern, as known in the painting, was rendered two times with applied plastic strips (Fig. 8.15).

Since lugs are quite varied in design, they might not have been solely functional in nature (to hold a rope for hanging up the vessel), but possibly also of aesthetic value. Lugs can be elongated or round, sometimes angular in cross-section, and even tunnel-like. One such piece is known from the EN (Nessonis I, *Theocharis 1962.Pl. VIII.3*), and was vertically applied to the pot. In Elateia 1 lugs were never found in connection with a rim or base. Judging by the inner surfaces, they were attached to both open and closed vessels, probably in the central zone of the vessel.

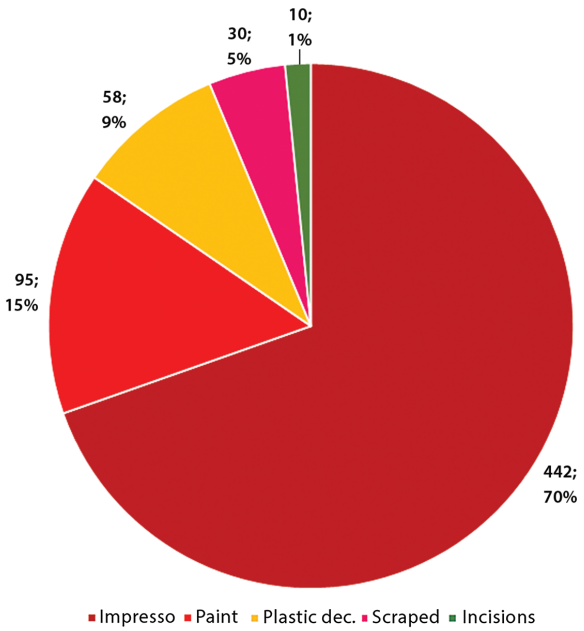


Fig. 7. Elateia 1, all five decorative styles (n=635 sherds).

Incisions made with pointed implements have been common since at least the MN, yet they are always small in number. The few specimens from Elateia 1 belong mostly to the light-brown category. Usually this type of decoration occurs in conjunction with impressions, framing them. Exclusively incised lines as an independent type of decoration appear only on 10 sherds.

Combinations of shapes and ornaments

For this preliminary analysis only a few but representative shapes were selected that were either common already in the EN (T11b and T21b, *e.g., Reingruber 2008.521, Fig. 6.1–6.4; Milojčić-v. Zumbusch 1971.Taf. 1–14*), or they appeared during the MN (T16, T22d, T65b: *Mottier 1981.Typentafel E–F*). In addition, the newly described base (T44a) was evaluated. In Figure 9 one such combination of shapes is exemplified for each area: The simple convex bowl with beaded rim (T11b) occurs in all areas, but in different frequencies, mostly in NW and CSW areas. The simple open dish with beaded rim (T21b) also occurs throughout the site, but more often in the central four areas. The chronologically sensitive base T44 occurs more often in the three western areas and only rarely in the two southern ones. The opposite is true for the simple open, slightly concave dish with thinning rim (T22d) and strap handle (T65b), which is frequent in the south and east. Collared jars were widely used in SW and CNE.

In two areas (NW and CSW) only four of the shapes discussed above appear, while all six are present in the southern areas, and five shapes in two areas

(the area NE is not of statistical relevance). It remains to be evaluated with other statistical methods whether this distribution is of chronological relevance and/or of functional significance. Namely, within a settlement area of 10 hectares it is quite possible that not all areas were used with the same intensity and also not for similar activities. In this evaluation, we suggest that in addition to functional significance, temporal importance may also be relevant.

As pointed out above, some vessel types were decorated more often than others and with specific techniques and patterns. The analysis is based on 121 both decorated and diagnostic vessel fragments.

With one white painted exception, the closed shapes are always ornamented with impresso and scraped decoration (Fig. 8.16). However, while impresso appears on traditional convex shapes with ring bases (T11, T12 and T41), the scraped decoration is associated with vessels with carinated walls, concave rims and flat bases. Often the walls of these vessels are very thin and may have a strap handle: such shapes are of a new appearance in the MN.

Impresso and scraped decoration, however, also occur on open shapes. As with the closed vessels, they are represented on mutually exclusive shapes: Impresso is again applied to open bowls well known since the EN II, and only rarely does impresso occur in association with the open concave shapes. It is never present on pointed rims (those are mainly painted or scraped) – a very clear dichotomy.

Chronologically sensitive are the bases T43 (15 examples) and T44 (31 examples). T43 is a flat base, reinforced on the inside by an additional layer of clay (Fig. 8.8). The base T44 has some similarities with the ring base T41 (Fig. 8.14), yet together with the body of the vessel it forms a slightly concave shape (Fig. 8.2). Single such pieces have been described already in Otzaki as base shape II.4. There they occur in the late EN (*Milojčić-v. Zumbusch 1971.53, Taf. 15.24–25, Taf. XXV.12*) and early MN (*Mottier 1981.Typentafel D.4–22*). In Elateia 1 they are usually decorated with impresso, be it with a comb-like instrument or a pointed stick, yet never with fingernails nor with a broad instrument. These two shapes seem to have been especially designed for impresso pottery. As they are very well burnished inside, they could have originally belonged to open shapes in combination with the straight or slightly concave rims T21/T22 (Fig. 8), or, alternatively, with a slightly closed variant thereof (T11/T12).

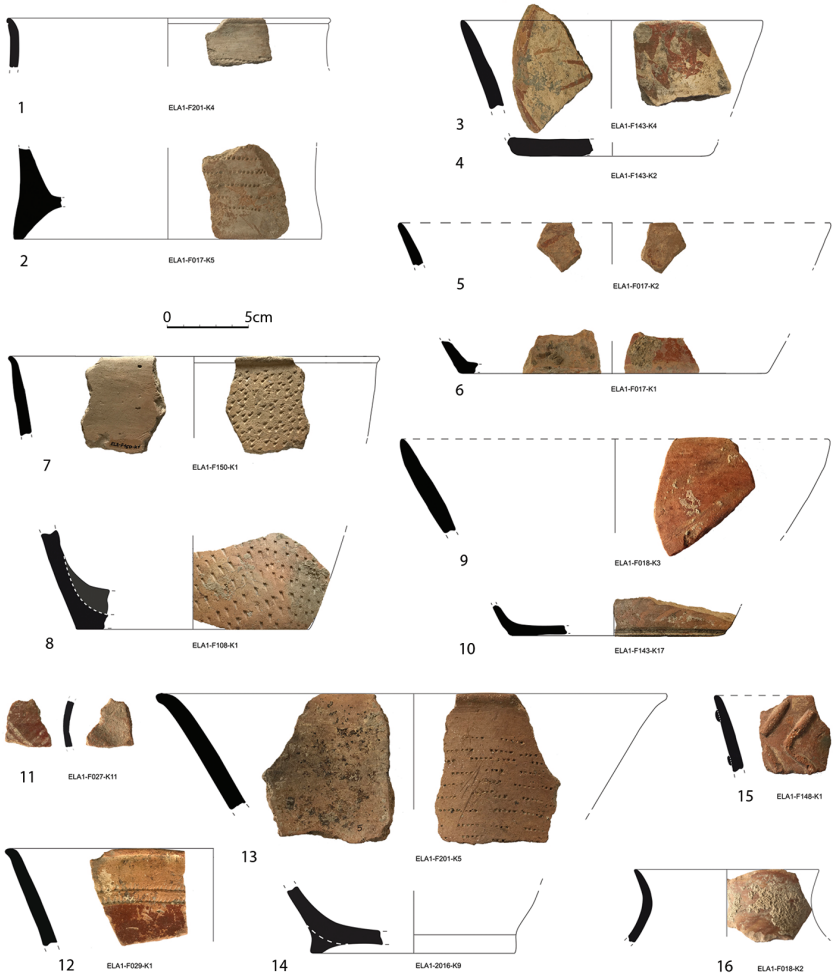


Fig. 8. Elateia 1, Reconstructed pottery shapes and decorative styles (drawings by Ellen Kühnelt; digitizing by Aggeliki Chalkia; photos by Frank Lünsmann, Agathe Reingruber).

Similar pairs of bases and rims can be found within the painted and scraped shapes, too: Here, the flat base T42 can be best combined with the open, slightly concave, pointed rim T22d (Fig. 8.3–6). The majority of the flat

bases with decoration are red painted (14) or scraped (3); in nine examples the paint also survived on the inside, proving that they belonged to open shapes.

The combination of wares, categories, shapes and decorative styles reveals which vessels (as end products) belonged to the 'standard repertoire' (Tab. 3), whereby combinations and exceptions are possible. In all styles, the patterns are of a simple linear nature, usually in the horizontal direction. Repetitions of lines and geometric elements can result in complex patterns. However, wavy patterns, circles or spirals are not present in the Elateia 1 repertoire. It can be assumed that most of the vessels were made, fired, used and also disposed of on site.

An interesting finding from this evaluation is that certain decorations were applied to certain shapes (Tab. 3), meaning that from the outset shape and style were planned together by probably the same person, the potter as a specialist (*Vitelli 1995*). The thus emerging standard vessels with impressed decoration are: (1) the closed or open convex or straight-walled bowl with a ring base (*e.g.*, Fig. 8.13–14); (2) the open bowl with a low or high arched base (T43/T44) together with a straight or slightly concave rim and usually decorated with comb-impressions (Fig. 8.1–2).

Vessels with red painting are mostly open, with a flat base, occasionally with a high ring base. The carinated or concave thin walls with a flat base and strap handle have scraped decoration, although this kind of decoration occurs with single specimens on different kinds of shapes. Plastic decorations and incisions are mostly related to open convex bowls.

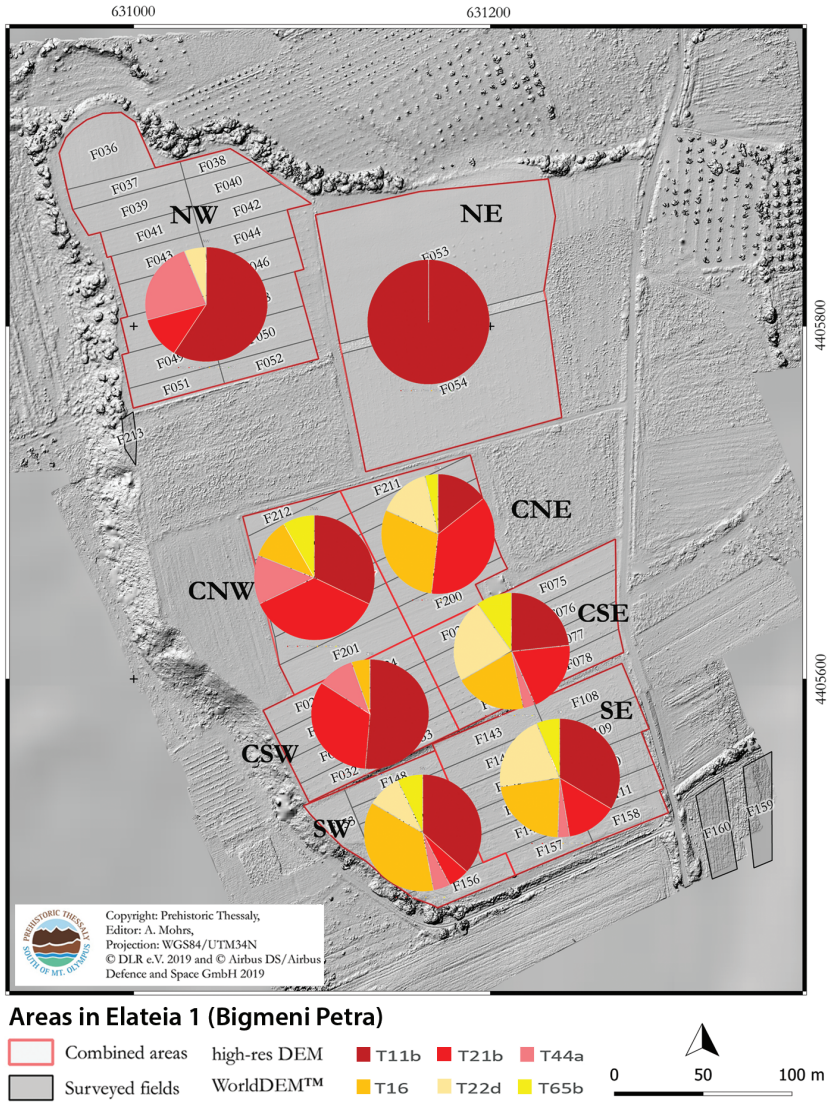


Fig. 9. Elateia 1, areas and frequencies of certain pottery shapes (% per area).

Both by the nature of the decoration and by the shapes, impressed and scraped pottery can be considered as two mutually exclusive categories: in Elateia 1 there are no carinated, impresso-decorated sherds, just as there is no scraped pottery on traditional ring bases. These two styles are never combined as they belong to the respective ends (extremes) of the spectrum, the one (impresso) having elements from the older end, the other (scraped) containing novel elements and thus belonging to the younger end. This result is of great importance for the relative chronology of the site.

All the more remarkable are the overlaps in styles, such as the overlap between impresso and painted (so-called 'fusion style', Fig. 8.12). In Elateia 1 these were an exception, with only two sherds of this kind, whereas in the later MN they became dominant. This could be an indication that the occupation in Elateia 1 ended early in the MN.

Relative chronological appraisal

In this first examination of the data recorded during our fieldwork some preliminary insights shall be proposed, which will be discussed in more detail in the final publication. As illustrated in Figures 6, 8 and 9, we were able to distinguish specific characteristics for each area, which relate to categories, temper, shapes and ornamentations. These particularities were not evenly distributed throughout the site, but instead showed distinct combinations of specific traits.

In the NW and CSW areas, the combinations of categories are similar, with the dark-brown surfaces being more frequent. The SW and SE areas show very strong affinities, which also exist with the CSE area, where the light-brown surfaces tend to be more common. The two areas CNW and CNE also show very similar combinations of pottery categories.

Figure 9 shows that the traditional shapes occur mainly in the western areas (T11b especially in NW and CSW), whereas the new shapes appear in the southern and eastern ones. Further, T44 was spread in the western part of the site. This chronologically sensitive shape appears in all areas and indicates that the site must have been founded at the transition EN/MN, since such bases never occur in the earlier EN and they were not found in the later MN, at least not in a stratigraphical context.

Regarding the decorative styles, all five of them are plotted here without going into further detail (Fig. 10). Even on such a general analytical level it is possible to show that impresso, plastic decoration and red painted ornaments were found in all seven areas (there is only one sherd with plastic application in the NE, and this area is not further taken into account). If we look more closely at the distribution of the styles, we notice that in the NW, CNW and CSE impressed decoration clearly predominates. Few painted sherds were found in the NW, and no scraped sherds occurred there. Therefore, only four of the five styles are present in this area. The situation is similar in the CSW, although incised ornaments were not found there.

Like no other category, the scraped ware can be spatially very well delimited, since it occurs mainly in the SE, but also in the CNE, CNW and SW, and only sporadically in the CSW and CSE. Together with the painted sherds, they convey a very consistent pattern: the areas CNW, CNE, SW and SE are those in which the two styles commonly occur. Since it is known from archaeological literature that scraped pottery is a more recent feature of the MN and impresso an older one (*Mottier 1981*), signs of a horizontal shift in the settlement pattern can be traced therein.

Despite (or perhaps even because of) the few incised sherds, the division between the areas presents a clear picture: while in the two areas NW and CSW incised lines appear as boundary lines for impressed patterns, independent incised decoration is more likely to be found in the other areas (CNW, CSE, SW and SE).

Judging by both the distribution of shapes and of ornaments some conspicuous similarities can be pointed out regarding the individual areas.

Category	Decoration	Rim (type)	Rim (description)	Base (type)	Base (description)	Lug/ handle
Red burnt, red slip, light-brown	impresso (all styles)	T11–12b/c T21b/c	closed, convex open, convex	T41a/e	low ring	–
Light-brown, red burnt, red slip	impresso (comb, instr.)	T22a/e	open, concave	T44	raised base with ring	–
Light slip	painting (red)	T22d, T23d, T30d	open, concave; thin-walled	T41c, T42a	high ring, flat base	strap handle
Red slip	painting (white)	body-sherds only	closed	–	–	–
Light-brown, red burnt	scraped	T21–T24, T31/32y, T34	open (all types) thin-walled, carinated	T42a, T42b	flat base, reinforced	strap handle
Red slip, light-brown	plastic decor. (knobs)	T21b/c/d	open, convex		–	–
Red slip, red burnt	plastic decor. (lugs)	body-sherds only	–		–	pierced lug
Light-brown	incision	T21b	open, convex			

Tab. 3. Elateia 1, predominant combinations of category, decorative style, and vessel type.

● Especially in the NW and CSW, similar combinations of categories, shapes and ornaments are present. In these areas only four of the six examined shapes and only four of the five decorative styles occurred. As was argued above, simple convex shapes and the impresso decoration both belong to the older features of pottery production.

● A completely different picture emerges in the southern part, where in the SW and SE (partly also in CSE) a much broader spectrum of both shapes and ornamentation can be seen. In particular, the shapes typical for MN (concave rims and collar vessels) occur there. They fit very well with the observed characteristics in terms of painted and scraped decorations.

● The CNW and CNE areas also show a certain degree of comparability, mainly on behalf of categories and shapes.

The earliest pottery features appeared in Elateia 1 within two foci in the western part of the site, and it is proposed that the original settlement was founded around (at least) two households in this area. New dwellings were built later on in the southern areas, and the NW area was probably abandoned as a living space but may have been further used for other purposes. The area CNW certainly was still in use, as new styles (scraped ware) appeared there too.

Apart from a chronological interpretation we should keep in mind also the potentially different kinds of uses of the areas. As will be shown in the final publication, based on the geophysical investigations and the evaluation of small finds from this site, next to the dwelling areas, other parts of the site were used for the transformation of resources, *e.g.*, grains were milled, pots were burnt, animals were slaughtered and processed: this was the case mainly in the areas CNW and CNE. Therefore, the fact that in these areas open bowls or collared jars were found may have to do with specific tasks carried out here.

Water must have been a major reason for the choice of this advantageous location by the first generation of settlers, and water may have been the reason why the last generation abandoned this site. Climate curves show that the absolute maximum of a warm and humid climate was reached around 5800 cal BC, a peak that was never equalled again in the entire Holocene of the last 11 600 years. Flooding and the swelling of small rivers into dangerous flows may have been a problem. If so, we can assume that the Tsantarli must have affected the settlement, and indeed there are two indications of

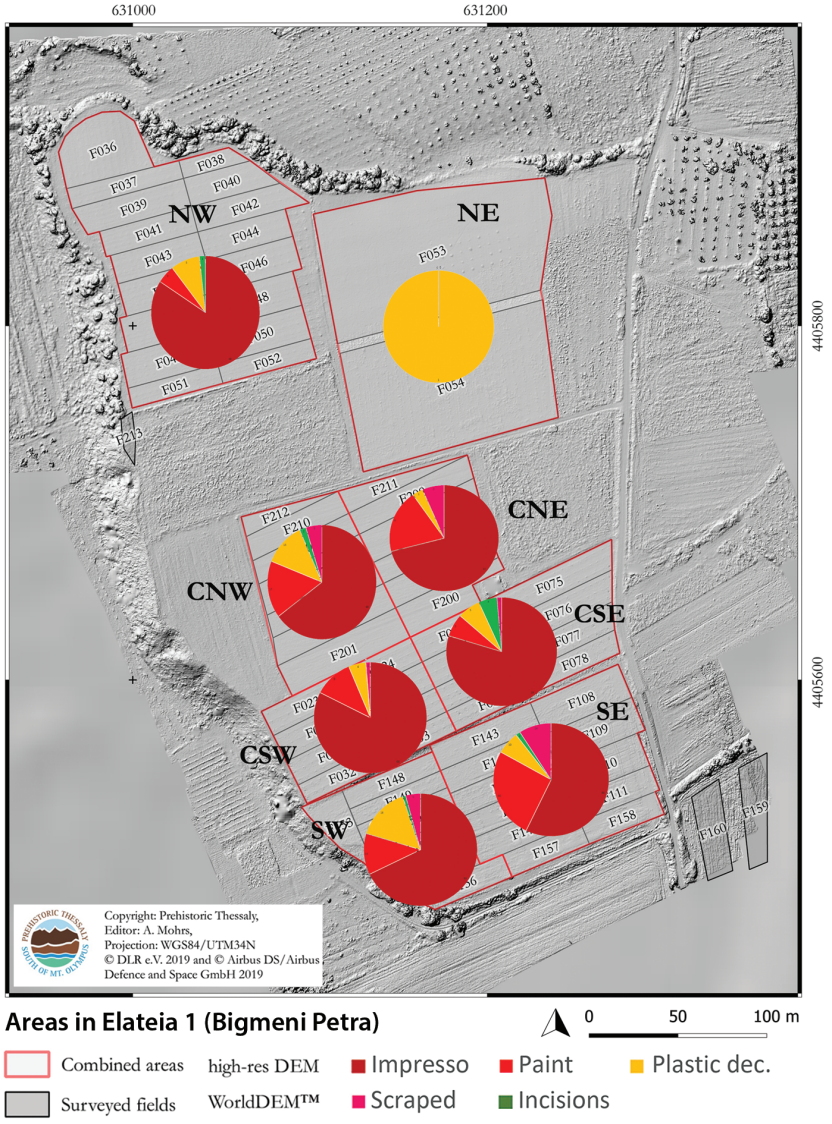


Fig. 10. Elateia 1, areas and frequencies of all five decorative styles (% per area).

this. As can be seen in the DEM (Fig. 2), there are two large gullies in the central part of the western escarpment, created by the drainage of excess water[1]. During our pottery processing, we observed heavily eroded and even water-rolled sherds between contour lines 76 and 74, in the areas NE and CNW (Fig. 11). It is therefore possible that water entered the settlement from the NE and crossed the site towards the SW, where it formed the gullies. The fact that a lot of water collected in this area is also indicated by the animal bones, because it is precisely the bones from there that did not contain collagen, because it may have been washed out by the water.

Absolute chronology

Evaluation of the results obtained from short-lived animal bones

During our surface surveys we were able to collect 117 animal bones, teeth and shells. Of these 39 animal bones were selected for radiocarbon analysis. Priority was given to sheep-goat and cattle, whereas pig was omitted. First, a collagen test was undertaken in the Laboratory of Archaeometry, NCSR 'Demokritos' in Athens. This involved treating tiny fragments of bone with a mild acid (HCl, 0.6N) at 7°C for several days and monitoring the dilution of the inorganic part and the possible production of collagen. The degree of preservation was rather poor, so most of them failed to produce any collagen at all: either they dissolved completely or they left a dark sediment.

The 12 most promising samples with some quantities of collagen, although of lesser quality, were sent to the 'Klaus Tschira' AMS laboratory of the Curt-Engelhorn-Centre Archaeometry gGmbH in Mannheim. Unfortunately, several of them did not produce manageable quantities of collagen and were not further processed, yet six bones were found with sufficient datable matter. The collagen extracted was purified by ultrafiltration (fraction >30kD) and freeze-dried. It was then combusted to CO_2 in an Elemental Analyzer (EA) and the CO_2 was converted catalytically to graphite on iron foils.

Table 4 shows the results of the six samples that were finally measured with the collagen yield, the C/N ratio and the percent of carbon combusted. Of these, three contained less than 1% collagen, the limit most of the laboratories accept for dating. These dates were run in 2018, before the laboratory in Mannheim lowered the limit to 0.6% collagen (report by Dr. Susanne Lindauer, May 6, 2020). However, the C/N ratio of these collagen samples with values between 2.9 and 3.3 indicates uncontaminated collagen and is regarded as highly reliable for dating and isotope analysis by most researchers (*Brock* et al. *2012.Fig. 4; Sealy* et al. *2014*). Therefore, we do not exclude these dates from the general assessment of the site, but refrain from placing too much emphasis on them because of the doubts raised by the low collagen yield: While one of the dates is consistent with the results from the samples with higher collagen yield, two gave very high or very low results compared to the others (Fig. 12). These two dates could still be valuable, as they may suggest human activity at the site not represented in the pottery record: MAMS-37738 at 6400–6260 cal BC (at 1 sigma interval) is of EN times and MAMS-37740 of late MN (5670–5620), but no archaeological materials from the surface of Elateia 1 can be related to either of these periods. Pottery styles of the EN (black-topped, early painted pottery) are absent and so are the late MN-styles (*e.g.*, grey-on-grey). It is not impossible that the site was repeatedly visited during these times, but we cannot confirm this adequately yet. Pending the results from other bone samples we consider these two dates for the moment as outliers. Moreover, from the same field units (F148 and F149) results were obtained that comply with the relative chronological appraisal.

Only three of the eight areas supplied bones that were adequate for dating, and these are the areas with the lowest proportions of water-rolled sherds and presumably least affected by intruding waters. The only date from area NW is – together with a date from area SW – the oldest. From the latter area a second date (exclusive of the two discussed above) is somewhat younger and identical in result to the single date from area SE.

The three consistent dates cover a maximum period of 200 years: between 6000 and 5800 cal BC. When judging by the medians of the three reliable dates in Fig. 12, calibrated with the latest version of the program OxCal v4.4.4, rounded to the nearest decade[2], this period can be limited to only 110 years between 5980 and 5870 cal BC (this calculation benefits enormously from the precise dates with small

1 We would like to thank the geologist Sotiris Valkaniotis for drawing our attention towards these features.
2 Last updated: 1/3/2021, © Christopher Bronk Ramsey 2021; atmospheric data from Reimer *et al.* (*2020*).

standard deviations of only *c.* ±30 BP, but is somewhat impaired by the wiggle in this part of the curve). According to our previous evaluations of the Aegean data sets (*Maniatis 2014; Reingruber* et al. *2017*), this period marks the beginning of the Middle Neolithic (MN I) in Thessaly. This result fits perfectly with that of the pottery analysis.

Pottery analysis points to a horizontal shift inside the settlement area: the oldest pottery styles appear in areas NW and CSW, the youngest in SW and SE. Although the absolute dates are too few to be statistically analysed in a model, they seem to support this view; at least they do not contradict the suggested horizontal shift. In view of their origin as surface material this result is all the more significant and encouraging. Based on the results we can even conclude that the site was inhabited only during four to five generations (calculating with 25 years per generation in time).

Failed samples and post-depositional processes

Dating surface materials is admittedly not without risk. The fact that no later archaeological material than that from the MN was found on the surface of Elateia 1, as well as the good conditions of some of the animal bones, encouraged us to use them for dating purposes. To our surprise and relief, all results fall within the same time-range. This fact once more supports our appraisal of the relative chronology of the site and that indeed no younger activities took place on this spot. We were further rewarded by the fact that even bones that did not contain any collagen are not useless, since they also carry information: their specific position may not be a matter of coincidence, but determined by post-depositional processes. If no collagen-matter is preserved, this may be an indication that it had been washed out when standing over longer periods of time in water. As such, it must be pointed out that from 12 samples collected from five fields in the northern areas NW and CNW (F046, F049, F051, F201, and F213), only a single bone contained enough collagen for dating (F213-B1) – a ratio of 1:12. On the other hand, the bones from the southern part of the site, south of the almond grove, gave almost three times as good results: five out of 24 samples contained datable collagen (ratio of nearly 1:5). The fields from which they derive in areas SW and SE (F145, F148, and F149) are among the higher parts of the settlement, which were presumably safe from intruding waters.

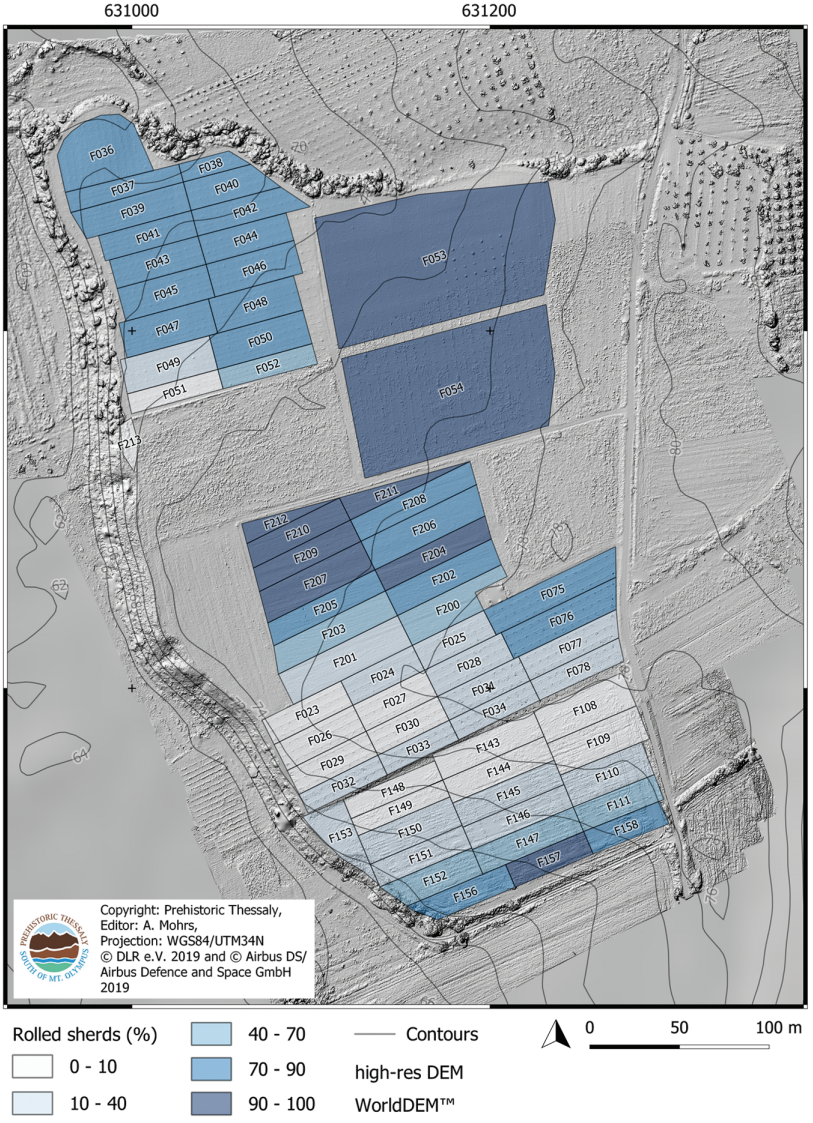


Fig. 11. Elateia 1, field units and frequency of worn sherds with surfaces as if rolled by water (in %).

We conclude therefore that water did indeed pose a problem at the end of the site's occupation and for several generations thereafter since the dwellers never returned. Mo-

MAMS	DEM	BP	+/–	d13c	calBC 1σ	%C	C/N	% Collagen	Context	Area	Material
MAMS-37738	DEM-3269	7464	26	–19.6	6400–6250	21.2	3.2	0.6	F148-B1	SW	cattle
MAMS-37739	DEM-3270	7098	26	–21.4	6020–5920	27.8	3.2	1.7	F148-B2	SW	n.d.
MAMS-45204	DEM-3403	7044	33	–13.9	5990–5890	32.9	3.3	6.1	F213-B1	NW	n.d.
MAMS-37741	DEM-3272	6995	25	–20.6	5970–5840	28.8	2.9	1.3	F149-B5	SW	large mammal
MAMS-37737	DEM-3268	6989	25	–18.3	5970–5830	19.3	3.2	0.5	F145-B3	SE	cattle?
MAMS-37740	DEM-3271	6732	26	–20.5	5670–5620	19.7	3.3	0.5	F149-B4	SW	sheep/goat

Tab. 4. ^{14}C dates from Elateia 1 with samples containing insufficient collagen marked in red.

reover, subsequent dense vegetation cover may have been a reason why the area was not inhabited again thereafter.

Conclusions

A process that started in the previous generations of archaeologists and is still a challenge for our generation (and will certainly continue into the next) is the integration of results obtained by relative chronological appraisal into the system of a revised absolute chronology. One such example where this task is still ongoing is the re-interpretation of finds previously considered to be of late EN date, where the EN was expected to have lasted until 5800 cal BC. With the firmly established ^{14}C chronology the time between 6000 and 5800 cal BC is demonstrably of early MN. Indeed, pottery categories from the EN were still in use in the MN, especially the red monochrome pottery (with or without a slip) and red painted surfaces, although new shapes were added to the repertoire. Therefore, on the basis of monochrome pottery alone a reliable relative-chronological dating cannot be obtained, and this fact is very important to acknowledge in connection with older appraisals dating back to the 20th century and the first years thereafter.

Transitions between phases are never clear-cut: this is a simple but sometimes forgotten truth. With only a few exceptions, older styles continue into the new phase (established by archaeologists). For example, red coating and red paint on a (predominantly) light-brown clay surface had been in use in Thessaly since the EN II (*c.* 6300 cal BC). All such examples from Elateia 1 preserved on diagnostic sherds can be dated to the Middle Neolithic. Even though the materials were collected from the surface, they still belong to a settlement that was inhabited for few generations only and that had not been damaged by subsequent occupation events.

Based on the evaluation of the pottery and together with the results from radiocarbon analysis, we are now able to determine more precisely which pottery categories and styles were in use coevally: the different categories correlate with certain decorative styles applied to them. One such 'standard' is clay with quartz temper, usually well smoothed and burnished, often coated with a red slip after impressed

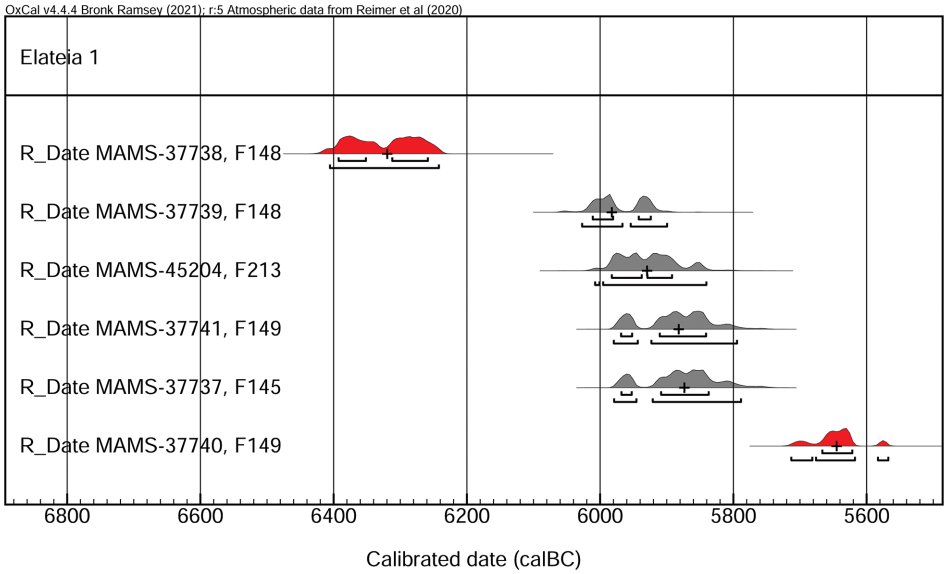


Fig. 12. Calibrated ^{14}C dates from Elateia 1 with two potential outliers marked in red.

decorations were applied to the still elastic surface. A second, but much rarer 'standard' is lime-tempered clay, usually with a burnished or polished surface. Yet to such vessels a light slip and red colour were added, or the slip was first added and then scraped away. If the painted or scraped lines were burnished over before the firing took place in an oxidizing atmosphere, they obtained a blurred appearance.

We were thus able to identify certain style combinations that can be anchored relative-chronologically with the help of published inventories from excavated sites: we could show that no materials predating 6100 cal BC and none postdating 5600 cal BC were found in Elateia 1. Additionally, the narrowing down of the sites' occupation within a maximum of 200 and a minimum of 110 years with the help of radiocarbon dates can serve to even better grasp the more or less coeval pottery styles: for this reason, the combination of styles as established at this site is all the more significant.

The impressed ornaments belong to the oldest documented decoration in Elateia 1. This style therefore cannot be confined to a specific phase of the EN (the so-called Pre-Sesklo of the EN III): it continues with new shapes and styles into the later MN. Indeed, the overwhelming amount of such products belong to the MN I and not to the EN III. Therefore, in the future more thought should also be given to such sherds when discussing their chronological position.

Two very different techniques in applying decoration on pottery – to penetrate the clay on the one hand and to add paint to it on the other – were practiced coevally during the EN and early MN, first without being combined. This finding could indicate that the vessels were not produced at the level of individual households, but by specialized potters. Eventually, impressions were accompanied by red stripes, and only later a 'fusion style' was created with red-on-white paint added to impressed surfaces. In Elateia 1 only one such sherd was found, but in Otzaki this kind of decoration prevailed during the later MN (*Mottier 1981.Typentafel D*). The case is similar with the scraped surfaces that came in use in Elateia 1 at a later stage during the site's occupation.

For Elateia 1 a precise stratigraphical context is not given, as all the sherds collected were from the surface. In the case of the survey material we expected some displacements due to cultivation and other human interventions or due to geomorphological transformations. But to our surprise, neither was the material randomly scattered nor was there a noteworthy mixing or blending that would have blurred the picture, and only the eroded sherds may have been carried over short distances by water. This made it possible to distinguish, on the one hand, focal points of activity and, on the other hand, different combinations of categories, wares, shapes and styles in certain areas. We therefore encourage accurate three-dimensional measurements of finds during systematic surveys, as their informative value should not be underestimated. At the flat site of Elateia 1, they led to the creation of a model that shows not only when, but also how the site was used 8000 years ago. This model is complemented by non-invasive geophysical surveys (forthcoming) and needs to be validated by excavations in the future.

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Including explicit priors on phase duration in Bayesian ^{14}C dating: re-evaluating the dates for basal Knossos and for Nea Nikomedeia (Early Aegean Neolithic)

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ABSTRACT – *Bayesian modelling of radiocarbon dates directly integrates information obtained through archaeological analysis. Here, I explain how to add known information/reasonable assumptions about the length of a deposition phase, using the example of date sequences from two Early Neolithic communities in the Aegean whose dating has been hotly debated,* i.e. *basal Knossos (Crete) and Nea Nikomedeia (Northern Greece). The consequences of the re-evaluation of their dates are discussed for the broader picture of the Neolithisation in the Aegean and for the chronology of the regional use of stamps.*

KEY WORDS – *radiocarbon dates; Neolithic; clay stamps; Knossos; Nea Nikomedeia*

Vključevanje nedvoumnih apriornih verjetnosti v čas trajanja faz v Bayesovem ^{14}C datiranju: ponovna ocena datumov iz najdišč Knosos in Nea Nikomedeia (zgodnji egejski neolitik)

IZVLEČEK – *Bayesovo modeliranje radiokarbonskih datumov neposredno vključuje podatke, ki jih pridobimo z arheološko analizo. V članku pojasnjujem, kako dodati znane podatke / utemeljene predpostavke o dolžini faze odlaganja na primeru časovnih zaporedij dveh zgodnjeneolitskih najdišč v Egejskem morju, o katerih se je že intenzivno razpravljalo, in sicer o temeljih v Knossosu (Kreta) in Nei Nikomedeiji (Severna Grčija). Razpravljam tudi o posledicah ponovne ocene teh datumov za širšo sliko neolitizacije v Egejskem morju in za kronologijo regionalne uporabe pečatnikov.*

KLJUČNE BESEDE – *radiokarbonski datumi; neolitik; glineni pečatniki; Knossos; Nea Nikomedeia*

Introduction

This paper has two goals. The empirical goal is to re-evaluate the dating of two important Early Neolithic sites in the Aegean, *i.e.* basal Knossos and Nea Nikomedeia. The methodological goal is to show how more precision and, crucially, accuracy may be achieved when a Bayesian dating analysis employs constraints on deposition durations obtained through archaeological analysis.

Section 1 introduces the broader context for the re-evaluated sites: the 7th millennium BCE in Southwestern Asia and Southeastern Europe. Sections 2 and 3 are technical, and describe the new Bayesian dating analyses of the previously available data for basal Knossos and Nea Nikomedeia, respectively. Section 4 discusses the archaeological consequences of obtaining these new dates with respect to the

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broad picture of Neolithisation in the Aegean and the chronology of the use of stamps/seals/pintaderas in the Aegean and Anatolia. Section 5 then concludes this paper.

The 7th millennium BCE and the need for more precise dating: an introduction

The 7th millennium BCE was a dynamic and interesting time in Southwestern Asia and Southeastern Europe. In the Fertile Crescent, which had been developing its food-producing Neolithic for several millennia by that point, different and complex histories emerged during this concluding Neolithic phase. In northern Levant and Upper Mesopotamia, the millennium's beginning marks the adoption of pottery, but its initial use hardly revolutionized the local lifeways (*Nieuwenhuyse, Campbell 2017*); it is only in the centuries mid-7th millennium that pottery becomes more abundant, and towards 6250 BCE true seals and actual sealings appear in Upper Mesopotamia (*Nieuwenhuyse, Akkermans 2019*). Interesting social processes surely accompanied these developments, but the evidence is for now insufficient to see which exact ones. To use the settlement pattern as an example, Olivier Nieuwenhuyse and Peter Akkermans (*2019*) argue that it is currently unclear whether there is a retraction of settlement at the time when pottery is introduced and then gains in variety and quantity, or it is rather the case that not all communities actually had any use of pottery until much later into the period. Be that as it may, in the last quarter of the 7th millennium decorated pottery and rapid stylistic innovation spread across vast expanses in this region, plausibly associated with new norms regarding mobility and hospitality (*Nieuwenhuyse* et al. *2016*).

Meanwhile in southern Levant a very different history was unfolding. The later 8th millennium BCE was characterized by the appearance of 'mega-sites' in the Jordanian highlands, while in the early 7th millennium the population of such sites apparently disperses into smaller places (see *Rollefson 2019* with references). Unlike in the north, no sign of an actual pottery tradition is to be seen until the second half of the 7th millennium, when the Yarmukian and several other regionalized cultural entities apparently develop, and are already using pottery technology (*Garfinkel 2014; Goring-Morris, Belfer-Cohen 2019*). At the spectacularly large site of Sha'ar Hagolan in the Jordan valley in the second half of the 7th millennium, complex village planning was practiced and a rich material culture developed, characterized by considerable public works and an art that follows a very strict and formalized canon (*Garfinkel 2019*). In sum, while the overall trajectory towards greater involvement with ceramic technology and an apparent rise in symbolic production is in common with the northern part of the Fertile Crescent, the local history of the southern Levant of the 7th millennium is markedly different.

In Anatolia, things similarly depended on the specific region involved. In the Cilician plain, the local pottery sequence of the 7th millennium has been analysed as exhibiting a growing sophistication over time, as well as regional connections (*Balossi Restelli 2006; 2017*), but otherwise we still know very little about the period, though new excavations at Mersin-Yumuktepe promise to add considerably to our knowledge (*Caneva, Jean 2016.21–23*). Across the Taurus range to the northwest, some economies included food production far earlier (*Baird* et al. *2018*), but it is the 7th millennium BCE that sees the rise of Çatalhöyük, one of the largest agglomerations of its time, without anything comparable known in



Fig. 1. Selected sites mentioned in the text: **Kn** ***Knossos;*** **NN** ***Nea Nikomedeia;*** **Ma** ***Mavropigi Filotsaïri;*** **Pa** ***Paliambela Kolindrou;*** **Re** ***Revenia Korinou;*** **Ul** ***Ulucak Höyük;*** **Çu** ***Çukuriçi Höyük;*** **Bar** ***Barcın Höyük;*** **Bad** ***Bademağacı Höyük;*** **Ça** ***Çatalhöyük;*** **Yu** ***Mersin-Yumuktepe. Base map made with R (*****R Core Team 2020*****) and Natural Earth, @ naturalearthdata.com; site locations from the DEFC database (defc.acdh.oeaw.ac.at), Karamitrou-Mentessidi*** **et al. (2015), *Adaktylou* (2017).**

Central Anatolia. The existence of this large population centre was not ahistorical either: for example, its pottery usage undergoes significant changes as the millennium goes by (*Özdöl 2012*), while architectural practices change roughly over the course of its third quarter (*Brami 2017.102–105*). Further west still, in the Turkish Lake District it is not yet clear what exactly the first half of the 7th millennium looked like,[1] but in the second the region definitely experiences the flourishing development of archaeologically recoverable material culture (see overview in *Duru, Umurtak 2019.251–269*). At the very western edge of Anatolia, close to the Aegean coast of Turkey, new agriculturalist sites also appear, including Ulucak (*Çevik, Erdoğu 2020*) and Çukuriçi (*Horejs 2017*), with long stratified sequences spanning the last three quarters of the 7th millennium. In northwestern Anatolia, in comparison, on current evidence Neolithic occupation starts a little later, with the earliest known such site in the region, Barcın Höyük, beginning slightly before the middle of the millennium (*Gerritsen* et al. *2013*). After this start, the Eastern Marmara region appears to feature continuous development through the second half of the 7th millennium, developing its material-cultural peculiarity, which can be described as a single 'Fikirtepe culture' (*Özdoğan 2013*) despite considerable variations between settlements (*Karul 2019; Özbal, Gerritsen 2019*).

Turning from Turkey to Greece, two regions are known to have been rather densely populated by agriculturalist communities by the end of the 7th millennium: Macedonia and Thessaly (see *Reingruber* et al. *2017* and *Urem-Kotsou, Kotsos 2020*, respectively, for current chronology and references). Despite a number of recent and active excavations adding to the evidence in Macedonia, it is still hard to discern, behind inter-site variability, unambiguous patterns of development other than in specific domains: (uncontestable) pottery changes and (apparent; the review of evidence in Reingruber (*2008*) still remains relevant) changes in 'small find' categories such as figurines and stamps/seals/pintaderas (henceforth I'll use 'stamps' without prejudice to the function, after *Çilingiroğlu 2009*). However, as these very specific categories of evidence are particularly likely to be preserved for archaeological investigation, it is often through their comparison that we can identify prehistoric relations between different sites and regions. To use stamps as an example, in the Turkish Lake District's Bademağacı, they first occur in a stratified context from Level 3 (*Duru, Umurtak 2019.207, Pl. 123*), *i.e.* apparently in the third quarter of the 7th millennium. In contrast, in Ulucak, near the Western Turkish coast, stamps occur from level Vb, in the last quarter of the 7th millennium (*Çevik, Erdoğu 2020*).[2]

To better understand the actual histories revealed by such archaeologically visible phenomena, we need to know the precise chronological relations between the sites. It should be stressed that chronology is not the simplistic hunt for who or which region was 'the first': if one is interested in local pride, each region has in fact quite a lot to offer; and if one is interested in understanding human histories, then there are plenty of questions more relevant than who was the first: 'what exactly?', 'how fast?', 'together with what or who?' and 'why now?' are just some that are of far more consequence. Understanding the prehistoric chronology well is a prerequisite for answering most of these.

Yet gaining precise chronological knowledge is not easy. The natural-scientific method of choice for the Neolithic is radiocarbon dating. But while beautiful in its principle of tracking a uniformly decaying radioactive element, in practice radiocarbon dating is not simple. As with any physical experiment, plenty of things can go wrong, sometimes at no fault of the experimenter; thus a single measurement is never an unquestionably reliable datum. The experimental techniques of radiocarbon dating continue to be developed and further refined (to appreciate this constant process of improvement, see, for instance, *Bird* et al. *1999*; *Brock* et al. *2010*). So are the data and algorithms needed for 'calibrating' radiocarbon measurements: turning physical measurements into calendar years based on a calibration curve, with a new set of curves published just recently (*Reimer* et al. *2020*).

Further aspects of modelling can also be complicated. Wood samples may come from older wood that stopped carbon exchange with the outside much be-

1 As far as radiocarbon chronology goes, the case for occupation in the first half of the 7th millennium basically rests on one date from Bademağacı level 8; though such early occupation is quite possible given the excavated evidence at this and other 7th millennium Lake District sites, future research will hopefully be able to add more to our knowledge.

2 Earlier layers of Neolithic sites are often only investigated in small exposures; but in these two cases, the relevant exposures of the earlier layers have been on the order of 100m² at Bademağacı (deduced from *Duru, Umurtak 2019.162–163*), and *c.* 135m² at Ulucak (*Çevik, Vuruskan 2020.102*), and thus the absence of stratified stamp finds in these cases may well be due to their genuine absence.

fore the tree was cut and used. Animals, including humans, may have drawn through their diet carbon from different sources with different radiocarbon concentrations. This is often labelled 'reservoir effects', where the reservoir refers to the carbon reservoir from which the carbon comes. Unfortunately, local reservoirs may have rather different qualities, and even the measurements of present-day marine reservoir properties can be rather scarce. For instance, in the whole of the Aegean Sea we only have three point measurements, at Nafplio, Piraeus and the Dardanelles/Çanakkale strait. The latter two are closer to each other in numerical value than to the Piraeus measurement, even though Piraeus is much closer to Nafplio than Dardanelles/Çanakkale is, *http://calib.org/marine/*. This all underscores just how non-trivial the issue is.

Finally, the dated sample may contain contaminants with a different carbon age, which in some cases just cannot be eliminated by any known procedure, and – what is even worse – with possibly no indication that something went wrong other than an unrealistic measurement (*van Klinken, Hedges 1998*), so if we are not lucky enough recognize it as unrealistic, we will just happily accept the wrong date.

In practice, difficult though these problems are, they can be largely counteracted by well-designed dating programs, generating not just single measurements, but longer series of dates sampled through the stratigraphy. The sheer number of dates in large series makes outliers, whatever the ultimate reason for their appearance, much easier to see and thus allows them to be weeded out by analysts. Perhaps even more importantly, when the dates are modelled jointly in a Bayesian framework, the stratigraphic information about dated samples can constrain the results in non-trivial and useful ways.

Bayesian modelling of archaeologically relevant radiocarbon measurements, pioneered by John C. Naylor and Adrian F. M. Smith (*1988*), has in the last few years become a nearly-standard method among prehistorians. Within the subfield of Aegean prehistory specifically, the importance of such statistical modelling is frequently acknowledged (*e.g., Reingruber 2020*) and practiced (*e.g., Maniatis 2014*). The point of Bayesian analysis is to incorporate the meaningful information gained by archaeological research into the process of obtaining calendar-age dates from ^{14}C measurements. This often allows time estimates to become much more precise, but also, importantly, more correct than if we ignored the actually known information and only relied on 'agnostic' calibration of single dates and their mechanistic and/or highly subjective combination (*Bayliss* et al. *2007*).

However, it is common that in practice not all of the actually known information gets incorporated in the results. The purpose of the current contribution is to explain how to include one particularly common type of information we can obtain from interpreting excavation results: the rough duration of a particular deposition phase of the site to be dated. I discuss the issue with the help of two case studies, of basal Neolithic levels at Knossos on Crete (often labelled 'Aceramic' levels), and of the Early Neolithic settlement of Nea Nikomedeia in Greek Macedonia. Douka *et al.* (*2017*) and Maniatis (*2014*) are the most recent dating analyses for these two, but neither includes the available prior knowledge about the apparent duration of the relevant deposition phase.

There may be different reasons for choosing not to specify the likely duration of a deposition phase in advance. In fact, for many common applications this duration would be among the main variables of interest: the fundamental work of introducing good Bayesian dating practice to prehistorians (*Bayliss* et al. *2007*) is concerned exactly with gaining inferences about phase duration.[3] But for the two case studies I report, there are arguably good grounds for making very specific assumptions about the duration of deposition.

In the current literature, basal Knossos gets assigned to anywhere from the later 8th to the middle of the 7th millennium BCE. But when properly modelled we obtain a fairly precise estimate of the 66th century BCE, which allows us to see how this short-lived occupation fits into the developments in the broader region. For Nea Nikomedeia, existing estimates are equally discordant and wide: from 6600/6400 BCE to the end of the 7th millennium. In this case, the reported radiocarbon measurements clearly contain anomalies that cannot be explained without a new dating program for the site. Still, on present evidence we can place this site's existence as a 50–150-yearly period somewhere roughly between

3 Similarly, the purpose of the Gaussian Monte Carlo wiggle-matching (GMCWG) method (see, for example, *Benz* et al. *2012.299–300*) is to get duration and date inferences in the case when we cannot independently estimate the length of a phase.

6300 and 6050 BCE, excluding both the highest and the lowest opinions in the literature. Both re-evaluations have consequences for our picture of the Neolithisation of the Aegean. For Nea Nikomedeia, I also discuss the consequences of the re-evaluation for the temporal distribution of stamps in the Aegean and Anatolia.

Accepting the specific proposals below for basal Knossos and Nea Nikomedeia will crucially depend on accepting the estimates of the phase duration that I accepted, as well as on the available radiocarbon measurements and on my choices regarding which ones to use. This is as it should be: if our respective understandings of the archaeological evidence differ; if our sets of data differ; or if we make a different choice of which data to discard as erroneous – this all may result in different date estimates as well. The key here is to first incorporate as much of our actual firm beliefs about the site into our dating analysis as possible; and second, to be explicit about our assumptions, so that they can be subsequently challenged or adjusted, as future evidence or future analysis may demand. To simplify future re-evaluation of my results, the original analysis files for OxCal (*Bronk Ramsey 2009*), as well as the result files, are all provided as online supplementary material. The analysis files include the uncalibrated dates discussed and used, coded in the OxCal format.[4]

Re-evaluating basal Knossos dates conditional on a very short occupation

The basal, and for all we know initial, occupation of Knossos, directly overlaying the bedrock, has been claimed to exist in three small areas AC (11 by 5m), X and ZE (*Evans 1994*), where it was labelled Stratum X; and in Trench II in the 1997 rescue excavations on the area of 1.5 by 1.5m, where it was labelled levels 38–39 (*Efstratiou* et al. *2013*). Small areas X and ZE of Arthur Evans's excavations are relatively far from the AC area, and contain architectural remains; I follow Agathe Reingruber (*2008*) in rejecting Evans's identification of the basal layer in AC with those at X and ZE, given that no dates are available from X and ZE, and that the 1997 excavators did not find similarities with ZE either (*Efstratiou 2013.27*). Note that Evans himself connected the architectural remains in ZE and X to Stratum IX rather than X (*Evans 2008.19–20*). Judging from Stratum IX ^{14}C dates, it represents a much later occupation. In contrast to X and ZE, trench II is at most 10m away from Evans's area AC (*Efstratiou* et al. *2013.2, Fig. 1.1*), and I accept the 1997 excavators' identification of their levels 38–39 with Evans's Stratum X. The cited excavators label these basal layers 'Aceramic'; I will refer to them as 'basal Knossos' to avoid using potentially theoretically charged terminology (see, for example, *Reingruber 2017* for a review).

The early radiocarbon dates were compiled by Evans (*1994*), and re-published with added information on their context by Yorgos Facorellis and Yannis Maniatis (*2013*), who also published further dates from the 1997 excavations. Finally, Katerina Douka *et al.* (*2017*) added still more dates on samples from both the 1997 and Evans's excavations, and modelled them statistically using OxCal.

The apparently very early dates from basal Knossos have deservedly received much attention in the literature, but their exact interpretation remains contested. Evans (*1994.1*) writes of "*some time near the end of the 8th, or in the earlier part of the 7th millennium BC*"; Nikos Efstratiou (*2013.29*) of "*the first settlers of Knossos around 7000 BC*" for the initial Knossos occupation; Liora Kolska Horwitz (*2013.173*) says the dates "*place the Stratum X occupation [=basal Knossos – Author] at the end of the eight millennium calBC*"; Facorellis and Maniatis (*2013*) say that "*radiocarbon dating has established absolute dates for the beginning of the Neolithic in Crete at 7030–6780 BC*"; Maniatis (*2014. 209*) writes that Knossos was established "*around 7000 BC*"; Çiler Çilingiroğlu (*2016.Tab. 1*) places Knossos X among a set of sites within "*7000–6600 calBC*"; Reingruber (*2008.121*) discusses the earlier radiocarbon dates and placed Knossos "*X and the upper [obviously "lower" is meant – Author] border of IX during the middle of the 7th mill. BC*".

In its turn, the latest Bayesian modelling in Douka's *et al.* (*2017*) study does not discuss the authors' interpretation of their analyses explicitly, despite the fact that the estimates obtained differ between each other. The dates on the map in Douka *et al.* (*2017. Fig. 6*) give for Knossos '6910–6480/6970–6590', which are called in the caption "*the numerical age estimates for the earliest Neolithic occupation (95.4% probability)*". An examination of the plot in

4 All results in this paper were obtained using OxCal 4.4 (*Bronk Ramsey 2009*), run on the Oxford servers made available to the archaeological project, for which I am very grateful. IntCal20 (*Reimer* et al. *2020*) was used as the default calibration curve, and the results were selectively checked against IntCal13 (*Reimer* et al. *2013*), as reported in the text.

this figure and of supplementary Tables S2 and S3 (available at http://dx.doi.org/10.4312/dp.48.3) shows that this should be read as the estimates for the beginning of the earliest occupation, rather than for its whole length, as could be erroneously inferred. In the main text, we read: "*Knossos was first occupied at the beginning of the seventh millennium BC (6900–6600 BC at 95.4% probability*" (*O.c. 317*)). Finally, regarding the modelled duration of occupation, Douka *et al.* (*O.c. 315*) state: "*the lifespan of the Knossos founder village was short; it seems to have lasted from a few years up to a maximum of 400 calendar years*". This must refer to explicit measurement of the phase's duration in OxCal, not directly shown in the paper.

Before we turn to modelling ourselves, it is useful to review the findings for basal Knossos from area AC's Stratum X and Trench II's levels 38–39. In area AC, we have numerous "*grain from a field of breadwheat*" (*Evans 1994.4*), *i.e. Triticum aestivum* (*Sarpaki 2013*) (still surprising today at this early time and this place); and "*a row of stake-holes, and the carbonised remains of some of the actual stakes were found to be still in the holes in which they had been set*" (*Evans 1994.5*). There were child burials dug into this layer, but their simultaneity is not as secure (*Reingruber 2008*). Bone tools, a figurine, beads and shell pendants are reported by Evans (*1994.5*). Animal bones from Evans's excavations were studied by Valasia Isaakidou (*2004*), divided by excavation area, and include cattle, pig and sheep/goat (with counts in her Fig. 6.1) for basal Knossos in AC. The lithic industry is described in James Conolly (*2008*), apparently for the combined sample from AC, ZE and X, which is unfortunate.[5] Conolly reports signs of resource stress in the assemblage, while Evans (*1994.5*) reports the obsidian to be Melian.

The small 1.5 x 1.5m area of Trench II from the 1997 excavations added to Evans's earlier finds "*some pieces of obsidian and dissolved unbaked mudbrick*" (*Efstratiou* et al. *2013.19*); more concretely, "*four pieces of obsidian – small flakes and broken blades – and one flint blade*", with the obsidian presumed to be Melian (*Efstratiou 2013.28*). The 1997 archaeobotanical sample presents multiple other cereals and pulses (*Sarpaki 2013.69–73*). Summing up, there is considerable evidence of human activity at basal Knossos, including harvesting grain and various other forms of work with animal and stone tools. However, the overall layer is thin, and is compatible with a short-lived occupation of several years (perhaps a single harvest season!), as defended by Reingruber (*2008.127*) and accepted as a real possibility by Douka *et al.* (*2017*).

The radiocarbon dates for basal Knossos include five measurements from grain and five from charcoal, which includes two dates from the same stake from Evans's Stratum X. Below I report four possible models for those dates, generated by two factors: (i) whether to include only dates from grain (a short-lived, and therefore more reliable material for dating associated events), or dates from both grain and charcoal; and (ii) whether to leave the length of basal Knossos with an implicit prior (similarly to *Douka* et al. *2017*), or impose on it an informative prior corresponding to the hypothesis of a short occupation of just several years; specifically, I defined a log-normal prior with the mean below two years, but allowing, in principle, much longer spans, albeit with low probability. Figure 2 illustrates the analyses made only on grain dates, and shows considerably different inferences about both the duration and timing of basal Knossos.

The first thing to note is that the two analyses in Figure 2 provide very similar posterior estimates for the five grain samples. The choice of prior on the phase length thus did not have a dramatic effect on individual date inferences. However, that choice had just such an effect on the inferences about the phase's length and overall timing. If we use the implicit prior, also used by Douka *et al.* (*2017*), the phase's start ranges from 6704 to 6491 cal BC at the 95% HPD (that is, the highest posterior density), but with a restricted phase length this becomes a shorter 6598 to 6484 cal BC. The length of the phase, Figure 3, is anywhere between zero and 250 years (95% HPD) with the implicit prior, but is below five years with my informative prior at the same HPD. The inferred durations (black) on the right in Figure 3 closely follow the prior's shape (light shaded).[6] This means that it is ultimately the prior, and not the data,

5 In the light of this, the suggestion of continuity between basal Knossos and much later overlying Neolithic layers (*Conolly 2008. 87*) is unfortunately suspect.

6 It is not clear to me why negative durations are reported at the lower end, as the OxCal construction of a phase with two boundaries should ensure a non-negative phase length. Perhaps this is due to a difference in default resolutions used by the program when running and checking constraints on the one hand, and when reporting on the other; in this case, "–2" should really be read "0".

which effectively drives the phase-duration inferences.

Thus the seemingly harmless implicit prior in fact represents non-trivial beliefs about the phase length that we incorporated into Bayesian analysis. It is instructive to explain how this happens. The assumptions we made for the implicit prior, similar to those in Douka *et al.* (*2017*), but also in most Bayesian analyses of Aegean prehistoric chronology known to me, are (i) that our measured grains belong to one phase, and (ii) that their deposition was at a uniform rate. It is this uniform rate assumption that keeps the boundaries of the interval from going to infinity, while still allowing them considerable freedom, as we effectively allow a rather long time to pass before the first of the grains was grown and charred.

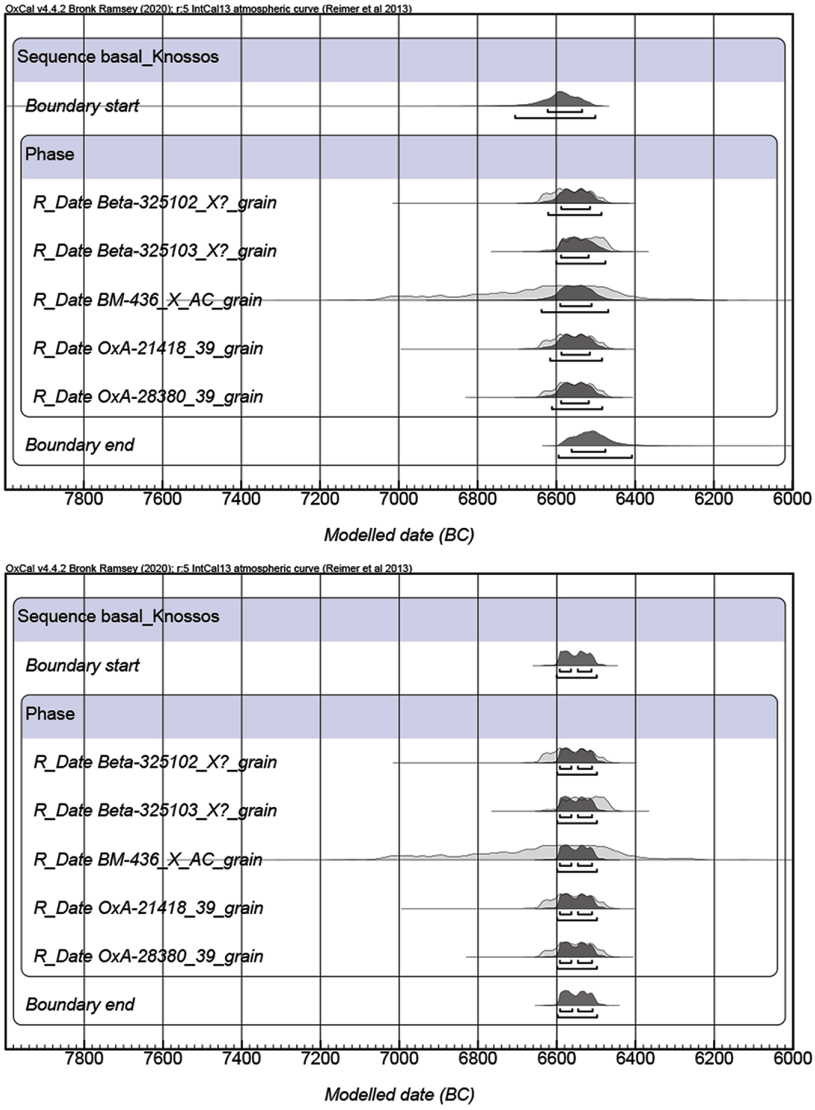


Fig. 2. Basal Knossos analysed with dates from grain only. Above: no additional prior on phase length. Below: log-normal prior on phase length with $\mu = 0.5$, $\sigma = 0.5$ (thus with the mean below two years, but a long thin tail allowing much longer durations). Here and in all subsequent analyses: (i) in plots, the lower interval lines correspond to 95% HPD (highest posterior density), upper lines, to 68% HPD; (ii) the corresponding OxCal scripts and result tables can be found in the online supplementary material at http://dx.doi.org/10.4312/dp.48.3

Now that we see the effects of choosing between the two priors on phase length, let us go back to the archaeological interpretation. I introduced the log-normal prior favouring a very short phase length on the basis of a hypothesis of very-short occupation, which may prove to be wrong in the future. Remaining agnostic about that specific hypothesis, do we have other reasons to choose between the two priors? I would argue yes. Note that the first three dates in Figure 2 stem from three grains of the same cache studied by Halbaek from AC Stratum X (*Douka* et al. *2017*). The other two dates are from seeds from level 39 of Trench II, which in principle may or may not belong to the same season's crop. Thus whatever our beliefs about basal Knossos as a whole, we should accept almost simultaneous actual deposition for the three dated grains from Stratum X, and perhaps for all five, as Trench II was at most 10m away from area AC and the seeds from it could well belong to the same deposition event. To see if choosing three or five seeds makes a difference, I checked whether a model featuring just the first three dates from Figure 2 with the short-length prior provided different inferences from those with five grain dates. The smaller three-date model (see the supplementary material at http://dx.doi.org/10.4312/dp.48.3) infers similarly prior-driven phase durations, but is less specific about when the short occupation occurred: roughly 6590 to 6500 cal BC at the 68% HPD, and 6630 to 6470 cal BC at the 95% HPD.

Let us spell out the substantive consequences of accepting either prior. If we choose the informative short-occupation prior for the grains, it is clear what

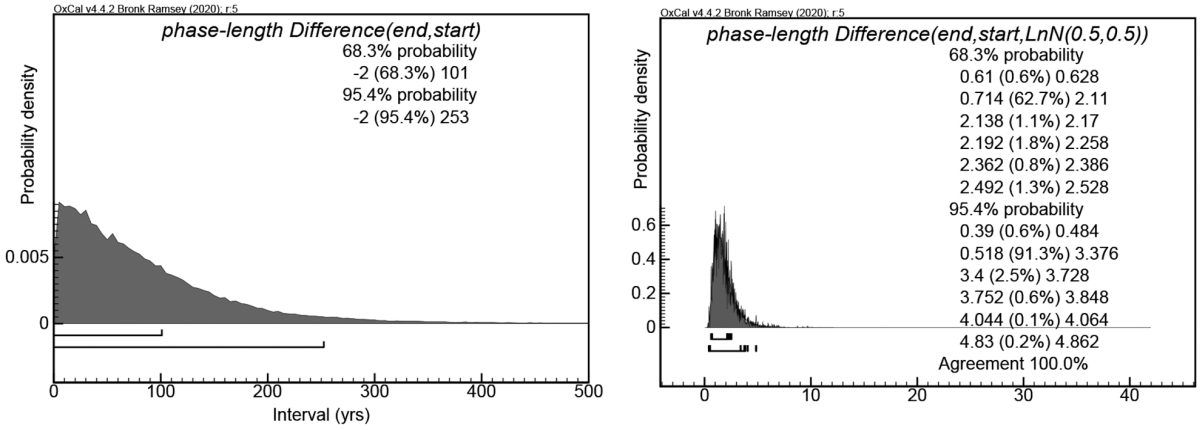


Fig. 3. The duration of basal Knossos from grain-only analyses in Figure 2. Left: no additional prior on phase length. Right: with log-normal prior on phase length with $\mu = 0.5$, $\sigma = 0.5$; the shaded area illustrates the shape of the prior, the solid black line, inferences; it is clear from the comparison that the inferences closely follow the prior. Note the difference in scale on the x-axis between left and right.

we are trying to date: the event of handling that crop, which may or may not coincide in duration with the overall basal Knossos occupation. If we choose the implicit prior that does not restrict the phase length, then we get inferences compatible with the Knossos occupation existing for decades, if not centuries, before the three/five grains were grown, and similarly after that event. Archaeologically speaking, it is not at all clear what we are actually measuring with a phase defined in this way.

While it is reasonable to disagree which prior is more appropriate for inferring the dates for the whole of basal Knossos, only the short prior is appropriate for dating the deposition of the grains. So even if we choose to believe the occupation could last a long time, we should still, on present evidence, place the event of growing the crop into the 66th century BCE (if we assume all five grains to be from one crop) or into the roughly one and a half century between 6630 and 6470 BCE (if we only accept the grains from AC).

Let us now consider what happens when we also include dates from charcoal, as seen in Figure 4. As we could now expect, the two models provide very different estimates for the phase date and duration. On the implicit prior on the left, basal Knossos ranges between roughly 6850 and 6450 cal BC at 95% HPD, with a duration anywhere between zero and 370 years. On the short-occupation prior, we infer a 95% HPD of about 6650 to 6600 cal BC for the phase, and a short duration, strongly induced by the prior.

Given the higher apparent precision of the model with the short-duration prior, one might wish to prefer the all-dates model with the short prior over the grains-only one. The satisfaction of using all available data might tempt one to accept one of the models in Figure 4, whichever accords better with one's beliefs. But I argue that closer examination of the quality speaks against those choices. Even the visual inspection of Figure 4 shows that the combined (BM-124)+(BM-278) and the OxA-9215 charcoal dates show poor agreement between the individual measurement (light shaded and outlined) and the inferred distribution (dark shaded). Indeed, the agreement indices A for the two resulting calibrated dates are low in both models (see the results in the table form in the supplementary material at http://dx.doi.org/10.4312/dp.48.3). Furthermore, on the seemingly more precise short-duration-prior model on the right in Figure 4, two of the grain dates show very poor agreement, namely Beta-325103 and OxA-28380. In other words, some data is not in very good agreement with the models. I conclude from this that it is preferrable to use the grain-only models for basal Knossos.

There are several possible reasons for the problem. First, it could be that the charcoal samples do not actually come from the same deposition event that affected the grains. This is perhaps unlikely for the stake from which the old dates BM-124 and BM-278 came from, as one of the dated grains is reported to be associated with that stake (*Facorellis, Maniatis 2013.Tab. 10.2*). For the other charcoal samples, theoretically they may have been produced by different fires. Second, the old-wood effect may well be in play; the two charcoal samples from the burned stake were considered by Evans to be unlikely come from an old tree, as "*the oak was probably only 15–20cm in diameter*" (*Evans 1994.5, fn. 11*), but its old date, when calibrated in isolation (*i.e.* the out-

line in Figure 4), is rather imprecise, and similarly for OxA-9215. The three other charcoal dates are measured considerably younger (over a century younger in uncalibrated BP), but even those measurements at face value appear to predate those from the grains. This is consistent with the dated wood having being old, and the whole basal occupation being very short; but we cannot on present evidence exclude the hypothesis of a longer light occupation, either. Finally, we cannot exclude the possibility that some of the measurements, especially from early dating, are objectively in error.

To conclude this case study: I argue that it is more appropriate to model the date of basal Knossos using only the measurements from grain; that the radiocarbon evidence is compatible with basal Knossos being a short-lived occupation of just several years, perhaps one season, though our radiocarbon data in themselves do not support this over alternatives; and finally, that this basal occupation happened specifically in the 66th century BCE. On presently available evidence, the reader may accept or reject this proposal judging for herself the merits of my reasoning. The advantage here is that this reasoning was made explicit above and is thus easy to evaluate independently.

Needless to say, it is also quite possible that in the future we will obtain more hard evidence about the basal occupation of Knossos, which can then significantly affect our inferences. But at least for the present evidence we applied some important model-checking steps: we checked sensitivity to the phase-length prior as recommended for priors in general, *e.g.*, by Christopher Bronk Ramsey (*2009.347*),[7] and performed an informal check of agreement of in-

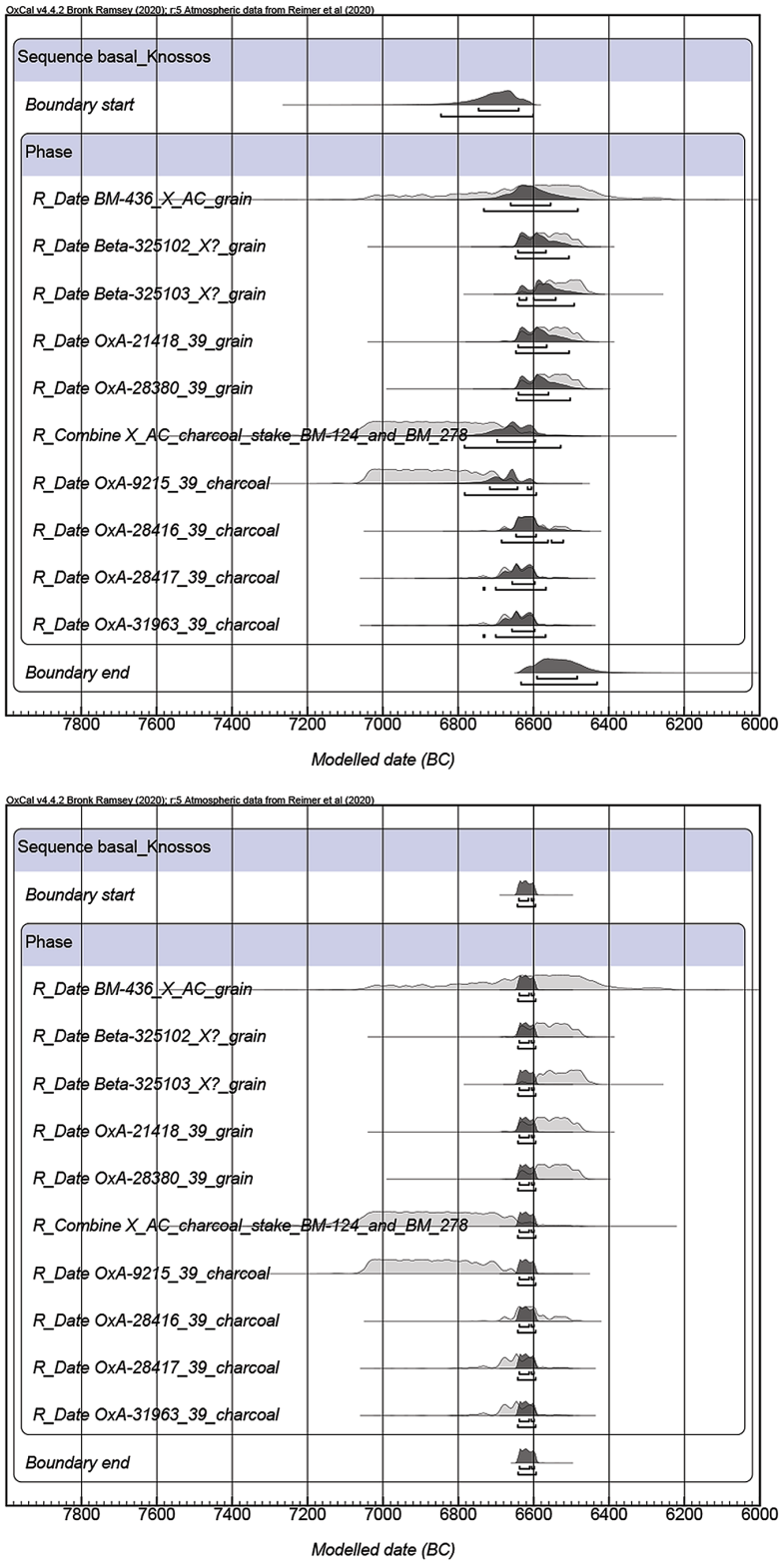


Fig. 4. Basal Knossos analysed with dates from grain and charcoal. Above: no additional prior on phase length. Below: log-normal prior on phase length with $\mu = 0.5$, $\sigma = 0.5$. See the online supplementary material at http://dx.doi.org/10.4312/dp.48.3 for analysis scripts and tables.

7 For the proposed preferred analysis, that is the one incorporating only dates from grains and restricting the length of the deposition event, I also checked the effect of the calibration curve. Using IntCal13 (*Reimer* et al. *2013*) instead of the current IntCal20 did not change the results significantly, resulting in slightly shorter HPD intervals for the start and end dates of the phase.

dividual radiocarbon measurements with the model (*cf. Bronk Ramsey 2009.356*).

Re-evaluating Nea Nikomedeia dates conditional on an occupation length of several generations

Until the last decade, it was a contentious issue whether Greek Macedonia featured any Neolithic sites before the last two centuries of the 7th millennium BCE. The site of Nea Nikomedeia, in the southwestern corner of the Plain of Macedon, has been central to the debate. The site was excavated in 1961–64, but has not yet received a full final publication: Gillian Pyke and Paraskevi Yiouni (*1996*) is the final presentation of the stratigraphy, architecture and the pottery, but for example lithics or small finds, including among others the stamps that played a role in the chronological discussions of Nea Nikomedeia, have not yet been definitively published.

The set of radiocarbon dates for Nea Nikomedeia includes four dates on charcoal or on unknown material made in the 1960s. The two earliest of which have huge laboratory-reported standard deviations and after individual-date calibration reach far into the 8th millennium BCE – much earlier than the very early, for Neolithic Greece, charcoal dates from basal Knossos. However, further dates on grain and animal bone were obtained in the 1980s and 1990s (*Pyke, Yiouni 1996.195*), and fall into the second half of the 7th or even into the 6th millennium BCE, and do not all agree well (see, for example, the discussion in *Perlès 2001.108–109*).

Different interpretations have been expressed in the literature regarding the ordering of Nea Nikomedeia. Representative examples include the following. Maniatis (*2014.Fig. 6*) lists Nea Nikomedeia among sites already existing between 6600 and 6400 cal BC, while Perlès (*2001*) broadly orders the site to roughly 6400–6000 cal BC (that is, to her definition of the Early Neolithic in Greece). Urem-Kotsou and Kotsos (*2020*) provide the range 6400–6200 cal BC for the site. Reingruber (*2008.394–396*), considering the apparently temporally advanced elements of the material culture, their similarity to early 6th millennium BCE sites in the neighbouring Republic of North Macedonia, and the then-lack of clearly comparable early sites in Greek Macedonia, orders the start of Nea Nikomedeia at between 6150 and 6100 cal BC. Significantly, when discussing the radiocarbon evidence Reingruber and Laurens Thissen (*2017. Region IId*) note the apparent inconsistency in our data about this site (see http://www.14sea.org/3_IId.html#site1), with several alternative interpretations of the evidence arguably remaining possible.

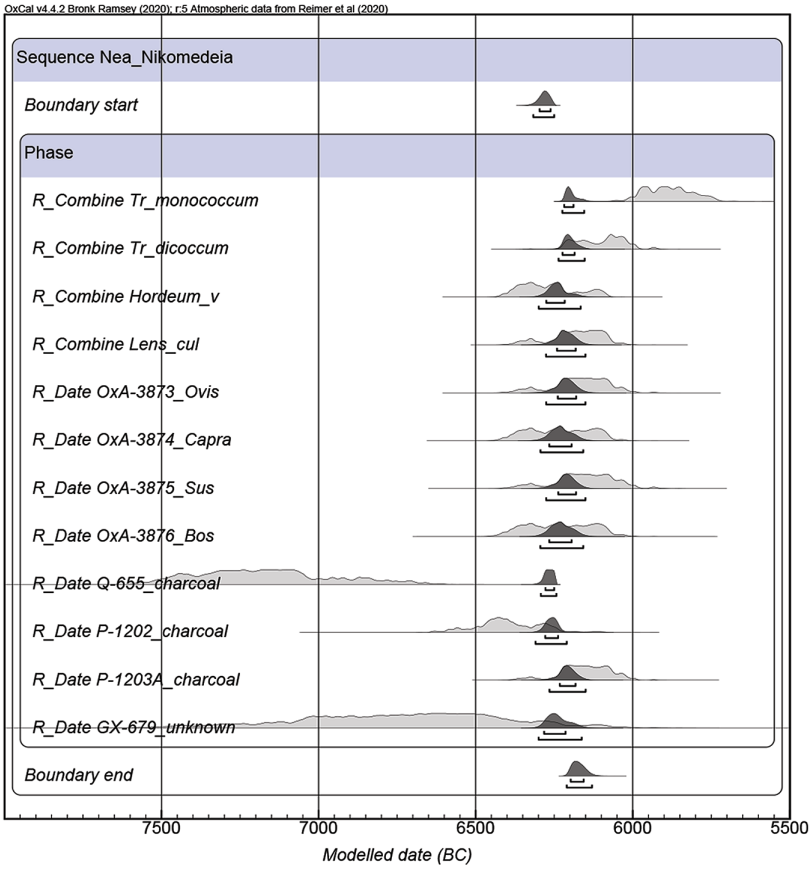
In recent years, the research context of Nea Nikomedeia has changed due to an enormous expansion of knowledge about the initial phases of the Neolithic in Greek Macedonia and bordering regions. While research is still ongoing and we lack final reports, it seems now beyond doubt that Greek Macedonia featured Neolithic settlements in the second half of the 7th millennium BCE, including most likely that millennium's third quarter and not just its end. Most preliminary information so far has been published from the site of Mavropigi-Filotsaïri in the Kozani prefecture, less than 100km east from Nea Nikomedeia (*Karamitrou-Mentessidi* et al. *2015*). The extensively excavated site of Paliambela Kolindrou, roughly 30km southeast of Nea Nikomedeia, features early dates (see *Maniatis 2014*) and shows evidence for rather complex landscaping behaviour at the initial settlement episode; importantly, Nea Nikomedeia-like houses succeed the small pit dwellings of the initial phase of the site (see *Kotsakis 2019* for a preliminary report). Rescue excavations at Revenia in the early 2000s uncovered another early pit-dwelling site, presented with an extensive catalogue of finds by Foteini Adaktylou (*2017*). Besides pit structures, there appears to be a later, but poorly preserved phase of above-ground dwellings at Revenia (*Adaktylou 2017*).[8] Taken together, the recently obtained evidence suggests an early presence of Neolithic settlements in Macedonia, and against that background Nea Nikomedeia is no longer exceptional.[9]

Still further inland from Greek Macedonia, we arrive to the Albanian Korçë basin, where the early Neoli-

8 Numerous dates for different pits – on charcoal, animal and human bone, and seeds – are reported by Adaktylou (*2017.Appendices 12, 22, 36, 42, 55, 72, 74, 102, 160, 163, 165, 168, 187, 195, 197, 242*). The dates show some spread, but mostly appear to point towards the third quarter of the 7th millennium BCE. Interestingly, stamps are present in several pits (*Adaktylou 2017.Appendices 378–379*), and also 'earplugs', with the lion's share of the latter in only two pits, Pit 44 (15 objects) and Pit 7 (seven objects) (*Adaktylou 2017.Section 6.5.5.6, Appendices 375–377*).

9 Urem-Kotsou and Kotsos (*2020*) is an up-to-date review of the sites in Central Macedonia, including the Early Neolithic ones; Maniatis (*2014*) published modelled dates from several of these, including Paliambela and Mavropigi; see also Bonga (*2019.162–163*), discussing the archaeological associations of some of the Mavropigi dates, and mentioning a possibly early date OxA-31863 from charred grain that seems not to have been formally published yet.

thic sites of Vashtëmi and Podgori (*Korkuti 1995.32–57*) show some decorated-ceramic affinities with Mavropigi, some 100–150km southeast (*Bonga 2017*). These Albanian sites might also be early (*Allen, Gjipali 2014*), though the radiocarbon dates stem from cores and are not in direct association with archaeological finds, and in any event remain isolated dates rather than series (see *Ruka 2018* for a critical overview). The chronological and spatial resolution of the ceramic associations also remain to be clarified, as Lily Bonga (*2017*) also discusses. In particular, a tradition appearing very similar to such polychrome decoration is a distinct part of the ceramic repertoire at Tell Čavdar in Western Bulgarian Thrace, almost 500km to the northeast of Mavropigi; *cf.* a polychrome ochre-on-red sherd in (*Bush 1984.81, Fig. 80c*), and several sherds described generally as "*dark-brown or red*" outlined by "*thin white bands or thickly placed white dots*" (*Georgiev 1981.87–88*), and represented at least in the V (Georgiev's Fig. 46) and VI (Fig. 47 middle right, 48 bottom left) horizons, and possibly later (the preliminary report does not specify the exact duration of this variety's appearance). The motifs appear, at least at first sight, rather similar to those at Mavropigi (*Bonga 2017.Fig. 5*). Unmodelled calibrated dates from horizons V and VI comfortably span the 62nd–57th centuries BCE at 68%, (*Reingruber, Thissen 2017*), while Mavropigi's fall exclusively into the 7th millennium (*Maniatis 2014. Fig. 3*).[10]



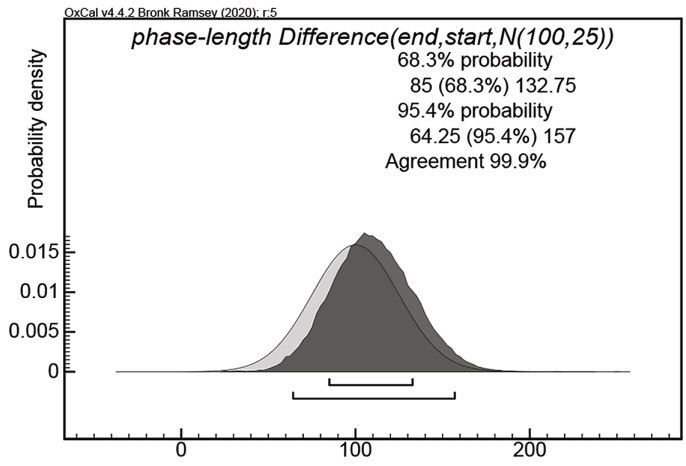


Fig. 5. Nea Nikomedeia: all dates reported in Pyke and Yiouni (1996); prior on the phase's duration: Normal(100,25).

Summing up, earlier dates for Nea Nikomedeia around the middle of the 7th millennium BCE as suggested by Maniatis (*2014*) would not look as isolated in the broader region today. It is thus all the more important to revisit the Nea Nikomedeia dates and model them jointly. Catherine Perlès (*2001*) and Reingruber (*2008*) discuss which Nea Nikomedeia dates can or should be treated as outliers, and thus

10 For further context, in the Korçë-basin site Vashtëmi from the older excavations there are just two pieces featuring red and ochre together (*Korkuti 1995.49*), and they have no white outline in contrast to the pieces found in Podgori. Thus this specific 'polychrome' tradition is only observed in Podgori (*Korkuti 1995.37, Pl. 7.6*; also *Andoni 2017*). For Čavdar, Georgiev (*1981.87–88*) writes that such polychrome decoration similarly appears in other settlements of the Karanovo I-Kremikovci I geographical group, and was also excavated at Gradešnica in Northwestern Bulgaria.

ignored. Maniatis (*2014*) reports dates after apparent individual calibration (as opposed to joint modelling), and does not analyse the most suspicious outliers; Thissen and Reingruber (*2017.134*) report the dates together with their individual calibrations at the 68% HPD, but unlike Maniatis combine the dates from grain and corresponding humic acid, which apparently correspond to the same samples. I am not aware of an actual joint modelling of the Nea Nikomedeia dates.

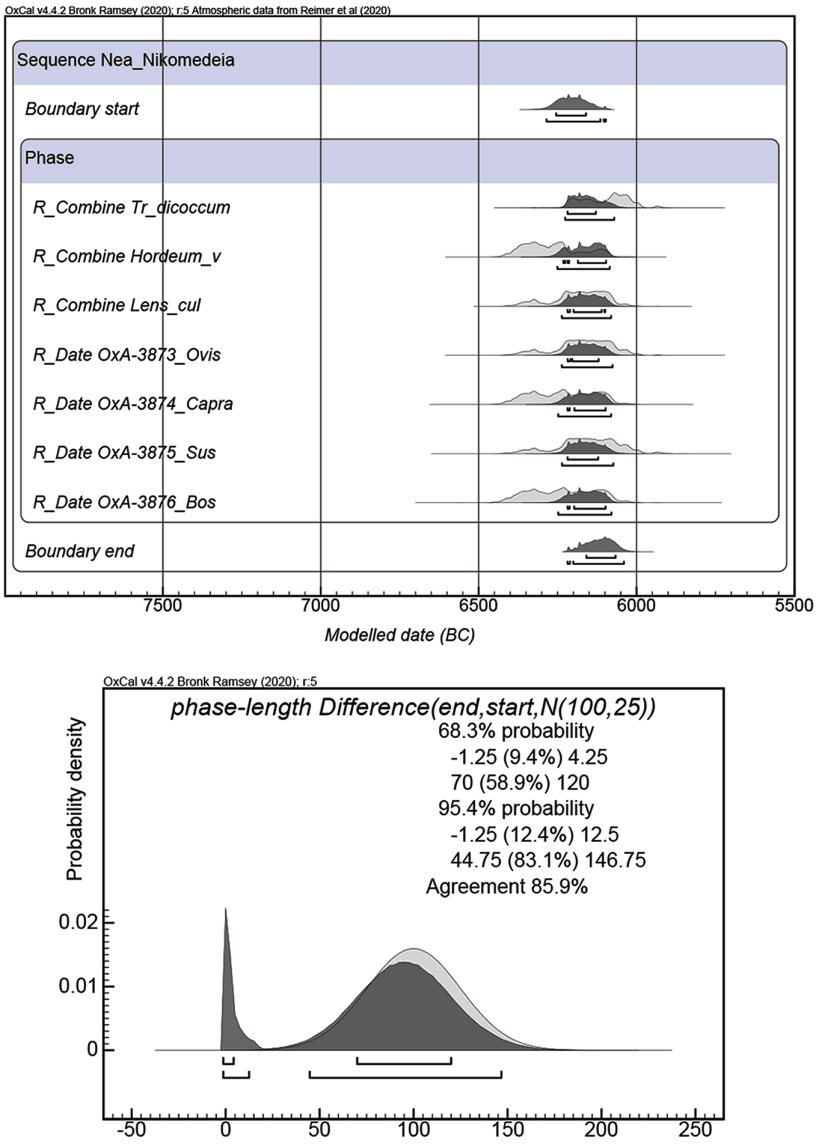


Fig. 6. Preferred model for Nea Nikomedeia: dates reported in Pyke and Yiouni (1996) without dates on charcoal and on unknown material, without the outlier combined date on grain,* Triticum monococcum *(OxA-1603)+(OxA-4280); prior on the phase's duration: Normal(100,25).

To model the dates appropriately, we now need to discuss the site's archaeological evidence. Nea Nikomedeia is a tell site, possibly with a long occupation history, but cleared for taking earth for road-fill down to its early Neolithic occupation (*Rodden 1996.5–7*). The remaining cultural layer was at most 20cm at a large portion of the site, but up to 70cm closer to the centre of the mound. The architectural remains have been tentatively evaluated by Pyke to correspond to three stratigraphic phases, which "*appear to follow in swift succession*" (*Pyke 1996.48*). She also reports that there was no apparent change in small finds. Yiouni (*1996.103–104*) studies the pottery of the site, and concludes that it is remarkably uniform across the stratigraphy, also suggesting "*only a short time span*". While Pyke and Yiouni (*1996*) refrain from voicing a calendar-years estimate for the duration of the studied (period of the) village, I accept here the agreeing estimates of 50–150 years by Stelios Andreou *et al.* (*2001.323*) and around 100 years (*Reingruber 2008.395*).

We now turn to defining a Bayesian dating model. I will go through the analyses I performed tutorial-style, in the order I did them, with the aim to demonstrate how one might proceed in practice. Considering the apparent short span of the occupation and its internal homogeneity, I model all dates as coming from a single deposition phase. Given that we do not have additional stratigraphical information on the relative relationships between the samples, I did not place any internal order on them. Finally, in agreement with the chosen prior duration estimate, I set an informative prior on the phase's duration, namely, Normal(100,25), which results in the 95% probability assigned to the duration(s) between 50 and 150 years, with a peak at 100 years. The results of such an analysis, taking into account all available dates including the likely outliers, are visualised in Figure 5 (see the online supplementary material at http://dx.doi.org/10.4312/dp.48.3 for results in the table format and the analysis file). This served as an exploratory analysis to see how all the different dates fit together.

What is obvious already from a visual inspection of Figure 5 is that the two dates accepted in the literature as outliers, Q-655 and GX-679, clearly look as such. This is no surprise: the plot on the right in Figure 5 shows that this set of dates drives the inferred length of the phase (dark shaded) in the direction of longer compared to the prior Normal (100,25) (light shaded), but not by much. There is no way to fit those implausibly early dates Q-655 and GX-679 well into such a short time span.

Another clear outlier is the combined date from *Triticum monococcum*: it is too young to fit in. Without knowing the archaeological context of the original sample, it is hard to say what exactly went wrong, but given that the mound seems to have originally had layers overlaying the studied early Neolithic occupation, an intrusion remains a possibility, as do all other reasons that can lead to outlying measurements. To my mind, it is clearly justified to exclude these *Triticum monococcum* samples as well as the two old charcoal dates if our goal is to date Nea Nikomedeia's studied occupation phase. It is not that those dates are necessarily 'wrong', but I believe it safe to conclude that if they are technically right, they are dating something else than the occupation phase of interest.

In addition to those exclusions, I subjectively prefer to exclude the two remaining charcoal dates P-1202 and P-1203A. It is not that they are obviously out of range of the rest of the dates on potentially shorter-lived material, and another analyst might prefer to include them as well (and we will see below what happens if we do).

The results are visualised in Figure 6. We can see from the plot on the left that our prior assumption about the length of the deposition in effect excludes considerable probability mass for most measurements, both on the older and younger sides. Agreement indices A, however, are high except for the two combined dates from *Triticum dicoccum* (A=88%) and *Hordeum vulgare* (A=66%) (see the table with the results in the supplementary material at http://dx.doi.org/10.4312/dp.48.3). For comparison, the grain-only model for basal Knossos with a short-deposition prior (on the right in Figure 2) featured agreement indices all over 100%. Alone, the level of agreement seen in the analysis in Figure 6 would be a moderate cause for concern.

However, when we consider the phase-duration diagram on the right in Figure 6, we can see that there is indeed a serious problem. The prior we put on the phase's duration is the same as it was in Figure 5, and is again light-shaded in this plot. But now we can see that it is bi-modal rather than uni-modal: in addition to the expected peak around 100 years, there is also a high peak close to 0. Note that this new peak strongly disagrees with our prior: our prior puts 95% of all probability into the interval of 50 to 150 years! Bayesian inference needs to see really strong reasons to override this. At the same time, we see that it has not shifted all the posterior probability mass to this unexpected peak: if it did, this would be a reason to consider if our prior could be in error, in which case we would need to adjust our analysis of the site accordingly. However, there is still a clear peak agreeing with the prior, so it is not that our assumptions of 50–150 years are fully incompatible with the data at hand. But of course only one of the two alternatives can be right: either Nea Nikomedeia had only a very short deposition phase, close to 0 years, or the deposition continued for several generations. Since there are good archaeological reasons to believe the latter option (after all, we are dealing with three building phases!), it is the unexpected peak that must be in error. But that peak is there for a reason in our analysis: there

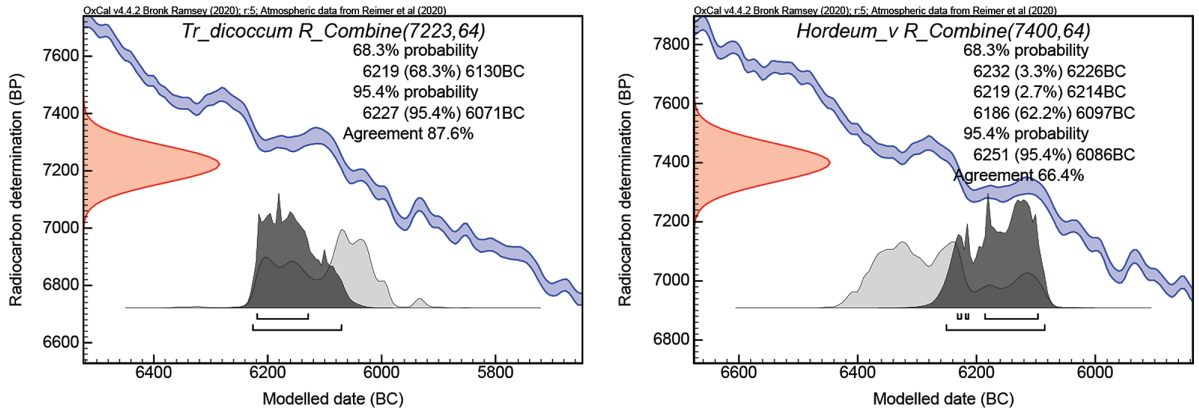


Fig. 7. Enlarged plots for combined dates from* Triticum dicoccum *and* Hordeum vulgare *from Figure 6.

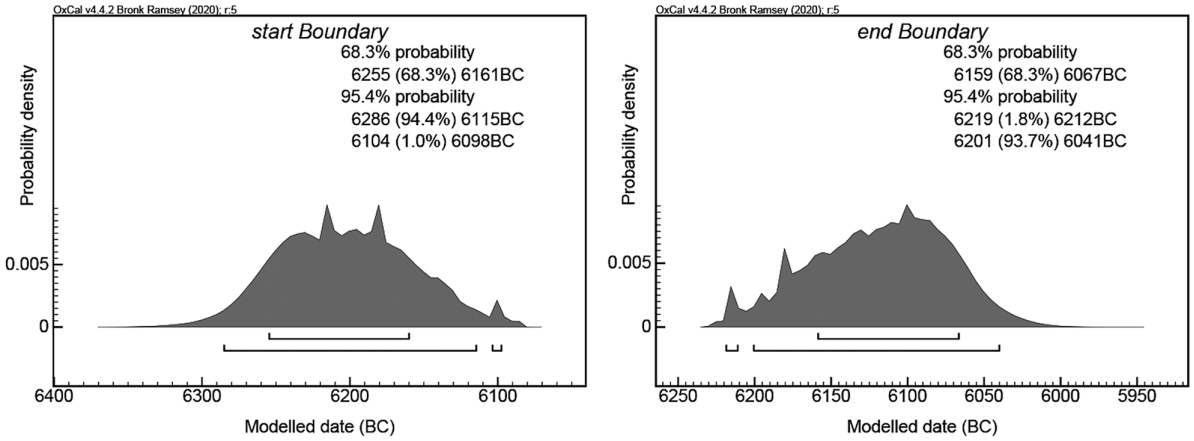


Fig. 8. Enlarged plots for the start and end boundaries from Figure 6.

must be strong enough 'pressure' from the data to force its existence. The only conclusion left is that there is a problem with our data in this analysis. It cannot all be quite correct.

What could have gone wrong? Visual inspection of the left plot in Figure 6 suggests that the main problem might be caused by the *Triticum dicoccum* and *Hordeum vulgare* dates. However, checking their independent calibrations (light shaded) and posterior calibrations (dark shaded), Figure 7, we can see that the problem is very subtle: it looks like the two dates are well compatible with each other. Just by looking at them, it is hard to predict there would be a problem.

Yet further close inspection of the analysis results shows the problem is actually very serious. Consider the posteriors for the start and end boundaries of our deposition phase, as shown in Figure 8. Note three spikes on each of the plots. They are clearly in the same temporal positions for the two phases. This shows that they correspond to the unexpected peak for the phase's duration close to 0 years: indeed, if the start and end boundaries are both selected from, say, the first spike, the resulting duration would be very short. This is really a 'wait a minute' moment for our analysis. Suppose for a moment that a very short phase really makes sense, given the data. But how could the data then favour three distinct, very specific datings for that very short phase? Why these dates? Examining the independent calibrations, choosing these particular three time points does not make sense. And indeed, it is nothing more than an artefact of our analysis, unfortunately. In reality, the true mathematical posterior in its short-phase part must be 'smooth', without noticeable spikes. It is just that our run fails to explore this true posterior properly. We can check that this diagnosis is correct by running the model again: the prediction is that the spikes will appear in different places on each run. This is, indeed, the case.[11]

In fact, the first time when I ran the analysis in Figure 6, OxCal completely failed to notice the unexpected peak, and I – mistakenly – believed the analysis was just fine. It was only when I ran it for the second time that the short-phase peak was discovered. MCMC is among the best options we have for performing Bayesian inference in complex models, but it faces various difficulties with posteriors of particular shapes. These difficulties are not absolute, and would have been properly dealt with if we could run MCMC for literally infinite time. As this is not really an option, we have to live with the fact that our convergence diagnostics sometimes think we are fine while in fact we have not yet obtained a good approximation of the true posterior. In particular, when there are several regions of the model space divided by an area of very low probability – as the true posterior of our model apparently is – it can sometimes lead to problems.[12]

Let us check if going with a different set of data or a different prior might convince us to prefer a different model. This will also serve as a sensitivity

11 To check this, one can examine the files with suffixes "start1.pdf" and "end1.pdf" in the supplementary material available at http://dx.doi.org/10.4312/dp.48.3, or run the script on OxCal to produce new, and different, results.

12 As a technical note, this particular case is probably so hard for OxCal because the short-phase area of the probability space is a very thin crest, but moving along it is somehow difficult for the sampler. Rather than exploring this crest in full, the sampler appears to jump off it into the other, prior-compliant, area of the posterior instead. It would appear that on the technical level OxCal's engine has a difficulty changing two highly correlated variables at the same time.

check: we need to know how robust the inferences of the model in Figure 6 are to the assumptions we put into it. I tested two such models: (i) the same as in Figure 5, but with two non-obvious outlier charcoal dates included, as seen in Figure 9; and (ii) the same as in Figure 5, but with an implicit prior on the phase's length, similar to the Knossos case study above, with results shown in Figure 10.

The model in Figure 9 stems from reasonable assumptions; its only difference from my preferred model is that it uses two dates on charcoal that are not obvious outliers. But the problem of the unexpected short-phase peak remains the same. This is not surprising if the problem was induced by the combination of date estimates we used in Figure 6: they are a subset of the data in Figure 9. Still, the results could have been otherwise: for example, by including the older charcoal dates P-1202 and P-1203A, that I chose to leave out, we could have been able to identify some other dates as probable outliers. Furthermore, having performed this analysis, we can check how much our results for inferring the time of Nea Nikomedeia deposition depends on those charcoal dates.

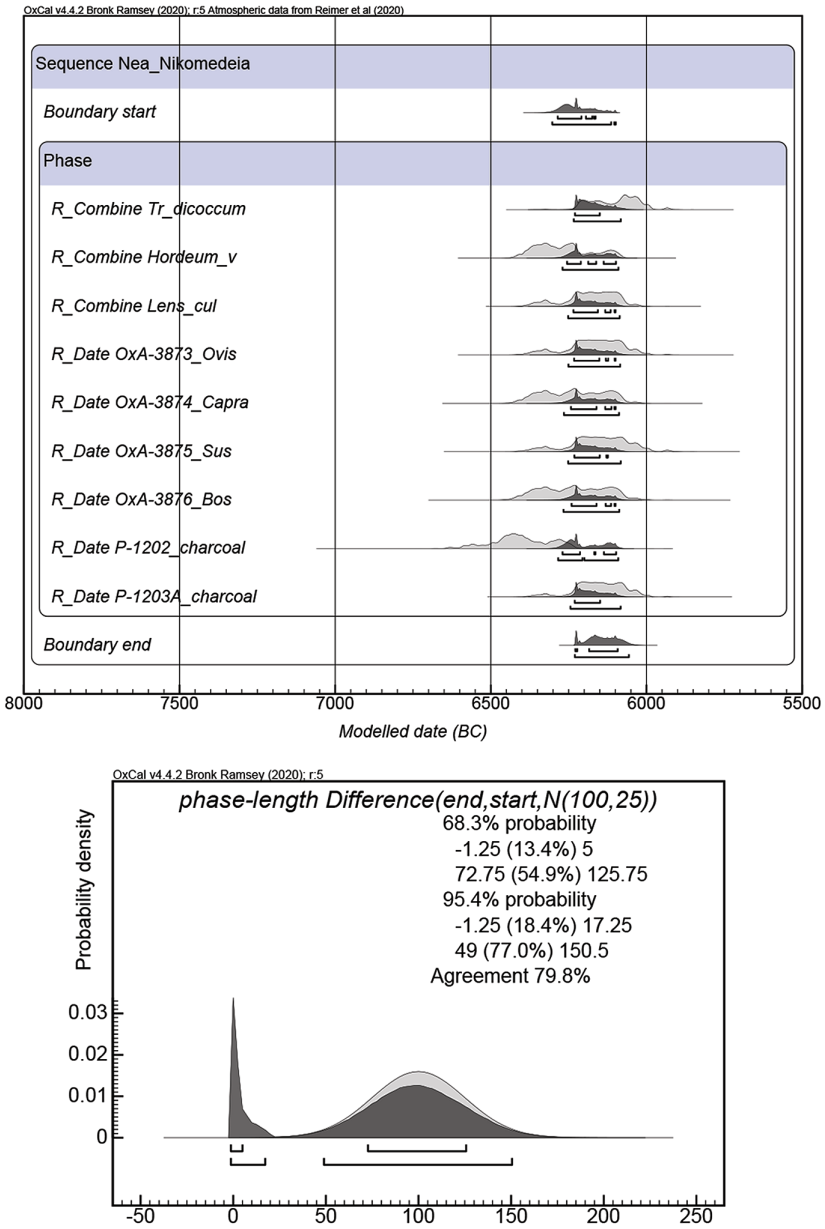


Fig. 9. Nea Nikomedeia: dates reported in Pyke and Yiouni (*1996*) without two outlier dates Q-655 and GX-679 and the outlier combined date on grain,* Triticum monococcum *(OxA-1603)+(OxA-4280); prior on the phase's duration: Normal(100,25).

Figure 10 shows what happens if we modify the model in Figure 6 by lifting our explicit prior imposing the duration of 50–150 years at 95% probability, and use instead the implicit prior induced by the assumption of a uniform rate of individual deposition events. As expected, under this implicit prior some durations very different from 50–150 years are judged possible: both short durations below 50 years, but also long durations over two centuries. The 95% HPD interval for the phase duration is from 0 to 350 years (see the table-format result in the supplementary materials at http://dx.doi.org/10.4312/dp.48.3). It thus includes both durations that are too short and too long, given what we know about the site.

It is also useful to rephrase this result in the following way: our radiocarbon data do not by themselves suggest a length of roughly 50–150 years; the explicit prior on this duration genuinely adds information to the Bayesian analysis that could not be recovered from the ^{14}C measurements themselves. In fact, the right plot in Figure 10 demonstrates the radiocarbon measurements that we have are compatible with a wide range of possible durations. Since we can be confident that Nea Nikomedeia existed roughly 50–150 years, it is crucial to include this as prior information. The model in Figure 10 is to be rejected, just as certainly as the model in Figure 5 that features obvious outliers.

Table 1 summarizes how the choice of model affects our estimates of the chronological position of Nea Nikomedeia. Comparing our preferred model, Figure 6, with the others, we note the following. All models result in wide 95% HPD intervals, which is partly due to the high standard deviations of the measurements themselves (see the scripts in the supplementary material for those at http://dx.doi.org/10.4312/dp.48.3), partly to a small plateau in the 62nd century BCE (see the calibration curve in Figure 8), and, quite likely, partly also due to problems with the measurements themselves. The model with an implicit prior on phase duration, seen in Figure 10, differs from the others by providing the widest, four-century-long interval into which it orders Nea Nikomedeia. This model is to be rejected as it is inconsistent with our knowledge about the site. Further, the model in Figure 5 infers a shorter interval than our preferred model. It thus seemingly offers better precision. But as discussed above, it includes obviously problematic measurements, and is therefore also to be rejected. Finally, our preferred model and the model in Figure 9, which keeps the reasonable looking charcoal dates in, largely agree: they both place Nea Nikomedeia within a *c.* 250-year-long interval, and position their intervals very close to each other, roughly between 6300 and 6050 cal BC. Our inferences are thus not strongly sensitive to whether we keep or discard the old dates from charcoal P-1202 and P-1203A. Such robustness is, generally speaking, a welcome result: good inferences should not depend too much on leaving out this or that specific observation. However, this does not cancel the problem inherent to our data that led to the short-phase-duration peak in both Figures 6 and 9. In other words, we have to reiterate the concern about the inconsistency of the dates and the analysis of archaeological evidence voiced by Reingruber and Thissen (*2017. Region IId*).

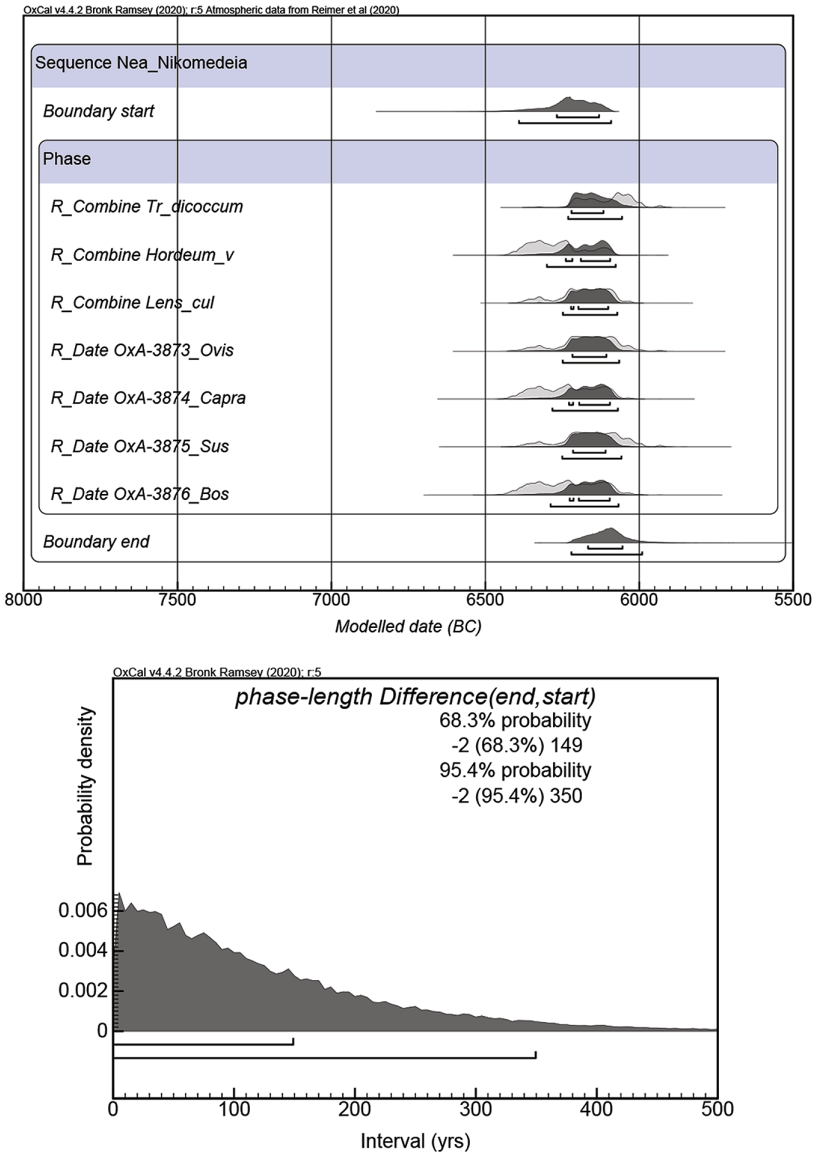


Fig. 10. Nea Nikomedeia: the same as in Figure 6, but with an implicit prior on the phase's duration.

	95% HPD
Fig. 3, all data	6317 to 6130 cal BC
Fig. 6, outliers and all charcoal out	6286 to 6041 cal BC
Fig. 9, outliers out, some charcoal in	6303 to 6057 cal BC
Fig. 10, as Fig. 6 but with implicit prior on lenght	6391 to 5991 cal BC

Tab. 1. The interval within which the 50–150-year occupation of Nea Nikomedeia should fall, according to four different models.

To conclude, on currently available evidence the occupation of Nea Nikomedeia, of length 50–150 years, should be placed between roughly 6300 and 6050 BCE at 95% HPD. This implies that in Thessalian terminology (*Reingruber* et al. *2017*), Nea Nikomedeia falls into EN II, pos-

sibly touching the transitional EN III/ MN I. The early dates in Maniatis (*2014.Fig. 6*) are then unwarranted, but the estimate of a 6150–6100 cal BC proposed by Reingruber (*2008*) may well be too late. The occupation does not appear to be particularly early in the Thessalian EN, but does not have to be at the very end of the 7th millennium either.

Discussion: Aegean Neolithisation and the chronology of stamps

More precise dating is not a goal in itself, and it can be helpful for archaeological interpretation. In this section, I describe the consequences we can draw from the dating re-evaluations above for two topics: the broader picture of Neolithisation in the Aegean region, and the spatio-temporal distribution of stamps in the Aegean and Anatolia.

The dates for basal Knossos previously given in the literature allowed one to place it very broadly: it could have been contemporaneous with the very earliest pottery sites in northern Mesopotamia (late 8th/very early 7th millennium BCE), or with the transformations of the Central Anatolian Neolithic around and after 6500 BCE. Our re-evaluation has placed basal Knossos firmly into the 66th century BCE, and this has many implications. First, it appears that the people who planted *Triticum aestivum* and created the Knossos basal layer were operating after agriculturalist sites such as Ulucak and Çukurici had been founded near the Western Anatolian coast. It follows that there was a non-negligible diversity in the Aegean agricultural practices towards the end of the first half of the 7th millennium, with different sets of crops exploited at different sites. At the same time, the movements of the basal-Knossos group also predate the significant changes that the Central Anatolian Neolithic undergoes in the third quarter of the millennium (*cf. Brami 2017*). The Aegean of the second quarter of the 7th millennium must have already been a dynamic and interesting place, before the appearance of Neolithic communities in Northwestern Turkey or the significant changes at Çatalhöyük.

For Nea Nikomedeia, our re-evaluation implies that this community was not a particularly early one in the region, and in particular it appears later than some other sites in Greek Macedonia such as Mavropigi or Paliambela (*Maniatis 2014*). However, some aspects of Nea Nikomedeia's material culture make a more precise determination very interesting: it is not only important who, or which site, was 'the first'. One such aspect is the use of stamps, with numerous examples preserved in Nea Nikomedeia (*e.g., Rodden 1965.86*). At the large and materially advanced site of Çatalhöyük in Central Anatolia, the earliest stamps appear in Level VII (*Türkcan 2013. 240*), dated to the 66th century BCE (*Cessford* et al. *2005*), but the majority of the corpus (see *Türkcan 2005; 2013*) comes from the higher levels. In Western Anatolia, in contrast, we only have stratified instances of stamps later in the 7th millennium: in the third quarter in the Lake District's Bademağacı (*Duru, Umurtak 2019.207, Pl. 123*), and in the fourth quarter at Ulucak (*Çevik, Erdoğu 2020*). In Greek Macedonia, Mavropigi features at least six stamps, but they have only been preliminarily published, and we thus cannot determine which period of this apparently long-lived site they come from (*Karamitrou-Mentessidi* et al. *2015.62, Fig. 42*). In Revenia Kolinou, several seals were found in a pit that has been radiocarbon dated by several measurements into the third quarter of the 7th millennium (Pit 7; *Adaktylou 2017.42–46*). To this picture, we can now add the rich use of stamps at Nea Nikomedeia as ordered into the late third or earlier fourth quarter of the 7th millennium BCE. This timing is similar, on present evidence, with that of the stamps of the Turkish Lake District, and might predate their use on the Western Anatolian coast. The study of seal motives and their exchange between areas would further benefit from better temporal resolution for individual examples.

Conclusion

My purpose in this paper has been to show how we can incorporate substantive assumptions about phase duration, stemming from archaeological work, into Bayesian modelling of radiocarbon dates. Using already available information about basal Knossos and Nea Nikomedeia, we were able to reach the following chronological conclusions, based on 95% HPD:

- The event of the deposition of charred grain in the basal Knossos levels occurred within the 66th century BCE (Fig. 2, right).
- The (studied part of the) village of Nea Nikomedeia probably existed between 6300 cal BC and 6050 cal BC, thus falling mainly into Thessalian EN II, and possibly also the beginning of the transitional EN III/MN I (Fig. 6). However, caution is in order because the available measurements were clearly demonstrated to be problematic when considered together.

The present re-evaluations of the dates for basal Knossos and Nea Nikomedeia may have to be adjusted in the future – in fact, I hope we will eventually get more data that would allow that, especially for Nea Nikomedeia. They are also conditional on particular modelling choices that I made and described. While I consider them reasonable, you are free to disagree and consequently to accept results from a different model instead. It is important to bear in mind that in statistical analysis there are modelling choices that are obviously wrong, and then there are legitimate, but incompatible alternatives.

As we discussed above, both basal Knossos and Nea Nikomedeia received very different dating interpretations in the previous literature. Those interpretations, in turn, played an important role in the discussions about the earliest Neolithic in the Aegean. Radiocarbon dating has the appeal of supposed objectivity. But its results in fact depend, often crucially, on the assumptions we put into our models. We could observe this in our two case studies. Moreover, even if we do not explicitly build a Bayesian model, but interpret dates individually, this also amounts to adopting very particular – and frequently very wrong! – assumptions about the archaeological reality from which our samples came.[13]

What Bayesian modelling of dates forces us to do is to make our assumptions explicit, so that we can compare, discuss, and crucially, improve them when needed. However, in order for future research to be able to do this, we also need to publish all the details of our models, and not just their results. This is why I provide all OxCal analysis files as an online supplement, so that they can be re-run (with newer calibration curves, for example) or modified (for instance, with new data). I suggest every archaeological paper engaging in statistical modelling of dates does the same. Such sharing is of considerable importance, because as we start modifying priors our figures no longer straightforwardly summarize the model. I suggest that our standards of reporting the model itself should be as strict as for reporting the radiocarbon data (*Bayliss 2015*).

I would like to end by noting that even though designing and interpreting models requires effort (just as noted already by *Bayliss* et al. *2007*), the technical overhead on implementing them is really not large. Specifically, in OxCal it only requires adding one line to the analysis script to put a prior on one phase's length: "*phase-length*", "*end*", "*start*", N(100, 25).

This line, from my Nea Nikomedeia model, orders a new variable "*phase-length*": to be created, which (i) records, in the OxCal output, the interval between "*end*" and "*start*", which are just my names for the two boundaries of the single phase in the model; and (ii) puts the Normal(100,25) prior onto this quantity. To record the length, but not restrict it implicitly, as in Figure 10, we simply omit the last argument N(100,25). Needless to say, other priors can be mentioned in this argument, to appropriately capture the substantive knowledge won through archaeological analysis. I hope that the ease with which the technical side can be conquered will lead to more radiocarbon modelling employing this possibility in future research.

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13 It is also worth noting that the reasonable statistical-philosophical alternatives to being a careful Bayesian (*Buck, Meson 2015*), is certainly not doing nothing, that is, only looking at one's data informally. It may be being a convinced and careful frequentist, but that would require no less care in designing and performing the needed statistical tests. There is, unfortunately, no escape from the complexity of doing careful science!

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New radiocarbon dates, stable isotope, and anthropological analysis of prehistoric human bones from the Balkans and Southwestern Carpathian Basin

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ABSTRACT – *The paper provides a detailed overview of new radiocarbon dates, stable isotopes, and anthropological information obtained on prehistoric human remains (mostly Neolithic) from the Balkans and southwestern Carpathian Basin. It covers a large chronological sequence from the Mesolithic to the Bronze Age (9746–2628 cal BC), which encompasses different archaeological cultures. In total 76 radiocarbon dates deriving from 27 sites were obtained, coupled with new isotopic (n=34) and anthropological (n=33) data. The results filled the gaps in some of the older interpretations, but also produced new insights regarding chronology, health, and diet, leaving a strong baseline for all future research into Neolithic lifestyles.*

KEY WORDS – *Neolithic; ^{14}C analyses; stable isotopes; diet; health*

Novi radiokarbonski datumi, stabilni izotopi in antropološke analize prazgodovinskih človeških kosti iz Balkana in jugozahodnih Karpatov

IZVLEČEK – *Prispevek vsebuje podroben pregled novih radiokarbonskih datumov, stabilnih izotopov in antropoloških informacij, pridobljenih iz prazgodovinskih človeških ostankov (večinoma neolitskih) na Balkanu in v jugozahodni Karpatski kotlini. Zajema dolgo kronološko sekvenco od mezolitika do bronaste dobe (9746–2628 cal BC) v različnih arheoloških kulturah. Pridobljeno je bilo 76 radiokarbonskih datumov skupaj z novimi izotopskimi (n=34) in antropološkimi (n=33) podatki iz 27 najdišč. Rezultati so zapolnili vrzeli v nekaterih starejših interpretacijah in prinesli nove vpoglede v kronologijo, zdravje in prehrano, ki predstavljajo močno izhodišče za vse prihodnje raziskave neolitskih življenjskih slogov.*

KLJUČNE BESEDE – *neolitik; ^{14}C analize; stabilni izotopi; prehrana; zdravje*

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Introduction

During the last few decades there has been a growing body of data on prehistoric radiocarbon dates in the Balkans. The ^{14}C analyses were undertaken as a part of various projects and studies, mainly to establish chronology of the Mesolithic – Neolithic transition, settlement, and demographic patterns, and coupled with stable isotope measurements, to infer dietary habits of Early Holocene communities (*Bonsall* et al. *2015a; 2015b; Borić 2009; 2011; Borić, Dimitrijević 2009; Mathieson* et al. *2018; McPherron* et al. *1988; Porčić* et al. *2021; Stefanović, Porčić 2015; Tasić* et al. *2015; Whittle* et al. *2002*). One of the latest projects that produced a significant amount of new ^{14}C data on human bones from prehistoric sites is the BIRTH project[1], which focuses on human fertility, health, diet, and population dynamics in the period between 10 000 and 5000 years BC. The main purpose of extensive dating of human osteoarchaeological assemblages within the project was to clarify long-standing debates about the chronology of some sites and burials from the old excavations, and in some cases to confirm the assumed chronological sequence. The latter was of special importance for the assumed Late Neolithic burials, considering their scarce presence in the archaeological record on the territory of the central Balkans and southwestern Carpathian Basin. To date, the only known Late Neolithic cemeteries are those at Botoš (*Grbić 1934*) and Gomolava (*Borić 1996*). Another important result of the extensive dating within the BIRTH project is that a complete sample of human remains discovered up to now is radiocarbon dated and available for further research. The sample consists of the Early and Late Neolithic human remains, primarily from the territory of the central Balkans and part of the southwestern Carpathian Basin. Besides, stable isotope analyses of $\delta^{13}C$ and $\delta^{15}N$ were done together with AMS dates for most of the human remains, which contributed to the better understanding of dietary behaviours of these past communities.

This paper covers a large chronological sequence, which encompasses different archaeological cultures, depending on the region. Samples were chosen for the purpose of different research questions within the BIRTH project, but the common aim was to date all available human remains that could be connected to the Mesolithic sequence of the Lepenski Vir culture (~9500–6300 cal BC; *Borić 2011*), the Early Neolithic Starčevo culture (~6200–5300 cal BC, *Whittle* et al. *2002*) and the Late Neolithic Vinča culture (~5300–4600/4500 cal BC, *Tasić* et al. *2015; 2016; Tripković 2011*) in the Balkans. Additionally, within the BIRTH project some of the human

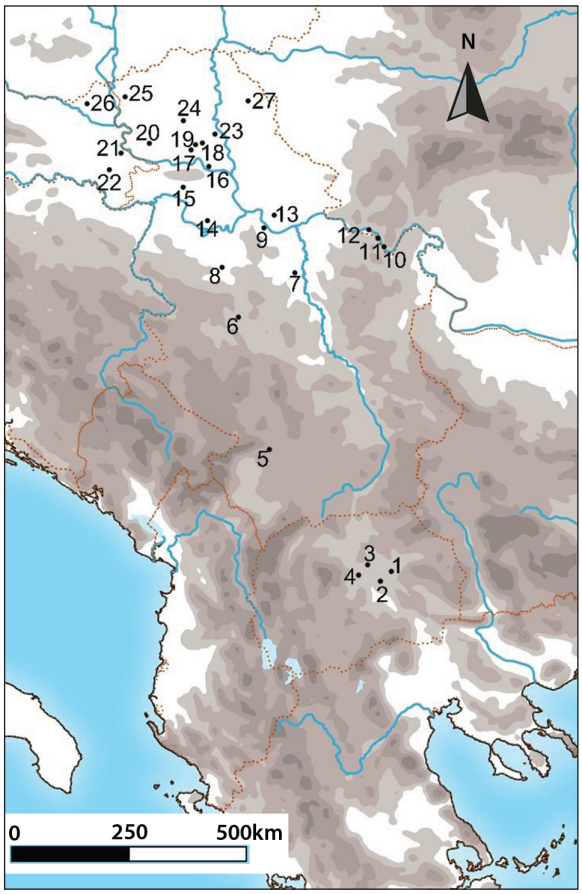


Fig. 1. Map of the sites used in this study:* 1 *Amzabegovo;* 2 *Govrlevo;* 3 *Tumba Madžari;* 4 *Pista Novo Selo – Mamutčevo;* 5 *Rudnik Kosovski;* 6 *Grivac;* 7 *Zmajevac;* 8 *Jaričište;* 9 *Vinča – Belo Brdo;* 10 *Vlasac;* 11 *Lepenski Vir;* 12 *Padina;* 13 *Starčevo – Grad;* 14 *Baštine – Obrež;* 15 *Highway E-70, 521km;* 16 *Sremski Karlovci – Sonje Marinković 1;* 17 *Sajlovo;* 18 *Klisa;* 19 *Novi Sad – Gornja Šuma;* 20 *Topole – Bač;* 21 *Vukovar Gimnazija;* 22 *Vinkovci Ervenica – Poljski jarak;* 23 *Gospođinci – Nove zemlje;* 24 *Zmajevo – Livnice;* 25 *Bezdan – Bački Monoštor;* 26 *Beli Manastir – Popova zemlja;* 27 *Iđoš (the base layer was formed out of mosaic SRTM (Shuttle Radar Topography Mission 1 Arc-Second Global (Digital Object Identifier (DOI) number: /10.5066/F7PR7TFT), as available from Earth Explorer site (https://earthexplorer.usgs.gov/) by J. Pendić, adjusted by T. Blagojević).

1 BIRTH: Births, mothers and babies: prehistoric fertility in the Balkans between 10 000–5000 BC, funded by the European Research Council (ERC).

remains from neighboring regions were AMS dated. These include the remains from the Early Neolithic Amzabegovo – Vršnik (~6500–5450 cal BC, *Whittle* et al. *2005*) and the Late Neolithic Sopot (~5400–3790 cal BC, *Obelić* et al. *2004*) culture sites. Several dates (n=4) come from later sequences – Eneolithic, Bronze Age and the Middle Ages, but were originally dated as deriving from the Mesolithic or Neolithic contexts.

Regarding the regional attribution of the sites, four regions have been defined: (1) the southern Balkans, including the sites from modern-day North Macedonia; (2) the central Balkans – including sites located north of the Ibar River, and south of the Danube and Sava Rivers; (3) the Danube Gorges – including sites located on the left bank of the Danube; and (4) the southwestern Carpathian Basin – a region that covers the Pannonian Plain in Serbia and northeastern Croatia.

In this study we thus present: (i) new radiocarbon dates obtained on human skeletal remains (n=76) from 27 sites dated from the Mesolithic to the Bronze Age (9746–2628 cal BC), with the addition of two Middle Ages dates, from the territory of the southern and central Balkans, and southwestern Carpathian Basin (Fig. 1), and discuss them in the context of individual sites[2]; (ii) anthropological (n=33) and stable isotope (C_{coll}, N, n=34) analyses of all newly dated individuals, to infer their biological characteristics and dietary strategies. These new data are discussed together with previously published studies. In addition, we present a large set of supplementary data, including methodological details given in Supplementary Material 1 (SM 1), the archaeological contextualization in Supplementary Material 2 (SM 2), and a catalogue of analyzed individuals in Supplementary Material 3 (SM 3). In Supplementary Material 4 (SM 4) the probability distribution plots are given.

It should be emphasized that the aim of this paper is not to offer new interpretations of some of the crucial Neolithic processes or phenomena on a local or regional level. Rather, the aim is to summarize and contextualize a new and large set of data regarding the chronology, health, and diet of the Neolithic communities. In this way, the opportunity is given to challenge or consolidate previous interpretations for some of the specific sites. This represents one part of the outcome of this kind of approach, and it is addressed in this paper directly. The other part is setting the comprehensive baseline for all future research on various subjects with specific research questions regarding the European Neolithic.

Results and discussion

Southern Balkans

Amzabegovo

The resulting date span places the only individual available today from this site in the first half of the Early Neolithic/Amzabegovo–Vršnik culture sequence (6209–6018 cal BC within the 95% CI; SM 4; Tab. 1 in SM 5). The remains belonged to a neonate, aged 38–40 gestational weeks, who was probably buried with a female interred in Burial 8 (see SM 3 for a detailed description). The neonate had active cribra orbitalia (CO), which could be a consequence of nutritional deficiency of the mother. It is common that pregnant and lactating women develop some nutritional disbalance, usually vitamin B12 deficiency or anaemia (*Walker* et al. *2009*). Their babies are therefore born with low vitamin B12 reserves, that are further depleted by the synergistic effects of low vitamin B12 concentrations in the mother's breast milk, coupled with poor living conditions and nutri-

2 All the dates from the central Balkans, and almost half of them from the southwestern Carpathian Basin (17 out of 31 dates) obtained on human samples from Early and early Late Neolithic contexts, were used as a part of the study that deals with the population dynamics reconstruction during the Early Neolithic (*Porčić* et al. *2021*, see Supplementary Material 4 (SM 4)). These uncalibrated values were used only in the form of the raw data, as a control sample-additional to the main probabilistic sample, designed for the purpose of the aforementioned study. Therefore, the majority of dates in the present study could be considered as being published and discussed thoroughly for the first time in this paper, since they will be discussed in more detail in the context of particular sites. Some of the dates obtained on human remains from the Danube Gorges sites (n=8) will be also published in this paper for the first time. Some of the other dates (n=18) from the Danube Gorges sites are discussed in a study that deals with the plant consumption revealed from human dental calculus analysis and TCA analysis (Jovanović et al. 2021 (n=17); *Penezić* et al. *2020* (n=13)). From the territory of the southern Balkans (modern-day North Macedonia), five new dates on human remains were obtained and published in this study (only calibrated values from the site of Govrlevo have already been published in *Fidanoski 2019*). One Medieval date with stable isotope values from this region, from the site of Vrbjanska Čuka, has been given in SM 4, but was not further discussed since only one tooth which is dated has been preserved from this individual. From the territory of the southwestern Carpathian basin (modern-day Croatia), 12 new dates were obtained during the BIRTH project, out of which 10 will be published in this study for the first time, while 2 dates from the site of Vinkovci Ervenica-Poljski jarak are discussed in the paper by Kristina Penezić *et al.* (*2020*).

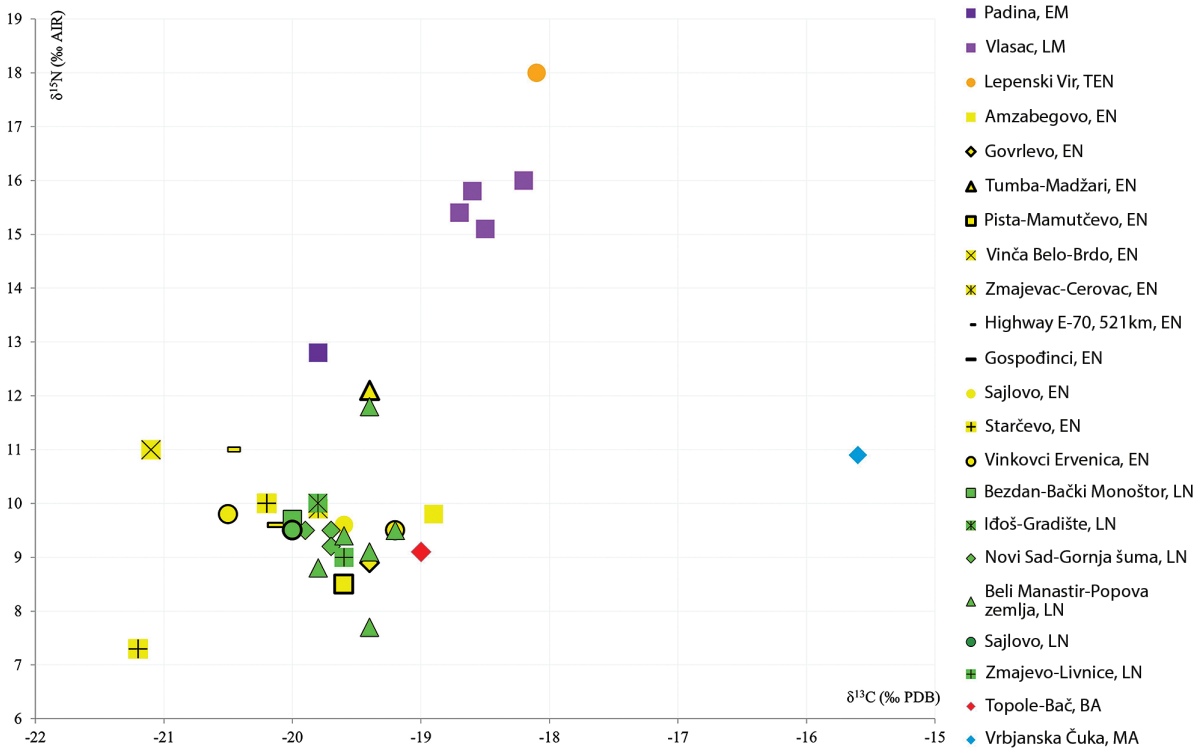


Fig. 2. δ13C and δ15N values of humans from prehistoric sites performed within this study (*EM *Early Mesolithic;* LM *Late Mesolithic;* TEN *Transformational/Early Neolithic;* EN *Early Neolithic;* LN *Late Neolithic;* BA *Bronze Age;* MA *Middle Ages).

ent losses from gastrointestinal infections (*Walker* et al. *2009*). Since it is known that the isotopic ratios of neonates reflect the mothers' diet (*e.g., Fuller* et al. *2006; Kinaston* et al. *2009; de Becdelièvre* et al. *2015*), in this case δ13C and δ15N of neonate (Fig. 2; SM 4) show that the mother probably favoured the consumption of terrestrial proteins (from C_3 plants, meat of herbivores) like most of the Early Neolithic individuals from the region (*Whittle* et al. *2002; Jovanović 2017; Jovanović* et al. *2018*). It is possible that at some point the mother had restricted access to animal food, which resulted in developing CO in this infant, since in populations with restricted animal food access, the risks of vitamin B12 deficiency-induced megaloblastic anaemia are greatly increased for infants (*Baker* et al. *1962; Sandberg* et al. *1981; Walker* et al. *2009*). She also had a δ13C value of –18.9 ‰, which is the highest value of carbon recorded for one individual from the Balkans during the Early Neolithic (excluding the Danube Gorges sites; Fig. 2; SM 4). At the closest sites of Pista, Tumba – Madžari and Govrlevo, human δ13C values range from –19.4 to –19.6 ‰, and thus different δ13C values from Amzabegovo may perhaps be connected to the different place of the origin of this woman. However, it is hard to conclude what led to this value, since the local animal isotopic baseline is currently unknown.

Most of the other human remains found at Amzabegovo were anthropologically analysed during the 1970s by János Nemeskéri and Imre Lengyel (*1976*) who concluded that the majority of them belonged to children and juveniles, while among the adults most of them were females. The height has been calculated for only one female (152.4cm), which is relatively short compared to the average stature for females in the Balkans' Early Neolithic (*Jovanović 2017*). Concerning the health status of the Amzabegovo population, they suffered from similar conditions (*e.g.*, periostitis, osteoarthritis (OA), spondylosis, fractures, nonspecific stress indicators, *etc.*) like their counterparts living across the Balkans and southwestern Carpathian Basin (*Veljanovska 1998; Masson 2014; Jovanović 2017*).

Govrlevo

The remains of three Neolithic individuals have been found at this site, and two of them were dated. Within the BIRTH project a fragment of human mandible from the individual marked as bb 1–04 (65) was AMS dated to the middle part of the Early Neolithic sequence (5990–5847 cal BC within the 95% CI; SM 4; Tab. 2 in SM 5). It corresponds well with other Early Neolithic dates from the site, and it is also the oldest one obtained so far (*Fidanoski 2019*). Since only the left half of the mandible is pre-

served with several teeth within alveolar sockets, the data on age and sex are limited. The ante-mortem loss of one tooth and abrasion indicate that these remains probably belonged to a young adult, between 25 and 35 years old. Supragingival dental calculus of degree 1 has been noted on one tooth which could be related to various factors, such as diet, oral hygiene, or genetics. Isotopic values of $\delta^{13}C$ and $\delta^{15}N$ (Fig. 2; SM 4) indicate that this individual had a terrestrial diet based on C_3 plants and meat of domesticates/wild game. These data are in accordance with the archaeozoological analysis from this site, which showed that animal husbandry (predominantly sheep, goat, cattle, and pig) played a more important role than hunting (*Ivkovska 2009*). Beside this, one more better-preserved mandible was also found at this site. It belonged to a young adult, and also contains traces of supragingival calculus of degree 1. The appearance of these mandibles could be related to the secondary manipulation of the deceased, or to some ritual deposition. A similar record was noted at the nearby Early Neolithic site of Tumba – Madžari, where one mandible was also discovered (*Stojanova Kanzurova 2020*). The practice of post-mortem manipulation and fragmentation of the body was present in the Mesolithic – Neolithic world in this region (*e.g., Srejović, Letica 1978; Zalai Gaál 1994, 2009; Radovanović 1996; Borić 2015, 2016; Živaljević 2015*), and most instances involved head manipulation. The funerary record from the Danube Gorges contains numerous examples of disturbed primary inhumations with missing body parts, and disarticulated elements (mainly skulls and mandibles) incorporated into later burials, or structurally deposited on their own (*e.g.*, on stone slabs, on/below building floors, or intermingled with animal bones). The deceased were thereby continuously connected with the world of the living (*Borić 2010*). There are also examples from the Late Neolithic, in the Lengyel and Tisza culture, which include the removal of skulls and/or mandibles from the certain individuals, which were sometimes replaced with wild boar mandibles or more rarely dog remains (*Zalai Gaál 1994; 2009*). Such mortuary rites were likely related to some beliefs connected to human-animal relationships, or perhaps to social exchanges. Thus, the findings of these two mandibles at Govrlevo could be perhaps related to some of these practices.

At this site another burial, mostly destroyed by the construction of a house, has also been discovered (*Fidanoski 2013*). Radiocarbon analysis confirmed its Early Neolithic provenience (5979–5735 cal BC within the 95% CI) (*Mathieson* et al. *2018*). Anthropological analysis showed that the remains belonged to a male, aged 25–30 years old (*Veljanovska 2017*). His height was 160cm (*Veljanovska 2017*), which is relatively short and below the average stature for males in the Balkans Early Neolithic (*Jovanović 2017*). The low presence of supragingival calculus could be related to various factors (diet, oral hygiene, or some other factor), while traces of caries suggest he probably had a diet rich in carbohydrates. The appearance of caries is common in the Early Neolithic humans from the region (*Jovanović 2017*), and could be the result of the increased consumption of carbohydrates at the beginning of the Neolithic. Although he had a healed porotic hyperostosis (PH), an active CO indicates that he was suffering from some nonspecific stress until he died, probably caused by anaemia, nutritional deficiency, or poor living conditions. During childhood, this individual also experienced some physiological stress events (*e.g.*, high fever, nutritional deficiency), evidenced by the presence of pit and linear enamel hypoplasia (LEH). According to the ADMIXTURE analysis (*Mathieson* et al. *2018*), he had an ancestry from the Near-Eastern Neolithic communities, probably from the region of the north-west Anatolia.

Tumba – Madžari

Several remains of Neolithic individuals have been found at this site (see SM 2), and only one infant has been AMS dated so far. The resulting date span places the infant's burial in the second half of the Amzabegovo – Vršnik culture sequence (5976–5760 cal BC within the 95% CI; SM 4; Tab. 3 in SM 5). The infant was found in the flexed position laying on its right side (Fig. 3). Anthropological analysis showed this skeleton belonged to an infant aged 3 to 6 months old (*Veljanovska 1998*). The stable isotope ratios of $\delta^{15}N$ (Fig. 2; SM 4) are higher than expected for these communities living in the region, probably due to the breastfeeding effect. However, one cannot exclude that higher levels of $\delta^{15}N$ ratios are sometimes caused by some physiological factor (disease or nutritional stress prior to death; *Fuller* et al. *2005; Neuberger* et al. *2013; Robertson* et al. *2014*). Since isotopic ratios of neonates reflect the diet of the mother, one can assume, according to the isotopic ratios of $\delta^{13}C$ and $\delta^{15}N$ (Fig. 2; SM 4), that the mother was probably taking a diet mostly focused on terrestrial proteins (C_3 plants and meat of domesticates and wild game). The interesting finding from this site is a female mandible (*Stojanova Kanzurova 2020*), which, as in the case of Govrlevo findings, could be also related to the secondary



Fig. 3. Remains of a child skeleton (Burial 1/1985), House 4, Tumba Madžari, Skopje (photo archive, Archaeological Museum of Macedonia, Skopje).

manipulation of the deceased, or to some ritual deposition.

Pista – Novo Selo, Mamutčevo

From two Neolithic burials found at this site (see SM 2), one has been dated. The resulting date span places Burial 1 in the second half of the Amzabegovo – Vršnik culture sequence (5613–5482 cal BC within the 95% CI; SM 4; Tab. 4 in SM 5). This is in accordance with the archaeological research and previous interpretations, which dated both burials from this site to the Amzabegovo – Vršnik II phase (*Veljanovska 2001*).

Anthropological analyses of both skeletal remains from this site shows they belonged to females, between 40 and 50 years old, with similar body height (Burial 1: 161cm; Burial 2: 162cm; *Veljanovska 2001*), which is more than the average female stature in the Early Neolithic Balkans and southwestern Carpathian Basin (*Jovanović 2017*). They had a strong presence of caries, like many other Early Neolithic humans from the region (*Jovanović 2017*). This, coupled with periapical tooth abscesses and several ante-mortem teeth lost (*Veljanovska 2001*), can be either a consequence of their diet enriched in carbohydrates, which led to the development of caries and consequently tooth loss, and/or because of their older age. The isotopic ratios of $\delta^{13}C$ and $\delta^{15}N$ (Fig. 2; SM 4) show that a female interred in Burial 1 had a terrestrial diet based on the consumption of C_3 plants, meat/dairy products (?) of domesticates and wild game. A small amount of supragingival calculus is present on the teeth of both females, probably as a consequence of several factors including diet, oral hygiene and their older age. They both experienced some nonspecific physiological stress during childhood as evidenced by traces of LEH (*Veljanovska 2001*). Concerning other paleopathological changes, the female interred in Burial 1 had curved femurs and strong platimery (*Veljanovska 2001*), which may be a consequence of biomechanical pressure, the specific position that the individual had, or some other factor. The other female had traces of OA and spondylosis on several vertebrae (*Veljanovska 2001*), which is in accordance with her older age. Osteolytic lesions detected on the skull (*Veljanovska 2001*) could reflect wide range of diseases (*e.g.*, from arachnoid granulations or vascular lacunae to aggressive malignant lesions such as lymphomas or metastases; *Ugga* et al. *2018*), and therefore their cause remains unknown.

Central Balkans

Grivac

Although very fragmented remains from several individuals have been found at the site (see SM 2), only two of them are available, of which the better preserved one (Burial 1) has been AMS dated. The results (6073–5997 cal BC within the 95% CI; SM 4; Tab. 5 in SM 5) confirmed the previous assumption, based mostly on pottery typology, that the site was occupied during the first half of the Starčevo culture sequence. The individual was buried inside the pit in a flexed position. Since the skeleton is poorly preserved, the sex could have not be estimated, while the tooth abrasion and degree of sagittal sutures closure indicate the age of ~30 years (*Jovanović 2017*). Supragingival calculus was detected on all preserved teeth in a small amount. Isotopic values of $\delta^{13}C$ and $\delta^{15}N$ indicate a mostly terrestrial diet (C_3 plants, domestic and wild herbivores and omnivores) with small input of aquatic resources (*Jovanović* et al. *2018*). The second individual from this site is a child, 5–10 years old, whose skeleton is also poorly preserved. Detected healed CO with small porosity indicates that the child experienced some nonspecific physiological stress, caused by nutritional deficiency, iron deficiency anaemia or some other factor (*Jovanović 2017*). Based on these findings, one can conclude that the diet and health of these individuals was similar to those of their counterparts living in the region (*Jovanović 2017; Jovanović* et al. *2018*).

Jaričište 1

Four burials have been found at this site (see SM 2). One of them (Burial 2) has been previously AMS dated (*Stefanović, Porčić 2015*), while the second one (Burial 4) has been dated within the BIRTH project. Anthropological analysis showed that five indi-

viduals were found at this site (*O.c.*). While individual from Burial 1 was not available for the analysis, Burial 2 contained two individuals (Individual 1 – child ~7 years of age, and Individual 2 – female ~40 years old). In Burials 3 and 4 the remains of children aged 6 and 3 years, respectively, were found. Previous radiocarbon analysis of a double burial (Burial 2) showed that these burials were not contemporaneous, and that the most probable temporal distance between the two deaths and burials was ~100 years (*O.c.*). However, this difference could have also been caused by a diet rich in aquatic resources. Nevertheless, this discovery gave valuable insights into the Early Neolithic funerary practice. It showed that the same burial place was probably reused, and that the younger burial did not destroy the previous one. It is thus possible that the child was buried intentionally next to the woman who died much earlier (*O.c.*). Within the BIRTH project, a sample of cranium from Burial 4 was AMS dated (5625–5520 cal BC within the 95% CI; SM 4; Tab. 6 in SM 5). The results indicate that burial was chronologically closer to the burial of a child from the double burial, but most probably not contemporaneous. Individuals buried at Jaričište 1 show poor health status, visible through presence of CO, LEH and PH, indicating a hard childhood and nutritional disbalance (*O.c.*). The youngest child who was AMS dated had the severe presence of CO and very strong meningeal reaction, which was possibly the cause of death. The skeleton of a female shows traces of mild periosteal reaction on the tibia, which is the result of some nonspecific infection, usually not fatal, because it is localised to only one region of the bone. This woman also had the presence of caries and ante-mortem tooth loss, with the teeth perhaps lost because of the presence of caries. The appearance of caries is common in Early Neolithic humans from the region (*Jovanović 2017*) and could be due to nutritional changes at the advent of this period. Anthropological analysis revealed the woman was 161.42cm tall, which is more than the average height of Early Neolithic females (*O.c.*).

Vinča – Belo Brdo

At this site a collective burial was found (*Vasić 1932*; SM 2), from which seven individuals were AMS dated within a previous study (*Tasić* et al. *2015*), while within the BIRTH project one fragment from the human skull marked as 'VI?'[3] was dated (5556–5475 cal BC within the 95% CI; SM 4; Tab. 7 in SM 5). The result confirmed the Starčevo cultural sequence. Collective burials are rare in Early Neolithic and Starčevo culture sites, where individual inhumations are the norm (*Chapman 1983; 2006; Tasić* et al. *1990*). Since its discovery, scholars have mostly debated the architecture of this feature (*Vasić 1932; 1936; Letica 1968; Perić, Nikolić 2006*), without questioning if it really represented a burial place. Nine out of ten individuals were found inside the pit, and one was found in the entrance hall. One of the possible causes of death of those people has been considered to be a fire on the roof part of the pit (*Korošec 1950; Mikić 1988*).

Recent AMS, anthropological and contextual study of this feature gave a new bioarchaeological perspective (*Jovanović 2017; Stefanović* et al. *2016; Tasić* et al. *2015*). Anthropological analysis showed that the minimal number of individuals was not nine, but 12, all being adults (*Jovanović 2017*). New radiocarbon dates indicated a span from 5700 to 5500 cal BC, showing that although some of the deceased were buried at almost the same time, the burial of these 12 individuals did not represent a single event. The reconstruction showed that none of the deceased was buried in a typical Starčevo flexed position (Fig. 4), and that seven individuals were buried in extended positions, and only one on the side. Some of the skeletons (II, III, IX) were placed with the face and chest toward the ground, which is commonly associated with the expression of rejection and taking away the dignity of the deceased (*Arcini 2009*). One of the alternative scenarios is that maybe those individuals died during sleep, due to the suffocation which resulted from fire. However, this scenario is questionable since there are no traces of burning, except on Skeleton I, which likely occurred post-mortem. The re-analysis of the skeletal remains showed that Starčevo group burial could represent a crime scene (*Jovanović 2017*). Traces of violence were detected on skulls II (a small fracture on the occipital bone), VI (trace of blunt force trauma on the left parietal bone) and VIII (dislocated skull, the chest placed toward the ground, left leg placed on the back, which was not possible without dismembering the leg, while right leg was contracted with a broken femur).

Since most individuals found at this pit were poorly preserved, the sex could rarely be estimated. The young adult ('VI?') dated within this study had a similar diet and health as the rest of individuals found at this site (*Jovanović 2017*). The isotopic values

3 It belongs to young adult, 20–30 years old.

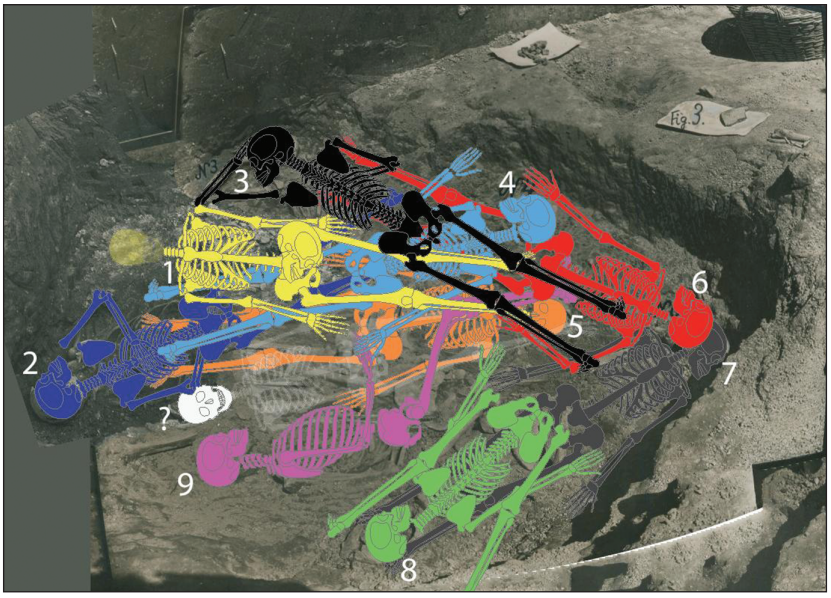


Fig. 4. Ideal reconstruction of the individual positions of Early Neolithic burials on Vinča Belo – Brdo site (reconstruction made by S. Živanović).

$\delta^{13}C$, $\delta^{15}N$ and $\delta^{34}S$ (Fig. 2) show a mostly terrestrial diet (C_3 plants and meat of herbivores and omnivores) with small input of aquatic resources (*Nehlich* et al. *2010; Jovanović* et al. *2018*). Although aquatic foodstuff represents a small part of the diet of these individuals, the isotopic ratios show that they had a diet much more abundant in aquatic protein than the inhabitants of contemporary settlements (excluding the Danube Gorges). This could be connected to the fact that site was located very close to the Danube, like sites in the Danube Gorges, where fish was a staple food during the whole Mesolithic – Neolithic sequence, and thus enabled easier access to fish and other aquatic resources (*Jovanović* et al. *2018*). Concerning the health parameters of those individuals, it is interesting to note the relatively low presence of caries compared to contemporaneous individuals in the region (excluding the Danube *Gorges, Jovanović 2017*). Since all individuals had similar diets, with larger contributions of aquatic resources than other Starčevo individuals, the presence of supragingival calculus may have resulted from the protein diet. This kind of diet coupled with the presence of calculus may have inhibited bacterial activity (*Powel 1985*), and influenced the lower incidence of caries, such as the case within the Danube Gorges, especially during the Mesolithic sequence (*Jovanović 2017*). The presence of pit and LEH indicate almost half of them experienced some physiological stress event between 2 and 10 years of age, some of them with multiple episodes, showing their childhoods were not easy and that they probably suffered some nutritional imbalance or had poor living conditions. This is also confirmed by the presence of CO and PH, with healed or both healed and active lesions at the time of death (*Jovanović 2017*). The largest number of healed lesions suggest that those individuals successfully coped with a nutritional imbalance or some disease which could have caused these lesions. It is also possible that the cases of PH with mixed reactions, at least in individuals VI and VIII, could be a consequence of the recent violence detected on them. The average height of these individuals was 161cm (*Schwidetzky 1971–1972; Mikić 1988*), which is the average stature of Early Neolithic individuals in the region (*Jovanović 2017*).

Zmajevac

The remains of at least four poorly preserved individuals (two children and two adults) have been discovered at Zmajevac (see SM 2). Only the remains of one individual who is the best preserved among them (marked as Individual 1) have been dated. The dated skull fragment gave a quite early Starčevo date (6204–6011 cal BC, within the 95% CI; SM 4; Tab. 8 in SM 5), which confirmed the relative chronology attribution made by the excavators. The remains belonged to a child, aged 10–11 years (see SM 3). Stable isotope values of $\delta^{13}C$ and $\delta^{15}N$ (Fig. 2) indicate a mostly terrestrial diet based on the consumption of C_3 plants, meat of domesticates and wild game, and/or possibly dairy products, as most of the Early Neolithic children in this region had (*Whittle* et al. *2002; Jovanović 2017*). Traces of supragingival calculus in low amounts were noted on some teeth, which is probably related to diet, oral hygiene, or genetics. While the observed second degree of teeth abrasion is expected on deciduous teeth, it is quite uncommon on the permanent teeth at this age and may indicate that this child consumed very abrasive food (*e.g.*, ground cereals which contained milling stone residue). During early childhood, it experienced some physiological stress event, evidenced by the presence of LEH. The childhood of this individual was not easy, as also witnessed by the presence of an active lesion of CO, indicating that the child was suffering from some nonspecific

stress until death, caused by anaemia, nutritional deficiency or poor living conditions. Possible traces of infection present on the frontal bone, coupled with CO, could have eventually led to the death of this child. The child also had pronounced *m. deltoideus* on the humerus, which could indicate that it was performing some intense physical activity. The second individual from this site is represented only by one bone, belonging to a child between 5 and 10 years of age. The third individual is an adult, more than 20 years old. Since only a few bones are preserved, a more precise age could not be established. However, atrophy of *m. gluteus maximus* could indicate older age of this individual. Curved *linea aspera*, depression on femur and strong platimery (see SM 3) indicate that this individual probably had constant biomechanical pressure, likely due to the specific position of the legs while performing some activity. The flattened diaphysis of right humerus and pronounced *m. teres major* and *m. latissimus dorsi* lend weight to the argument of the specific position and activity of this individual. Since only a few bones are preserved, detailed reconstruction of the activity patterns of this individual could not be done. The fourth individual is represented only by one tibia, which indicates adult age, more than 20 years.

Rudnik – Kosovski

Although four burials have been discovered at this site, only one is preserved and dated (Burial 1). The date places this individual in the first half of the Starčevo culture sequence (6325–6088 cal BC within the 95% CI; SM 4; Tab. 9 in SM 5). Considering its geographical position – the southernmost part of the central Balkans, combined with a date that indicates the very beginning of the Starčevo culture, this find could be considered as one more evidence for the assumed south to north direction of the spread of the Neolithic through this territory (*Whittle* et al. *2002*). The remains belonged to a female, more than 50 years old, whose skull is the only preserved part of the skeleton (*Jovanović 2017*). The woman lost two teeth during her life, which probably happened due to caries detected on several teeth (*Jovanović 2017*). The strong presence of caries can be connected to her terrestrial diet (mostly based on C_3 plants and meat/dairy products of domesticates and wild game), as indicated by stable isotope ratios of $\delta^{13}C$ and $\delta^{15}N$ (*Jovanović* et al. *2018*). Both supragingival and subgingival calculus of degrees 1 and 2 were detected on her teeth, which could be a consequence of diet, age, and poor oral hygiene. Barely discernible PH was detected on parietal and occipital bones, with healed lesions (*Jovanović 2017*).

Danube Gorges sites

Unlike other regions in this study, that of the Danube Gorges has been extensively explored within the framework of different archaeological and bioarchaeological studies (*e.g., Srejović 1969; Jovanović 1969; Bonsall* et al. *1997; Roksandić 2000; Stefanović, Borić 2008; Borić, Dimitrijević 2009; Stefanović 2012; 2016; Borić, Price 2013; Bonsall* et al. *2015a; 2015b; Filipović* et al. *2017; Živaljević* et al. *2017; Jovanović* et al. *2018; 2021; de Becdelièvre 2020; de Becdelièvre* et al. *2020*). Those studies yielded *inter alia* a large amount of AMS dates, stable isotope and anthropological data on humans who lived in that micro-region and discussed them comprehensively. Therefore, we will not discuss in detail all the new dated individuals from these sites, but rather just single out those who represent outliers.

From Padina, only two adult individuals from Burials 14 (1) and 18 have been AMS dated within the BIRTH project, and the results (9136–8753 and 8801–8489 cal BC within the 95% CI, respectively; SM 4; Tab. 10 in SM 5) confirmed their relative chronological attribution, placing them to the Early Mesolithic sequence. Stable isotope data obtained for Individual 14 (1) (Fig. 2; SM 4) indicates it had a similar diet as other individuals from Padina during the Early Mesolithic, which was mainly based on the mixture of wild game and aquatic resources, especially freshwater fish (*Borić, Price 2013; Nehlich* et al. *2010; Jovanović* et al. *2018*).

From the site of Vlasac, 17 individuals were AMS dated. Almost all individuals were dated to the Late Mesolithic sequence (dates spanning from 7527–6257 cal BC within the 95% CI; n=14, SM 4; Tab. 11 in SM 5), two to the Early Mesolithic phase (Burial 64a; 7936–7589 cal BC within the 95% CI; and Burial 52; 8167–7603 cal BC within the 95% CI; SM 4; Tab. 11 in SM 5), which is in accordance with their relative chronological assignment. Only one individual from Burial 26 yielded a Medieval date (889–1012 cal AD at 95% CI; SM 4; Tab. 12 in SM 5) and thus more detailed discussion is given in Supplementary Material 6 (see SM 6).

The isotopic ratios of $\delta^{13}C$ and $\delta^{15}N$ (Fig. 2; SM 4) obtained in this study are in accordance with the data published in other dietary studies, which showed that aquatic resources were important throughout the Mesolithic, but that Late Mesolithic humans started to include more anadromous and potamodromous species of fish in their diets (*e.g., Jovanović* et al. *2018*).

While in the previous two sites the AMS dates mostly confirmed presumed chronological sequence, at the Lepenski Vir site the 14 new dates obtained within the BIRTH project clarified some long-standing debates about chrono-cultural assignments for some burials, but also gave one unexpected result. The results showed that Burials 20 (9176–8762 cal BC within the 95% CI; SM 4; Tab. 13 in SM 5) and 105 (7708–7519 cal BC within the 95% CI, SM 4; Tab. 13 in SM 5) are dated to the Early Mesolithic sequence, which is quite surprising for Burial 20, since it was previously associated with the Early Middle Neolithic phase. The individual buried in this grave was a gracile female of non-local origin (*Borić, Price 2013*), although during the Mesolithic most of the individuals were locals. She was buried in a flexed position not typical for Mesolithic burial practice, since individuals were usually buried in extended supine or seated positions (*Borić 2015; Stefanović 2016*). Therefore, she represents the first individual buried in a typical Early Neolithic position during the Mesolithic sequence in this region if a measurement error in the date is to be excluded. Her stable isotope ratios ($\delta^{13}C$ –19.6, $\delta^{15}N$ 14.6; *Jovanović* et al. *2018*) are indicative for both Mesolithic and Neolithic periods at this site, since a protein diet based on aquatic resources was the staple food throughout the sequence, although in the Transformational/Early Neolithic[4] and Early Middle Neolithic phases in the Danube Gorges some individuals consumed fewer aquatic resources and favoured more terrestrial products (C_3 plants and meat of herbivores), which is not the case with this woman. For Burial 105, the precise chronological distribution did not exist, and the AMS date placed the remains to the Early Mesolithic phase.

Regarding other burials from this site dated within the BIRTH project, for three of them (Burials 11, 91, 98) the dates are in accordance with their chronological assignment (Transformational/Early Neolithic phase; SM 4), while for Burials 16, 27a, 27d, 57, and 93 it was not certain in some previous studies (*e.g., Borić, Price 2013; Stefanović 2016*) whether they were associated with this phase. The obtained AMS dates (see SM 4; Tab. 13 in SM 5) confirmed they also belong to the Transformational/Early Neolithic phase. The relative chronological distribution related to the Early/Middle Neolithic phase of Burials 39, 66, 83a was also questioned in the published studies (*Borić, Price 2013; Stefanović 2016*), although newly acquired dates (see SM 4) confirmed they belong to this phase, except for the Burial 39 (see SM 4), which is associated with the Transformational/Early Neolithic phase.

Their isotopic values (Fig. 2; SM 4) are in accordance with the dietary patterns, which as aforementioned were related to the broadening of the dietary spectrum toward terrestrial food resources at the onset of the Neolithic in the Danube Gorges for some individuals (*e.g.*, Burials 39, 57, 83a, 93). This light shift is connected with the arrival of migrants and contacts between local hunter gatherers and the first agro-pastoralists, who probably brought new foodstuff and dietary habits to the Danube Gorges (*Borić, Price 2013; de Becdelièvre* et al. *2020*). The skeleton from Burial 98 has low $\delta^{13}C$ (–18.1) and the highest value of $\delta^{15}N$ (18.0) (Fig. 2; SM 4) among this group of individuals because it belonged to a neonate. As it is supposed that isotopic ratios of children reflect the mother's diet during pregnancy (see the section on Amzabegovo), and the newborns at Lepenski Vir in general exhibit $\delta^{13}C$ in the range of values recorded for the females, while $\delta^{15}N$ values are higher (*Grupe* et al. *2003; Borić* et al. *2004*). Those higher ratios indicate that diet was not the only factor which influenced $\delta^{15}N$ values, and that other factors such as physiological processes or pathological conditions should also be considered when interpreting this data (*Fuller* et al. *2005; Neuberger* et al. *2013; Reitsema 2013; Robertson* et al. *2014*). This neonate was one of the 40 neonates buried mainly underneath the rear of trapezoidal buildings at Lepenski Vir (*Borić, Stefanović 2004; Stefanović, Borić 2008*). The practice of burying young children underneath the floors is common among Neolithic communities across Anatolia and the Balkans (*Bachvarov 2008*), and was also attested in the nearby site of Vlasac during the Late Mesolithic. Sofija Stefanović and Dušan Borić (*2004; 2008*) argue that the neonates were interred into burial pits cut through the floor and not sacrificially deposited before the floor was furnished, as was proposed in some studies (*Srejović 1969; Radovanović 2000*). They also highlight that the houses may have a protective role and that ritual reveals a pronounced concern of the community for the death of babies and changes in the perception of the newborns by the members of this society.

4 Stratigraphically and chronologically, the Mesolithic and Neolithic sequence in the Danube Gorges is divided into the Early Mesolithic (~9500–7400 cal BC); the Late Mesolithic (~7400–6300 cal BC); the Transformational/Early Neolithic (~6200–5900 cal BC); and the Early/Middle Neolithic (~5900–5500 cal BC) (see SM 2).

Overall, the health status of all newly dated individuals is in accordance with general picture which suggest relatively good health status of Mesolithic – Neolithic inhabitants over time (*Nemeskéri, Lengyel 1978; y'Edynak 1978; Borić* et al. *2014; Stefanović 2012; 2016; Jovanović 2017*), with the exception of treponemal infections, which occur as a major pathological condition in all periods (*Stefanović 2012*). Anthropological studies in Europe showed that with the onset of Neolithic many more individuals had some kind of growth disruption as a consequence of the new lifestyle and poor diet, while in the Mesolithic only a small number of individuals had traces of bad health (*Papathanasiou 2011; Jarošova, Dočkalova 2008; Wittwer-Backofen, Tomo 2008; Jovanović 2017*). However, there is a slight decrease in health in the Neolithic Danube Gorges (*Borić* et al. *2014; Stefanović 2016; Jovanović 2017*), which was not as dramatic as that documented in other Early Neolithic populations in Europe, including those in the nearby regions. Although the number of non-healed lesions is slightly higher in the Neolithic sequence, the distribution of nonspecific stress indicators is similar in both periods, which indicates stability in health over time (*Jovanović 2017*). Higher rates of PH are noted for both periods, which could be potentially connected to infectious disease (*Stefanović 2016; Jovanović 2017*). The general stability in health may have been the consequence of a protein rich diet, especially one based on aquatic resources. At the onset of the Neolithic some humans started to have a more terrestrially oriented diet, which caused few cases of caries, but the frequency was still very low comparing with the rates of the communities who lived outside of this region during the Early Neolithic (*Jovanović 2017*). Additionally, although the rates of enamel hypoplasia are similar throughout the sequence, there is however a higher number of stress episodes in the Neolithic, which can possibly be related to new dietary strategies (*Jovanović 2017*).

Southwestern Carpathian Basin

Starčevo – Grad

Several burials have been discovered at this site (see SM 2) and two of them were previously dated (*Whittle* et al. *2002*). The remains of two individuals interred in Burial 1, found during the most recent excavations in 2000s, were AMS dated within the BIRTH project. Both belong to the second half of the Starčevo culture sequence (5638–5545 cal BC, and 5661–5559 cal BC within the 95% CI: SM 4; Tab. 14 in SM 5). The first skeleton belonged to a female, 55–60 years old (marked as Skeleton 1, *Jovanović 2017*), buried in a flexed position. At the distance of 0.6m northeast from the Skeleton 1, on the same level, the remains of a child, aged 5–7 years (*Jovanović 2017*) were detected and marked as Skeleton 2. The mean difference between median and mean values of the calibrated dates for these two individuals is 23 years, which could indicate that they were buried together intentionally, but probably not as a part of the single burial event. However, it could also indicate that same burial place was reused, as in the case of some other Starčevo burials, such as Burial 2 at Jaričište 1 (*Stefanović, Porčić 2015*).

Beside these two individuals, in another trench, within the excavation layer, a diaphysis of a left femur with traces of injury probably caused by sharp edge tool (*Jovanović 2017*) has been discovered in a pit associated with the Starčevo culture. Possible traces of injury or palliative treatment were also noticed on a female's occipital bone from Burial 1 (*O.c.*), and presence of a higher degree of PH with mixed healed and active lesions could be the consequence of the same trauma. OA was detected in all preserved vertebrae (*O.c.*), which is in accordance with the woman's old age. The woman experienced several episodes of physiological stress (*e.g.*, nutritional imbalance, high fever, *etc.*) during her childhood, as evidenced by traces of LEH (*O.c.*). She lost two teeth during her life, which is expected due to her old age, while the appearance of both mostly moderately pronounced supragingival and subgingival calculus, especially the large amount on the side of the jaw where she lost teeth ante-mortem, could be connected to some tooth pathology and poor oral hygiene, rather than diet (*O.c.*). Her isotopic values of $\delta^{13}C$ and $\delta^{15}N$ (Fig. 2) indicate she had a mostly terrestrial diet (based on the consumption of C_3 plants and meat/dairy products of domesticates and wild game), as did a child (Fig. 2) buried in the same pit. This is in accordance with archaeozoological (predominance of domesticates, but also a significant contribution of wild animals; *Clason 1980*), previous stable isotope analyses (*Whittle* et al. *2002*) and organic residue analysis of pottery with traces of dairy products (*Stojanovski* et al. *2020*) from this site.

Topole – Bač

Three prehistoric burials found at this site have been AMS dated within the BIRTH project (*Stefanović* et al. *2020*). The new dates solved the almost 20-year mystery of whether Burials 1 and 2 represent one single event or not. Alasdair Whittle and colleagues (*2002*) had some doubts regarding the dating of those two burials, as well as Jovanović and collea-

gues (*2017*) who concluded that Burials 1 and 2 were almost certainly buried at the same time, and that because of terrestrial dietary patterns they should rather present a single Early Neolithic burial, rather than Mesolithic and Neolithic as the first AMS dating by Whittle and colleagues (*2002*) showed. The new BIRTH dates confirmed that Individuals 1 and 2 were buried at the same time, since calibrated dates almost completely overlap (for Individual 1, the 95% CI span is 6065–5985 cal BC, while for the Individual 2, the 95% CI span is 6066–5986 cal BC; SM 4; Tab. 15 in SM 5), and both belong to the Early Neolithic Starčevo culture. New BIRTH stable isotope values (see SM 4) also showed that this young female (Burial 1) and middle-aged male (Burial 2) had similar, mostly terrestrial diets, like their counterparts from the region (*Whittle* et al. *2002; Nehlich* et al. *2010; Jovanović* et al. *2018*). While almost the same isotopic ratios were obtained for the male (similar skeletal elements, *i.e.* hand bones, were analysed both times), the new and old $\delta^{15}N$ ratios slightly differ in female. Namely, the old $\delta^{15}N$ value is 8.6‰ (*Whittle* et al. *2002* sampled rib), while the new $\delta^{15}N$ value is higher, 9.6‰ (in our study the frontal bone was sampled). These variations could be a consequence of sampling different skeletal elements[5] or due to different laboratory procedures, since the samples were dated in different laboratories.

Both individuals had relatively good health status. The female experienced some stressful event during childhood, as evidenced by traces of LEH, and small traces of supragingival calculus. She was 163.84cm tall (*Jovanović* et al. *2017*), which is more than the average female height during the Early Neolithic (*O.c.*). The male also had a small amount of supragingival calculus. He was 171.32cm tall (*Jovanović* et al. *2017*), taller than most other males from the Early Neolithic (*Jovanović 2017; this study*). His weight was 64.06kg, which is slightly higher than that of his counterparts, while the body mass index, as a general indicator of health, showed that he had a normal body mass index (*Jovanović* et al. *2017*).

The third individual buried several metres away from the first two was also mostly placed beneath the floor of the same structure. It was a young female, dated to the later, Early Bronze Age period (2873–2628 cal BC within the 95% CI; SM 4; Tab. 16 in SM 5), although it was previously assumed that it could be older than Burials 1 and 2 (*Jovanović* et al. *2017*), which indicates the disturbance of the Starčevo culture layers in the later periods. This result reveals the possibility that this area was continuously used for living and burial practices. Stable isotope analysis (Fig. 2; SM 4) showed she had a diet predominantly based on terrestrial resources (C_3 plants, meat/dairy products of domesticates and wild game). Anthropological analysis revealed that she was 168.83cm tall, while her weight was 66.66kg, with a normal body mass index (*O.c.*). The ellipsoid lesion with horizontal lines noted on the frontal bone could be the result of an infection or blunt force trauma (*O.c.*).

Klisa

At this site five Neolithic burials have been found (see SM 2), but only three individuals which are preserved today and interred in Burials 6, 8 and 10a were AMS dated. The dates have quite close spans, with the Burial 6 being slightly older (5984–5845 cal BC within the 95% CI; Tab. 17 in SM 5) than the Burial 10a (5978–5780 cal BC within the 95% CI; Tab. 17 in SM 5), while the Burial 8 appears to be the oldest (6002–5886 cal BC within the 95% CI; Tab. 17 in SM 5) (see SM 4). Anthropological analysis showed that the remains of these three individuals belong to a 4 to 5-year old child (Burial 6), a female aged 15–18 (Burial 8) and a male (Burial 10a), who was aged more than 40 at death (*Jovanović 2017*). Isotopic values of $\delta^{13}C$, $\delta^{15}N$ and $\delta^{34}S$ for the female and male indicate they favoured the consumption of terrestrial proteins (C_3 plants, domestic animals and hunted game), with small input of aquatic resources (*Jovanović* et al. *2018*). One vertebrae of catfish was found during the anthropological analysis, which is rare in the archaeological record from the Starčevo sites outside of the Danube Gorges (*Živaljević, Stefanović 2016; Živaljević 2017*). The child was possibly breastfed until ~2 years of age, while the increased $\delta^{15}N$ value just prior to the child's death, was possibly a consequence of disease or nutritional stress (*Jovanović 2017*). Both child and female had LEH, which indicates they experienced some nonspecific stressful event during childhood. Supragingival calculus is moderately pronounced on several of the female's teeth (*O.c.*), which could be

5 The frontal bone with more cortical tissue renews slower than the rib, and thus the stable isotope ratios should mainly reflect a dietary signal formed over a more extended period than in the case of a rapidly renewed tissue (such as rib). Hence, it is possible that this female consumed fewer protein resources at the end of her life (lower $\delta^{15}N$ value; rib sample, *Whittle et al. 2002*) than earlier (higher $\delta^{15}N$ value; this study, SM 4). For a more detailed discussion see *Ivana Živaljević* et al. *2021*.

due to genetic factors or poor oral hygiene. The male had barely discernible PH, which was healed at the time of death (*O.c.*). Noted OA on some vertebrae (*O.c.*) could be the consequence of physical activity and degenerative changes, which is possible considering the age of this male. He was one of the few males from this time period living outside of the Danube Gorges region for whom the stature could be calculated (170.58cm) (*O.c.*).

Sremski Karlovci – Sonje Marinković 1

The only known Neolithic burial (Burial 1) from this site has been AMS dated and yielded an early Starčevo date (6210–6027 cal BC within the 95% CI; SM 4; Tab. 18 in SM 5). Anthropological analysis showed that this burial belongs to a female individual, aged 35–50 years old (*Jovanović 2017*). She had moderately pronounced forms of both types of dental calculus as a consequence of diet (supragingival) and tooth pathology (subgingival). Her isotopic values of $\delta^{13}C$ and $\delta^{15}N$ indicate she had a diet mostly based on terrestrial proteins (such as C_3 plants, domestic animals and hunted game), but also with some input from aquatic proteins (*Jovanović* et al. *2018*). She had the 2nd and 3rd degree of PH which was active at the time of death (*O.c.*). OA changes were noted on the sternum, foramen magnum, scapula, and cervical vertebrae (*Jovanović 2017*), which in this case may have developed as a consequence of injury, since in the inferior part of the sternum, there is a curvature toward anterior-posterior side. Her stature was 150.37cm, like many females who lived in the region during the Early Neolithic (*O.c.*).

Baštine – Obrež

The skeletal remains of the only known burial from this site (Burial 1) were AMS dated and the obtained date span places this individual in the second half of the Starčevo culture sequence (5624–5517 cal BC within the 95% CI; SM 4; Tab. 19 in SM 5). It belongs to a child, aged 4–6 years (*Jovanović 2017*). It had barely discernible CO, healed at the time of death, which suggests that this child successfully coped with some nonspecific stress (*O.c.*). Although this event did not cause the death of the child, it seems that an injury on the left tibia made with some sharp tool, followed by periosteal reaction (*O.c.*), could have been fatal. The isotopic bone values of $\delta^{13}C$ and $\delta^{15}N$ reflect a generally terrestrial dietary pattern which include C_3 plants, domestic animals and hunted game (*O.c.*). However, $\delta^{34}S$ suggests little input of aquatic food resources, while the abundance of mollusc remains (such are *Helix, Unio, Vivipara, Limnaea* and *Planorbis* genera) (*Bruckner 1960a; 1960b*) support the sulphur isotopic results. A shallow depression detected behind and along the length of the coronal suture could have arisen if this child was wearing something on the head, connected to everyday habits or cultural traditions (*Jovanović 2017*).

Bezdan – Bački Monoštor

Three Neolithic burials were found at this site (see SM 2), and only the remains found in Burial 3 (Fig. 5.a) have been AMS dated. The result (4996–4844 cal BC within the 95% CI; SM 4; Tab. 20 in SM 5) indicates this individual lived at the beginning of the Late Neolithic. The remains belong to a middle-aged male (see SM 3), whose $\delta^{13}C$ and $\delta^{15}N$ ratios (Fig. 2; SM 4) are consistent with typical Early and Late Neolithic dietary patterns in the region (*Whittle* et al. *2002; Gamarra* et al. *2018; Nehlich* et al. *2010; Lightfoot* et al. *2011; Jovanović* et al. *2018*), where the bulk of protein was mostly derived from terrestrial foods based on C_3 plants, domestic animals and hunted game. The man experienced several physiological stress episodes during childhood, as evidenced by traces of pit and LEH, and some of them have happened around the age of 10, indicating he probably grew up in poor living conditions where he suffered from some nutritional deficiency, which is also noted in other two individuals from this site. According to the stature (167.51cm) and body mass (56.66kg), the body mass index was 16.86, indicating he was underweight, which lends weight to the argument for poor living conditions and nutritional deficiency. Noted traces of low to moderate supragingival calculus and periodontitis may be caused also by poor nutrition, or poor oral hygiene/genetics. The presence of grooves with more severe teeth abrasion on the right-side molars indicate he probably processed some type of object in the mouth on the right side of the jaw, which is also supported by greater robustness of the right bones of the upper body. Overall, although muscle attachments are generally not pronounced, they are more marked on the upper limbs. The strong active bilateral periosteal reaction on tibias (Fig. 5.b,c), fibulas and calcanei could be due to bacterial infection. Based on the atrophy of the femur muscles and on the curvature of the tibias it is possible that this man was not mobile. Curvature of the tibias and the platimery of the femurs could be the result of his specific position due to the low leg mobility. His bones are very gracile which can also be a consequence of pathological condition. Bodies of four cervical vertebrae are recessed, as a consequence of some pressure on the cervical part of the spine, which could also be due



Fig. 5. Bezdan – Bački Monoštor, Burial 3.* a *in situ;* b *periosteal reaction on the left tibia;* c *periosteal reaction on the right tibia (*a *courtesy of the Town Museum of Sombor;* b, c *photos J. Pendić).

to particular position of the body. On the same vertebrae traces of OA are noted. A benign tumour – osteoma has been detected on the frontal bone. Those kinds of tumours are slow growing and usually cause no symptoms, with men being affected only slightly more than women (*Wei, Stevens 2014*).

Beside Burial 3, two other undated Burials, 1 and 2, which according to the relative chronology belong to the Late Neolithic, have also been anthropologically analysed (see SM 3). Inside Burial 1 (Fig. 6.a) a middle-aged female was buried in a flexed position. This woman experienced several stress episodes during her childhood, as evidenced by traces of LEH, which occurred between the ages 1.3–3.9 years. Ante-mortem tooth loss is probably due to the presence of caries detected on several teeth (*e.g.*, left mandibular molars; Fig. 6.c), which indicates she perhaps had a diet strongly based on terrestrial resources, especially on carbohydrate rich food. Supragingival calculus was present on multiple teeth in small amounts. She had barely discernible CO and PH with active and healed lesions, indicating she probably lived in poor living conditions where various factors could have led to developing these conditions, such as nutritional deficiency, *etc.* Traces of non-masticatory activities noted on her teeth and unusual dental mandibular arches (Fig. 6.b,c; see SM 3) suggest she used her teeth as a 'third hand', which is also confirmed by her muscle attachments which are more pronounced on the upper limbs, especially on the right side. It is possible that this female performed some sort of physical activity since early childhood (see SM 3) that was frequently and continuously repeated, but her muscle attachments do not indicate any kind of hard physical labour. On the distal ends of both humerus the epigenetic feature perforatio fossa olecrani is noted. Besides the genetic origin (*Hauser, de Stefano 1989*) this feature can also be a consequence of continuous use of upper limbs in some physical activity (*Mays 2008*). OA was detected on both hip joint and forearm bones, which in the case of upper limbs can be due to her physical activity. The metopic suture which usually fuses until the age of 8 (*Scheuer, Black 2004*) is still present in this middle-aged female. Persistence of metopic suture (metopism) in adulthood represents a non-metric anatomical trait (*Hauser, de Stefano 1989*), which could have genetic origin (*Torgersen 1951; del Sol* et al. *1989*), although some other factors cannot be excluded (*e.g.*, mechanical causes, hormonal dysfunction, *etc.*). It has little clinical significance, and in some cases can cause problems with frontal sinuses. She was 158.58cm tall (close to average females' height during the Early and Late Neolithic; *Masson 2014; Jovanović 2017; this study*) and weighed 60.52kg, with a normal body mass index.

Inside the Burial 2, two individuals have been found. Individual 1 represents an old adult, buried in a flexed position (Fig. 7.a), while Individual 2 represents a child, whose remains were poorly preserved (see SM 3). The adult has very similar health as the female from Burial 1, indicating that both probably lived in poor conditions. They also experienced several stress episodes during childhood, as evidenced by traces of LEH, which occurred between the age 2.4–3.9 years, and could be connected (as in the case of woman from Burial 1) to the consumption of solid food (which can be contaminated), or some other nonspecific physiological stress event. In support of this there is healed CO, which also points to some stress event probably occurred during childhood. A large amount of ante-mortem teeth loss is related to the higher presence of caries (Fig. 7.b,c; see SM 3), implying this individual perhaps had a diet strongly based on terrestrial resources, especially on carbohydrate rich food, like the female from Burial 1. The presence of a large amount of supragingival calculus on one carious tooth was probably due to poor oral hygiene. At the moment of death this old adult had PH with mixed lesions, supporting the hypothesis that humans buried at this site pro-

bably lived in poor conditions. Additional porosity detected on other skull bones confirms this individual likely suffered from nutritional deficiency. A circular dent on the parietal bone was most likely caused by blunt force trauma (Fig. 7.d), while traces of bandaging on the lateral borders of the scapulae could be caused by the same event/injury. Overall, the muscle attachments of the upper limbs are more pronounced than on the lower limbs, especially on metacarpal and phalanges which could be the result of some intense physical activity that this adult did with the arms (see SM 3). Although morphological characteristics of the skull bones suggest female sex, the estimation of sex was difficult since there are huge differences in the left and right great sciatic notches and composite arches (Fig. 7.e), where one suggests male and another female sex, respectively (see SM 3). These differences are not due to trauma, since there are no traces of injuries, and rather can be caused by a pathology that did not leave traces on the bones, congenital anomaly, or a specific position in which this adult spent a significant amount of time. Furthermore, visible epiphyseal line on the left femur head, platimery and OA of both femurs head (especially on the left one and on the left acetabulum), could also be a consequence of the presumed specific position of the left leg that the individual adopted during walking, and/or another activity that it did since childhood. However, one cannot exclude that long-term nutritional imbalance during childhood and perhaps the presence of rickets led to slow growth and development, which caused degenerative changes on vertebral bodies, auricular surfaces, and along epiphyseal lines of both femurs. Other OA changes on two thoracic vertebrae and on the sacral promontory probably developed due to old age.



Fig. 6. Bezdan – Bački Monoštor, Burial 1.* a *in situ;* b *traces of non-masticatory activities on maxillary;* c *mandibular teeth; on mandibular teeth 36 and 37 the presence of caries is also noted (*a *courtesy of the Town Museum of Sombor;* b, c *photos J. Pendić).

Iđoš – Gradište

Only one out of two Neolithic individuals from this site has been dated. The AMS dating places Burial 1 at the very beginning of the Late Neolithic (5213–5027 cal BC within the 95% CI; SM 4; Tab. 21 in SM 5). The remains belonged to a male, aged 30–35 years old. The isotopic ratios of $\delta^{13}C$ and $\delta^{15}N$ (Fig. 2; SM 4) show he had a terrestrial diet based on C_3 plants, domestic animals and hunted game, with possible small input from aquatic resources, like some other Early and Late Neolithic individuals from the region (*Whittle* et al. *2002; Lightfoot* et al. *2011; Nehlich* et al. *2010; Gamarra* et al. *2018; Jovanović* et al. *2018*). He had a mild OA and lithic lesions on both glenoid cavities, pronounced muscle attachments on scapulae, clavicles, radius, which coupled with OA changes on all vertebrae and one Schmorl's node, indicate that he intensively used the upper limbs during some physical activity (see SM 3). The appearance of squatting facets indicates this male probably squatted while performing activities with the upper limbs. All bones have dark-brown colour and traces of burning. Since traces of burned wattle and daub have been discovered in Trench 5 (*Marić, Pendić 2017*), it could be hypothesised that there was maybe a fire at the house roof, which affected buried skeletal remains or, which is less likely, led to suffocation in the fire as a potential cause of death for this male.

The undated human skeletal remains found inside a Late Neolithic pit (see SM 2), in Trench 6 (unit 6007), revealed the remains of two individuals – a female and poorly preserved young adult. The female, aged 45–50 years old, had severe teeth abrasion and periodontitis. On some teeth specific abrasions and grooves were noted indicating that she used her teeth in non-masticatory activities. It is interesting to note that among the inhumated bones, five fragments of cremated human bones were found.

They had traces of white and black colors, which according to Simon Mays (*1998*) is indicator that the temperature of burning was over 600°C. The presence of transversal cracks suggests that the bones were placed in the fire with the soft tissues still present. It is unclear if these cremated human bones reflect some ritual or mortuary rite, since cremations are rare in the Neolithic (*Borić 2015*), or this is a consequence of a fire which caused the body to burn completely.

Zmajevo – Livnice

Two Neolithic burials were found at this site (see SM 2). Burial 1, with dislocated remains, belongs to a probable male, aged 30–40 years (see SM 3), whose skeletal remains were poorly preserved and have not been dated. Only the better preserved Burial 2 (Fig. 8.a,b) was dated and yielded a date which spans between 5299–5099 cal BC (within the 95% CI; SM 4; Tab. 22 in SM 5). The date confirms the assumed chronological sequence and places this individual into the Vinča culture. The remains belonged to a male, aged more than 50 years old. The isotopic ratios of $\delta^{13}C$ and $\delta^{15}N$ (Fig 2; SM 4) show he had a diet based on terrestrial proteins derived from C_3 plants, domestic animals and hunted game. OA detected on the upper and lower limbs is in accordance with his old age, and the presence of sharp osteophytes on vertebrae certainly caused pain to this individual (Fig. 8.c). Active periosteal reaction on the left tibia (Fig. 8.d) (see SM 3), coupled with the presence of initial stages of osteomyelitis on both fibulas, indicate that this was most likely the result of some systemic infection, considering its bilateral presence. Furthermore, lesions and porosity on the inner vault of the skull lend weight to the argument that the infection spread from postcranial skeleton to the whole body. More pronounced muscle attachments on the upper limbs implied he performed some intense physical activity in a specific position leading to the curvature of the forearm bones. Complete loss of teeth (Fig. 8.e) coupled with pronounced muscle attachments on the mandibula could possibly indicate that this male used his teeth in non-masticatory activities. He had a hard life, as evidenced by the presence of healed fractures on a few ribs, and probably after the injury he wore a bind around both scapulae and ribs (see SM 3). Atrophy of the muscle attachments is more present on the lower than upper limbs and can be connected to the presence of sacroiliac fusion, which certainly led to reduced use of the lower limbs and less mobility of this male. Fusion of the sacrum and iliac bones could have been caused by his old age, trauma due to his injury, or arthritic changes. Furthermore, the observed differences between the left (moderately male characteristics) and right (moderately female characteristics; SM 3) great sciatic notch are probably a consequence of sacroiliac fusion, congenital malformation, or other pathological conditions. The specific position in which this male was buried (lying on his back, hands were placed on the pelvis, with the legs bent at the knees, on the right side; Fig. 8.a), could be due to his illness and reduced mobility of the lower limbs.

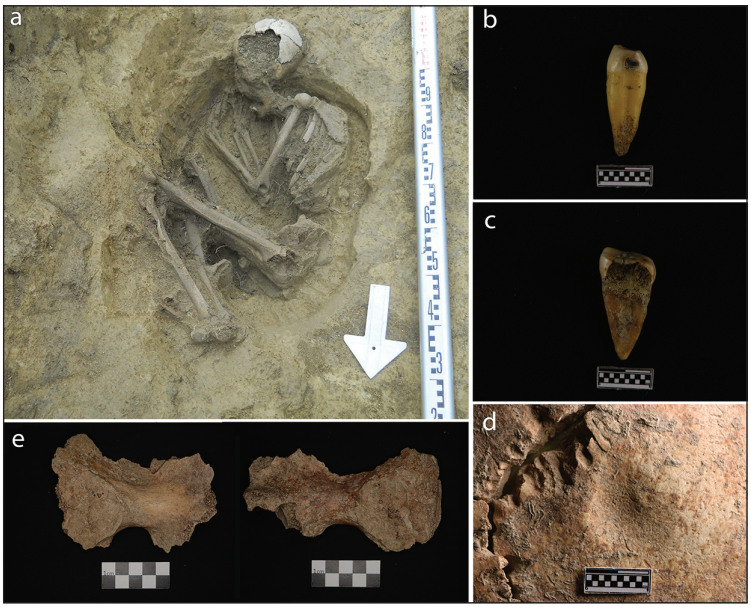


Fig. 7. Bezdan – Bački Monoštor, Burial 2.* a *in situ;* b, c *presence of caries on teeth 25 (distal side) and 47 (distal side);* d *circular dent (10.49 x 8.35mm) on the lower part of the parietal bone, near the juncture of the sagittal and lambdoid suture, most likely caused by a blunt force trauma;* e *differences in the left and right great sciatic notches and composite arches (*a *courtesy of the Town Museum of Sombor;* b, c, d, e *photos J. Pendić).

Gospođinci – Nove zemlje

The resulting date span places the only individual found at this site (see SM 2) in the first half of the Starčevo culture sequence (6066–5991 cal BC within the 95% CI; SM 4; Tab. 23 in SM 5). This individual is poorly preserved and anthropological information is limited (see SM 3). The sex could not be estimated due to the fragmentation, although a few fragments of cranial bones suggest they could belong to a female. The teeth abrasion indicates that the individual was ~30 years old. Traces of supra-

gingival and subgingival calculus in medium amounts were noted, which is probably related both to the diet and teeth pathology and/or oral hygiene. Stable isotope values of $\delta^{13}C$ and $\delta^{15}N$ (Fig. 2; SM 4) indicate a mostly terrestrial diet based on proteins deriving from C_3 plants, domestic animals and hunted game.



Fig. 8. Zmajevo – Livnice, Burial 2. **a, b** ***in situ;*** **c** ***presence of sharp osteophytes on vertebrae;*** **d** ***active periosteal reaction on the left tibia;*** **e** ***mandible showing complete loss of teeth (*****a, b** ***courtesy of the Provincial Institute for Protection of Cultural Monuments, Vojvodina;*** **c, d, e** ***photos J. Pendić).***

Sajlovo

Only the Neolithic individuals from Sajlovo (see SM 2) have been dated, and the results show that Burial 22 belonged to the second half of the Early Neolithic sequence (5707–5566 cal BC within the 95% CI; SM 4; Tab. 24 in SM 5), while the AMS date (5293–5059 cal BC within the 95% CI; SM 4; Tab. 24 in SM 5) places Burial 19 into the very beginning of the Late Neolithic, although based on pottery findings it was assumed that it also belonged to the Early Neolithic. The previously assumed absence of the Late Neolithic stratum at Sajlovo could be reconsidered, based on the new evidence.

Anthropological analysis revealed that Burial 22 belongs to a child, aged 6–7 years old. The skeleton is poorly preserved and thus anthropological data are limited (see SM 3). The isotopic ratios of $\delta^{13}C$ and $\delta^{15}N$ (Fig. 2; SM 4) show it had mainly a terrestrial diet based on C_3 plants, domestic animals and hunted game. Besides the vicinity of the Danube River (*c.* 4km) and the fact that one vertebra of carp was found during anthropological analysis, its isotopic data indicate that aquatic resources were rarely used. The child experienced nonspecific physiological stress several times during childhood, as evidenced by traces of pit and LEH. One of those stress events occurred around the age of 2, which perhaps could be connected to weaning, since this age is inside the time frame when children cease breastfeeding and completely transfer to solid food (*e.g., Jovanović* et al. *2017*), or perhaps was the result of some other stress factor.

Burial 19 (Fig. 9.a) belonged to a female aged 45–50 years (see SM 3). This Late Neolithic woman had similar physical characteristics, diet, and health status as Early Neolithic individuals. She was 149.13cm tall, which is shorter than the average recorded for the Early Neolithic females (*Jovanović 2017*). The stable isotopic ratios of $\delta^{13}C$ and $\delta^{15}N$ (Fig. 2; SM 4) show she had mainly a terrestrial diet which included C_3 plants, meat (dairy products?) of domestic animals and hunted game. The presence of caries supports this conclusion, and furthermore indicates the use of food enriched in carbohydrates. The presence of a small to medium amount of supragingival calculus (Fig. 9.b) could be a consequence of poorer oral hygiene, diet and her older age. Her childhood was not easy, as has also been noted for most of the Early Neolithic humans from the region (*O.c.*). The presence of LEH suggests she also experienced nonspecific physiological stress around the age of 2, like the child from Burial 22. Barely discernible PH, which was healed at the time of death, could also be an indicator of some stress event. This woman may have had limited range of motions due to pain caused by OA, spondylarthrosis, and Schmorl's node on the cervical vertebrae, whose presence is consequence of degenerative changes as a result of her older age. Furthermore, atrophy of muscle attachments on both upper and lower limbs lends weight to this argument.

Highway E-70, 521km

The resulting date span places the only individual available from this site (see SM 2) in the second half of the Starčevo culture sequence (5616–5486 cal BC within the 95% CI; SM 4; Tab. 25 in SM 5). Anthropological analysis showed that it was a female, between 30–40 years old (see SM 3). The presence of caries could be the result of her mostly terrestrial diet (C_3 plants, domestic and wild game) with a possible small input of aquatic resources, as evidenced by stable isotope values of $\delta^{13}C$ and $\delta^{15}N$ (Fig. 2; SM 4). The pronounced muscle attachments of the upper limbs, egg-shaped humeral head and curvature of both humeral diaphysis (Fig. 10.a) indicate she performed intense physical activity with her upper limbs. The pronounced muscle attachments of her upper limbs in combination with specific abrasion of her front teeth (Fig. 10.b) may indicate that she used her teeth in non-masticatory activities. OA was noted on two lumbar vertebrae, while on one of them there is a shallow depression-Schmorl's node (Fig. 10.c), which could be a consequence of physical work. On the medial side of the right tibia a mild inactive periosteal reaction is noted, which is the result of some nonspecific infection, probably not fatal, because it is localised to only one region of the bone. Both tibias are slightly medially curved, especially the right one, which could be connected to the appearance of periosteal reaction. However, since it was inactive at the time of death it shows that this woman successfully coped with this issue. Analysis revealed she had a lower height (147.43cm) and less weight (46.76kg) than most of the other Early Neolithic females (*Jovanović 2017*), with normal body mass index.

Novi Sad – Gornja šuma

Three possible Neolithic burials (1, 2, 4) from this site (see SM 2) were dated, and the AMS dates span within the very beginning of the Late Neolithic Vinča culture, with the possibility that individuals from Burials 1 and 4 lived and were buried roughly at the same time (Burial 1: 5296–5066; Burial 2: 5224–5050 and Burial 4: 5291–5058 cal BC within the 95% CI; SM 4; Tab. 26 in SM 5). The isotopic ratios of $\delta^{13}C$ and $\delta^{15}N$ (Fig. 2; SM 4) of all individuals have roughly similar values, indicative of a terrestrial dietary pattern with the inclusion of C_3 plants, domesticates and wild game. Burial 1 belongs to a male, aged 20–25 years old (see SM 3). Cribra humeri, cribra femori (Fig. 11.a), PH as well as porosity on some of the bones suggest he had some nutritional imbalance, and traces of LEH indicate he probably had some nutritional deficiency since early childhood. Traces of supragingival calculus of degree 1 and periodontitis were also noted in this male, which in this case may also be caused by poor nutrition (*e.g.*, especially deficiency in vitamin C), or other factors. The presence of periostitis on the right radius and tibias may indicate this young male had some systemic infection. Burial 2 belongs to a middle-aged adult (see SM 3), who suffered from severe OA on ulnas (Fig.11.b), which could be caused by the possible injury since traces of bandaging were noted on the left radius, whose diaphysis is also slightly enlarged in that area.

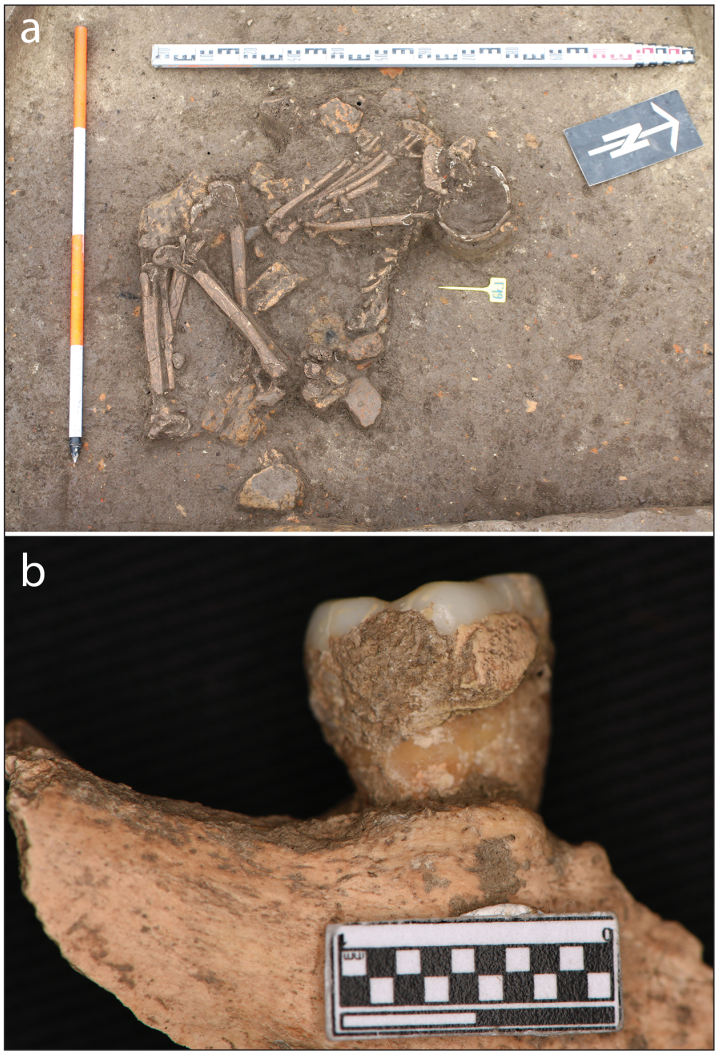


Fig. 9. Sajlovo, Burial 19.* a *in situ;* b *presence of supragingival calculus on tooth 48, buccal side (*a *from* Veselinov 2013*;* b *photo J. Pendić).

Active periosteal reaction noted on the inner side of one rib body usually indicates the presence of some lower respiratory tract disease (*Davies Barret* et al. *2019*), while the presence of the same reaction on the right femur could be due to trauma, metabolic disease, or some other factor (*Ortner 2003; Waldron 2009*). The presence of epiphyseal lines on the right femur and humerus in this middle-aged adult indicate this may have occurred as a consequence of disturbances in growth and development, malnutrition (*Johnston, Zimmer 1989*), environmental and sociocultural factors (*Johnston, Zimmer 1989; Belcastro* et al. *2019*), or perhaps due to some kind of hard physical labour (*Stefanović 2006*) that this individual did in childhood. Burial 4 belongs to a child, aged 5–7 years old (see SM 3). The child had a strong presence of nonspecific stress indicators (CO, cribra femoris and PH; Fig. 11.c,d), and a mixture of active and healed lesions suggest it tried to cope with this condition, but unfortunately without success, since it died. It also had other health issues, probably caused by long-term nutritional imbalance. Its pelvis was not developed enough in relation to the rest of the postcranial skeleton, especially in relation to the femurs, which could be the consequence of an irregular osteogenesis process. Furthermore, iliac fossa is almost missing on the iliac bones, suggesting some developmental disorder. Lower limb bones indicate the child had the initial stage of rickets (see SM 3), caused by long-term sitting or lying because of the underdeveloped pelvis. Limited movement and assumed excessive lying in the house could have led to vitamin D deficiency, and consequently the development of the rickets. In support of this there is a small dent on the metatarsal bone, which can be the consequence of some specific position which this individual habitually maintained. Muscle attachments on the upper limbs are too pronounced for a child of this age, which could indicate the child did some intense physical activity or leaned on its hands due to the limited mobility of the lower limbs. Mostly active periosteal reactions were noted on both upper and lower limb bones. Although periosteal formation can result from a variety of etiological factors (*e.g.*, traumas, metabolic, rheumatic, cancer and circulatory disorders and infectious diseases, all summarised in *Marques* et al. *2018*), it is possible that the main cause, in this case, was either rickets or mechanical strains caused by movements.

Beli Manastir – Popova zemlja

Nine burials were AMS dated from this site (see SM 2), and according to the obtained results all burials belong to the Neolithic, whereas most of them are



Fig. 10. Highway E-70 521km, Burial 1.* a *the pronounced muscle attachments and the curvature of the left humeral diaphysis;* b *specific abrasion of the front teeth;* c *shallow depression-Schmorl's node (photo J. Pendić).

dated to the Late Neolithic Sopot culture (4706–4489 cal BC within the 95% CI), corresponding well to the previously dated burials (*Mathieson* et al. *2018*). Three possible clusters of burials, closely related in terms of temporal provenience, can be observed. The first cluster consists of Burials 6 and 3 (4706–4555 cal BC and 4704–4552 cal BC within the 95% CI; SM 4; Tab. 27 in SM 5). Within the second cluster are Burials 2, 4 and 37 (4691–4541 cal BC, 4691–4536 cal BC, 4692–4538 cal BC within the 95% CI; SM 4; Tab. 27 in SM 5). The third cluster consists of Burials 5, 1 and 11 (4687–4526 cal BC, 4681–4495 cal BC, 4681–4489 cal BC within the 95% CI; SM 4; Tab. 27 in SM 5). Only Burial 16 (5882–5741 cal BC within the 95% CI; SM 4; Tab. 27 in SM 5), was dated to the Early Neolithic Starčevo culture, which is also in accordance with another Starčevo culture date from this site (*O.c.*). All dated individuals belong to children aged 2–15 years old, except one, Burial 3 (Fig. 12.a), where an old female was interred. They were all buried in a typical Neolithic flexed position (*e.g.,* Fig. 12.b; see also SM 3).

Anthropological analyses showed that the most of individuals buried at this site had poor health status, visible through presence of CO, PH, and periostitis (see SM 3). Although in all cases lesions were healed, they are however indicative of hard childhood and nutritional imbalance of these individuals. The bilateral presence of periostitis on the tibias of the children interred in Burials 4 and 5 could

possibly indicate to some systemic infection. Besides children, healed periostitis is present in old woman (Burial 3), on femurs, left fibula, and the right tibia, coupled with osteomyelitis on the left tibia. Since these nonspecific infection indicators are bilaterally present, it is also likely that she had some systemic infection. This woman had a hard life, which is evident by the presence of degenerative OA on both hips and osteophytosis on multiple vertebrae, which probably caused pain and limited mobility of the spine. Analysis revealed she was 151.75cm tall, which is the average height of Late Neolithic females in the region (*Masson 2014; this study*). The woman also had caries and ante-mortem tooth loss, which she perhaps lost because of the presence of caries. The appearance of caries seems to be common in Late Neolithic humans from the region (*Masson 2014; this study*), and could be due to a mainly terrestrial diet, enriched in carbohydrates. The stable isotopic ratios (Fig. 2; SM 4) of these individuals range from -19.8 ‰ to -19.2‰ (Δ=0.8‰; n=7) for carbon and 7.7‰ to 11.8‰ (Δ=4.1‰; n=7) for nitrogen, and are consistent with typical Early and Late Neolithic dietary patterns in the region (*Whittle* et al. *2002; Nehlich* et al. *2010; Lightfoot* et al. *2011; Gamarra* et al. *2018; Jovanović* et al. *2018*), showing that they consumed terrestrial resources (C_3 plants, domesticates and wild game) with no isotopic evidence for the use of aquatic food. The only exception from this site is a child interred in Burial 6 whose $\delta^{15}N$ value (11.8 ‰) is higher than others who have below 9.5 ‰, but this is probably due to the young age of this child and can be related to the effects of breastfeeding or some other physiological factor. Possible traces of trauma are detected in a child interred in Burial 2, visible through the presence of some ante-mortem tooth loss.

Vukovar – Gimnazija

Five burials were found at this site (see SM 2), and only one, Burial 3 has been AMS dated. The result (3361–3104 cal BC within the 95% CI; SM 4; Tab. 28 in SM 5) shows it belonged to the Eneolithic, probably Baden culture, although it was previously presumed that it belonged to the Early Neolithic. In the light of this new date and since all other burials are found at the same level, although archaeological data are modest one can assume that they also belong to the Eneolithic as well. The dated skeleton belongs to a child ~10 years old, whose stable isotope values show a terrestrial diet, as seen in other individuals buried at this site (*Lightfoot* et al. *2011*). A diet based on terrestrial C_3 plant resources, domesticates and wild game seems to be common from the Early Neolithic to the Eneolithic in the Carpathian basin (*Giblin 2011; Lightfoot* et al. *2011; Gamarra* et al. *2018; Jovanović* et al. *2018*), apart from individuals found at the mass burial site of Potočani whose diet was more enriched in terrestrial proteins, such as meat and dairy products, than elsewhere (*McClure* et al. *2020*). The child experienced some nonspecific physiological stress, evident in the presence of LEH and CO, common stress indicators in Early and Late Neolithic communities in this region (*Masson 2014; Jovanović 2017*). Although at the moment of death the CO lesions were healed, it seems that some other unknown factors led to the child's death.

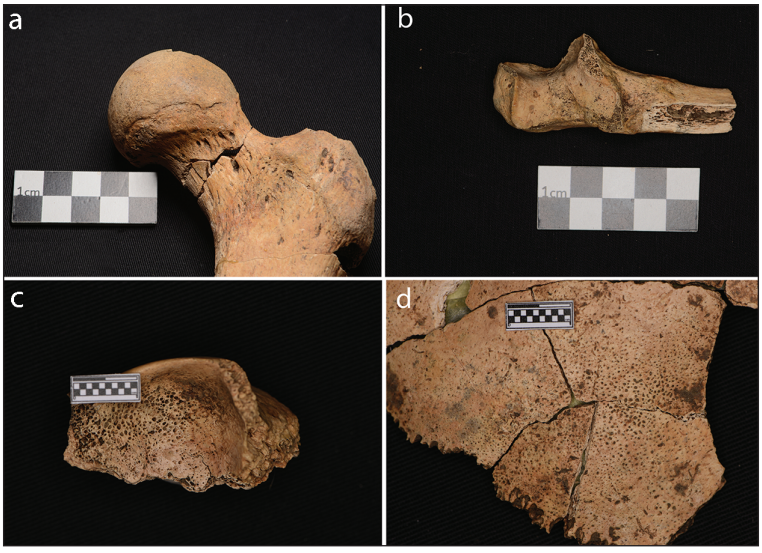


Fig. 11. Novi Sad – Gornja šuma; Burial 1.* a *Cribra femori on the left femur;* b *Burial 2: Osteoarthritis on the right ulna;* c *Burial 4; Cribra orbitalia on the left orbital roof;* d *Porotic hyperostosis on the skull bones (photo J. Pendić).

Vinkovci Ervenica – Poljski jarak

The only dated burials from this site are Burials 2 and 3 (see SM 2), which confirmed their assumed Early Neolithic culture attribution (5777–5664 and 5731–5646 cal BC within the 95% CI, respectively; SM 4; Tab. 29 in SM 5). Two old females (>50 years old) were found inside them. According to the AMS dates it could be argued that these individuals lived roughly at the same time, maybe representing two generations. They both had a very similar terrestrial diet (Fig. 2; SM 4) based mostly on C_3 plants, domesticates and wild game meat, which probably caused higher incidence of caries followed

by abscesses and a large amount of ante-mortem tooth loss. A similar dietary (*Whittle* et al. *2002; Nehlich* et al. *2010; Lightfoot* et al. *2011; Gamarra* et al. *2018; Jovanović* et al. *2018*) and oral health (*Masson 2014; Jovanović 2017*) pattern is seen in other Early Neolithic individuals from the region. Both women had two types of calculus (see SM 3), whose appearance was connected to pathological conditions detected on the teeth and poor oral hygiene rather than diet, especially in woman from Burial 2. They both had some of the non-specific stress indicators which implied a hard childhood and nutritional imbalance. The woman interred in Burial 2 had OA on both hips and several vertebrae, coupled with the presence of Schmorl's nodes and bony ankylosis on both pelvic bones and sacrum, as well as in two lumbar vertebrae. These modifications are probably the result of degenerative changes (or perhaps injury/disease) and were certainly painful and caused restricted mobility of this female. The female from Burial 3 also had OA on the same bones as the woman from Burial 2, as well as on shoulder joints, where one can notice that the right one is more affected than the left, which can be related to the fact that right humerus is shorter than the left one. Regarding stature, the woman from Burial 2 was shorter (149.69cm) than the woman from Burial 3 (157.51cm). However, she was approximately around the average stature for an Early Neolithic female in the region (*Jovanović 2017*).



Fig. 12. Beli Manastir – Popova zemlja. **a *Burial 3;* b *Burial 4,* in situ.**

Conclusion

This paper presents a comprehensive set of different types of data (the results of anthropological and stable isotope analysis, and the results of radiocarbon dating), obtained on the prehistoric human remains from a vast geographic area. The sample consists of all the available human remains from the Neolithic sites at the territory of southern and central Balkans, and southwestern Carpathian Basin, analysed or re-analysed within the project BIRTH. The results filled in the gaps in some of the older interpretations, but also produced new insights for particular sites regarding different issues – chronology, health and diet, and the interpretation of contexts within the sites. These results are mainly presented in the contexts of the individual sites and discussed as such within the appropriate temporal and spatial attribution, and to a lesser extent on a regional basis.

New radiocarbon dates obtained on human remains also contributed to the reconstruction of Early Neolithic population dynamics. They were used within a larger sample of dates, and as a separate, control sample, for implementing the *summed calibrated radiocarbon probability distributions* (SCPD) method, which enabled testing the main hypotheses of the Neolithic Demographic Transition (NDT) theory regarding changes in the population dynamics during the Early Neolithic within the territory of the central Balkans and parts of the southwestern Carpathian Basin (*Porčić* et al. *2021*). The results indicate a fast and constant population growth at the beginning of the Early Neolithic, followed by several episodes of a decrease in population size, and then population recovery and new growth (the so-called boom and bust pattern), combined with high growth rates. These results are mostly consistent with the results for other European regions, and also with the predictions of the NDT, even though some local differences and specificities have been observed (*O.c.*).

The distribution of Early Neolithic sites with burials in the south and central Balkans and southwestern Carpathian Basin, albeit insufficiently researched in some areas, reveals some common elements in mortuary practices and the social need for burials. The deceased are found within the settlements and usually buried into pits, underneath the house floor or into sporadic burials scattered across settlements, or within the excavation layer. They are mostly found in typical Neolithic flexed positions. There are also examples of re-using of pits for burial purpose (*e.g.,* at Jaričište and Starčevo – Grad) and the potential

re-burying/relocating of the deceased and secondary manipulation of mandibles at Govrlevo and Tumba – Madžari, which can be due to some ritual deposition. Analysis of mortuary practice also show existence of collective burial at Vinča – Belo Brdo site, and those kinds of burials are rarely seen in the Early Neolithic and Starčevo culture sites. This site is also unique, since almost all individuals found here bear traces of violence, which are rarely witnessed in other sites in this period. Anthropological analyses of Neolithic burials showed that the remains of children and females were more represented than male ones, while the burials of neonates are usually missing (apart from in the Danube Gorges), which may be due to taphonomic factors (*e.g.*, type of soil, recovery issues, *etc.*). The rest of the age groups are more-or-less evenly distributed between infants to old adults.

Regarding the Late Neolithic, the important findings represent the discovery of more than 15 burials AMS dated to the Late Neolithic. Since they are rarely discovered, every find of the human remains from this period are important, as they can lead to a better understanding of the biological characteristics, mortuary practices and possible social ranking of members of the Vinča and Sopot culture communities. A few existing studies focused on some social aspects and demographic issues (*e.g., Zoffman 1987; Stefanović 2006*), but rarely on the diet and health of these people (*Masson 2014*). The discovery of Late Neolithic burials sheds new light on their physical-anthropological characteristics and lifestyle, showing continuity between the Early and Late Neolithic in terms of diet and health.

The stable isotope results showed that most of the Early and Late Neolithic humans, apart from those in the Danube Gorges, consumed a terrestrial diet based on C_3 plants and animal resources, with no isotopic evidence for the usage of aquatic resources. The only exception are a few sites located in close vicinity to the rivers, such as Vinča – Belo Brdo, Sremski Karlovci, Obrež – Baštine, and Klisa, suggesting their inhabitants had a higher intake of aquatic proteins. The proximity of the Danube River was certainly of crucial importance for their aquatic intake, as is the case with the Danube Gorges communities. The Danube Gorges sites had excellent riverine positions where many whirlpools aided in specialised fishing, thus aquatic resources were a staple food throughout the Mesolithic – Neolithic sequence, albeit some individuals shifted their diet toward more terrestrial foodstuff during the Neolithic.

There is also continuity in the health status between Early and Late Neolithic communities, where both show poor health, like most of the contemporary Neolithic communities across Europe.

The study shows these individuals had hard, stressful childhood and unbalanced nutrition (especially those buried at Zmajevac, Vinča – Belo Brdo, Starčevo – Grad, Bezdan – Bački Monoštor, Sajlovo, Novi Sad – Gornja šuma, Vinkovci Ervenica – Poljski jarak). Furthermore, some of them bear traces of intense physical work, such as those found at Zmajevac, Bezdan – Bački Monoštor, Zmajevo – Livnice, Highway E-70, 521km. They also show signs of restricted mobility (*e.g.*, Bezdan – Bački Monoštor, Zmajevo – Livnice, Novi Sad – Gornja Šuma, Beli Manastir – Popova zemlja, Vinkovci Ervenica – Poljski jarak) and repeated infections (Zmajevac, Bezdan – Bački Monoštor, Zmajevo – Livnice, Highway E-70, 521km, Novi Sad – Gornja šuma, Beli Manastir – Popova zemlja.

In contrast, the Neolithic humans in the Danube Gorges show no significant decline in health compared to the Mesolithic inhabitants of the same region. The only major health problem through the time were infections. This stability in health over the Mesolithic – Neolithic period may result as a consequence of a food abundant in proteins, especially one based on aquatic resources. In the Neolithic, some humans started to include more terrestrial resources in the diet, which caused few cases of caries, while changes in dietary strategies seems to be related to higher number of stress episodes visible through analysis of enamel hypoplasia. In general, analysis of health status showed that communities in the Danube Gorges seem to have been of better health than the Neolithic groups living in other regions. This marked difference is a result of multiple factors, most prominently the differences in dietary pathways, environmental conditions, cultural habits and, at least for the Danube Gorges, adherence to the Mesolithic traditions. This study has given a detailed and strong baseline for all future research regarding particular questions of interest within different research frameworks concerning the Early and Late Neolithic lifestyles.

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Chronological modelling of the Chalcolithic settlement layers at Tell Yunatsite, Southern Bulgaria

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ABSTRACT – *This article publishes a new series of radiocarbon dates from Tell Yunatsite, Southern Bulgaria. Context-based excavations undertaken over a large surface area, as well as a small test trench, provided a long stratigraphic sequence (11 'building levels') covering a large part of the Chalcolithic period in Thrace (5th millennium BCE). Bayesian statistics and Gaussian Monte Carlo Wiggle Matching were employed to achieve a fine chronology for the multilayered tell. Implications and problems on the application of the calibration curve for the Late and Final Chalcolithic in Bulgaria are also discussed.*

KEY WORDS – *radiocarbon dating; chronology; stratigraphy; Chalcolithic; Gaussian Monte Carlo Wiggle Matching; Bayesian statistic*

Kronološko modeliranje halkolitskih naselbinskih plasti na telu Yunatsite, jug Bolgarije

IZVLEČEK – *V članku predstavljamo novo serijo radiokarbonskih datumov s tela Yunatsite v južni Bolgariji.S pomočjo v kontekste usmerjenih velikih izkopnih površin in manjših testnih sond smo prepoznali dolgo startigrafsko sekvenco (11 'gradbenih nivojev'), ki pokriva velik del halkolitskega obdobja v Trakiji (peto tisočletje pred našim štetjem). Za natančno kronologijo večslojnega tela sta bili uporabljeni Bayesova statistika in Gaussovo Monte Carlo usklajevanje krivulje. Poleg tega smo analizirali tudi posledice in probleme uporabe kalibracijske krivulje pri datiranju poznega in končnega halkolitika v Bolgariji.*

KLJUČNE BESEDE – *radiokarbonsko datiranje; kronologija; stratigrafija; halkolitik; Gaussovo Monte Carlo usklajevanje krivulje; Bayesova statistika*

Introduction

Tell Yunatsite (42°13'56"N; 24°15'45"E), also known as Ploskata mogila (the 'Flat mound'), is situated in Southern Bulgaria, in the western part of the Upper Thracian Plain (Fig. 1). The diameter is 110 x 100m at its base and the height is 12m above the modern-day surface. The tell developed on a low terrace on the ancient bank of the Topolnitsa River near to its confluence with the Maritsa River[1]. It is located in a fertile plain bounded by mountains – the Rhodope Mountains to the south, Rila and Ihtimanska Sredna Gora Mountains to the west, and Sashtinska Sredna Gora Mountain to the north (Fig. 2).

The first excavations of the site were carried out by Vasil Mikov in 1939. Systematic archaeological excavations of the tell's eastern section began in 1976

1 The course of the Topolnitsa River has changed through time and in the 20th century AD it was rectified with dikes.

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and continue into the present (*Mikov 1940; Katincharov* et al. *1995; Tell Yunatsite 2007; Boyadzhiev* et al. *2004; 2009; 2011a; 2011b; Mazanova 2011*). So far, the excavations have yielded evidence of habitation from the 5th millennium BCE until the 6th century AD – including Chalcolithic, Early Bronze Age (EBA), Iron Age and Roman Age occupations, as well as a Medieval cemetery. Long-term habitation was documented in two periods – the Chalcolithic and the Early Bronze Age. Seventeen consecutive building levels from the EBA have been excavated over approx. 40% of the tell's area (Yunatsite Б1-Б16/17[2]).

Stratigraphy of the Chalcolithic layer

This paper focuses on the Chalcolithic sequence. Until 2012 the latest layer from this period (building level BI) was excavated over approx. 40% of the tell's area (Fig. 3). A large series of ^{14}C dates was obtained from this level (*Tell Yunatsite 2007.232–238; Boyadzhiev 2015; Boyadzhiev, Aslanis 2016; Mathieson* et al. *2018*).

Since 2012 research has concentrated on a smaller area in the central eastern part of the tell, known as Mikov's trench (sq. M-H 3-7), and the adjacent squares to the south (sq. О 4-7, П 4-6) (Fig. 4). The main objective has been to understand the stratigraphy of the Chalcolithic habitation. The first step was aimed at exposing the levels between the latest habitation layer (BI) and the surface reached in 1939 at the bottom of Mikov's trench, thus merging it with the squares to the south. The second step aimed at continuing the excavations in this section, gradually reaching the earliest habitation layer of the tell. A stable sequence up with Mikov's trench was provided by detailed research of the remains of consecutive buildings preserving the stratigraphic order of the habitation layers (Fig. 5).

The excavations indicated a long lifespan of the buildings. Different reconstruction events have been attested, including numerous floor plasters, interior renovations (*e.g.*, moving the oven) and even the reconstruction of walls. Based on a partial excavation of the tell, the separation of distinct 'building levels' is therefore quite challenging. In fact, the term 'building level' is here used only provisionally, as different buildings of the tell may have been built or destroyed at different times, had a different period of use and/or went through different interior reconstruction events.

One of the key problems regarding the interpretation of partially excavated unburnt building structu-

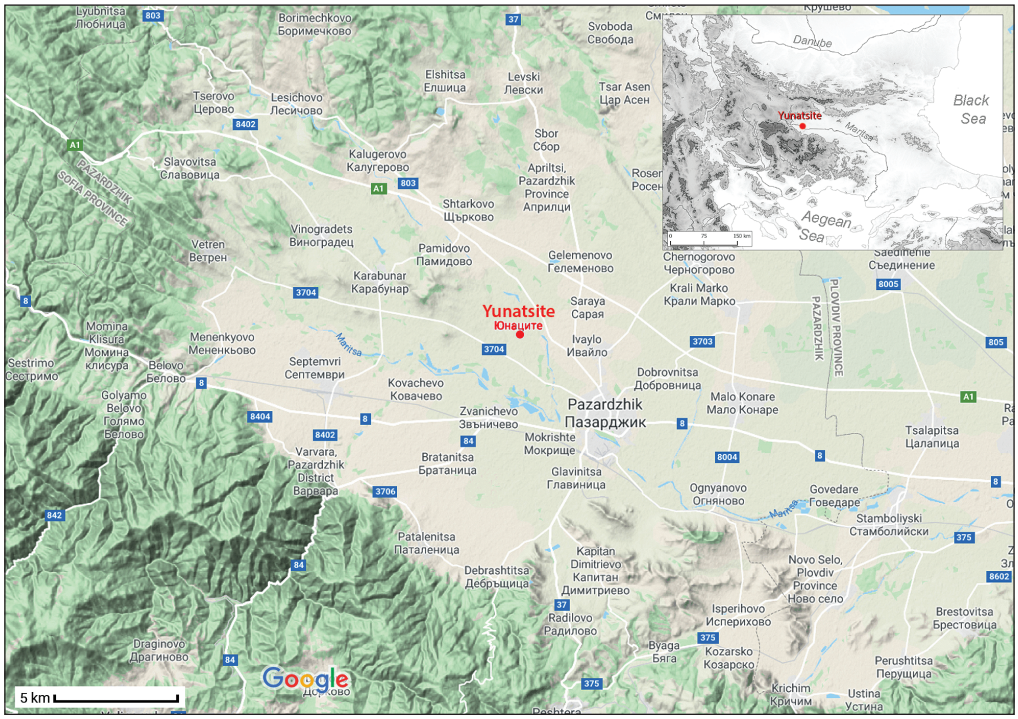


Fig. 1. Location of the Tell Yunatsite in Southeast Europe (from Google Earth).

2 During the large-scale systematic excavations the following labelling of the main layers was accepted (in Cyrillic): *А* Roman and Iron Age; *Б* Early Bronze Age; *В* Chalcolithic.

res is the reliable differentiation between renovations of a house (*i.e.* those which occurred within the lifecycle of a 'building level') and the building of an entirely new house (*i.e.* occurring at the start of a new 'building level'). Similar problems emerge in small excavated areas with no building remains at all (especially with no floor-destructions-floor superpositions) or layers without distinctly identifiable limits.

Since 2000, renovations of a single building at Yunatsite are considered to be part of one 'building level'. A new level, on the other hand, is marked by the entire destruction of a building, as evidenced by a layer of debris covering its surface and/or by a levelling layer separating the remains of one building from those of another. The high probability that neighbouring buildings have different lifespans is also considered. So far (until 2019), six 'building levels' have been identified.

Building level BI

The latest (uppermost) Chalcolithic building level was largely exposed before the year 2000. During these earlier excavations, it was assumed that the base of building level BI was marked by the level of the uppermost floor of the respective buildings (*Matsanova, Mishina 2018*) (Fig. 6). Newer research between 2002 and 2017, however, showed that level BI covered a much longer time-span. Consecutive floor plasters and reconstructions of interior structures (*e.g.*, ovens) were attested, showing earlier stages in the lifecycle of a single building.

Reliable stratigraphic evidence for the superposition of level BI and the lower levels was revealed in two



Fig. 2. Aerial view from the East over the Pazardzhik field with Tell Yunatsite in the centre.

sectors on both sides of Mikov's trench. The first sector in the south (sq. П-О 7-3)[3] provided a connection with structures reached in 1939 at the base of the trench. The building (BIII-1) reached in the western part of this trench (sq. О-Н 7-6) was assigned to level BIII.

The second sector is located between the northeast corner of Mikov's trench and the periphery of the tell (sq. Л3-М3) – a small area which was not excavated in 1939. In the upper part of this sector an oven from Building BI-2 from level BI was excavated. Under this level the remains of consecutive buildings (floor plasters and debris) were exposed. Due to erosion at the edges of the tell the upper layers were more eroded and less preserved compared to the lower features.

Building level BII

In 2001–2003, two buildings from building level BII were uncovered in the northern part of the tell (BII-14 and BII-15). Both were continuously used, with



Fig. 3. Photogrammetric model of Tell Yunatsite with the area studied in 2012–2019 (graphic by B. Whitford).

3 The labelling of the squares follows the Cyrillic alphabet.

two major construction phases (*Boyadzhiev* et al. *2004. 170*).

The most important structures to clarify the stratigraphy of the Chalcolithic layer were three buildings from level BII excavated in 2014–2019 south of Mikov's trench.

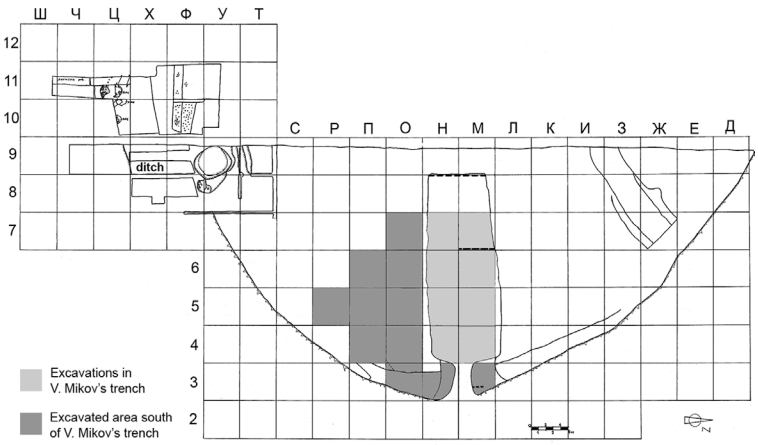


Fig. 4. Tell Yunatsite. General plan of the excavated part of the tell and the area studied in the last years. Locations of the profiles illustrated in the paper are marked with dashed black lines (graphic by Y. Boyanin and K. Boyadzhiev).

Building BII-22 is situated in the easternmost part of the tell (sq. О3-О4). The western wall was attested, and it is at least 8m long and oriented N/NE – S/SW. In the northern part of the building the base of an oven was uncovered. It is situated under oven No. 1 from building BI-6, level BI (*Matsanova, Mishina 2018. 129, 135–136, Fig. 12.1*). Most of building BII-22 was uncovered under building BI-6. Its debris was levelled when the surface of level BI was prepared for the construction of building BI-6.

Building BII-21 is located west of building BII-22, in squares О4-О5, П4-П6. It is approx. 10.60m long and 8.50m wide and divided into a few separate 'rooms'. An upper floor made of greenish clay was exposed. In some negative structures cutting this floor level a stratigraphic sequence of more floor plasters is visible, testifying the continuous lifecycle of the building.

In the northeast part of the building a podium was found built on top of the greenish clay floor. Under this a lower podium was attested in the profiles of some negative features.

The building burned down in a sudden event. In two of the 'rooms' a high concentration of broken vessels, some filled with charred grains and fruit seeds, were uncovered. On top of the floor and the burnt building debris there was a plaster of fired clay (in some places a sequence of a few plasters), followed by a homogeneous layer of black clayish soil, a layer of grey-greenish soil and a layer of levelled orange debris. In these layers no structures were found (except for small trenches and postholes), and only few finds were recorded. The uppermost layer of debris is covered by the base of level BI.

The analysis of this depositional process connected to the destruction of building BII-21 shows that the fire did not affect (or at least not heavily) the neighbouring building BII-20 (to the west). While the above-mentioned homogeneous layers of black and grey-greenish soil accumulated, BII-20 still existed after this event. Building level BII obviously covers a long timespan, with different reconstruction events in different parts of the settlement.

The sample Poz-108890 (5620±40 BP) is a bone (*Bos taurus* phalanx) taken from the layer of grey-greenish clayish soil under the levelled debris (context 222C), in sq. П4. It marks the final phase of level BII in this area.

The sample Poz-109086 (5590±40 BP) was taken from a concentration of charred lentils stored in vessel 10 and found under the burnt debris (context 385), on top of the greenish floor level in the northeastern part of building BII-21 (sq. О4). It dates the burning event.

Building BII-20 is situated west of building BII-21, in squares О6-О7 and П6. It is preserved partially under building BI-8 from level BI (*Matsanova, Mishina 2018.129, 135, Fig. 12.1*) and had at least two construction phases. The bone sample Poz-108910 (*Bos taurus*, phalanx) was taken from the homogeneous clay surface (context 48) underneath the burnt debris which defined the end of the building.

In the small area east of Mikov's trench (sq. Л3-М3) building level BII is defined by a sequence of 11 floor plasters, preserved over an area of two square metres (*Boyadzhiev* et al. *2015.95–96*).

Building level BIII

One building from this level has been partially excavated – building BIII-1. Its location is essential in cla-

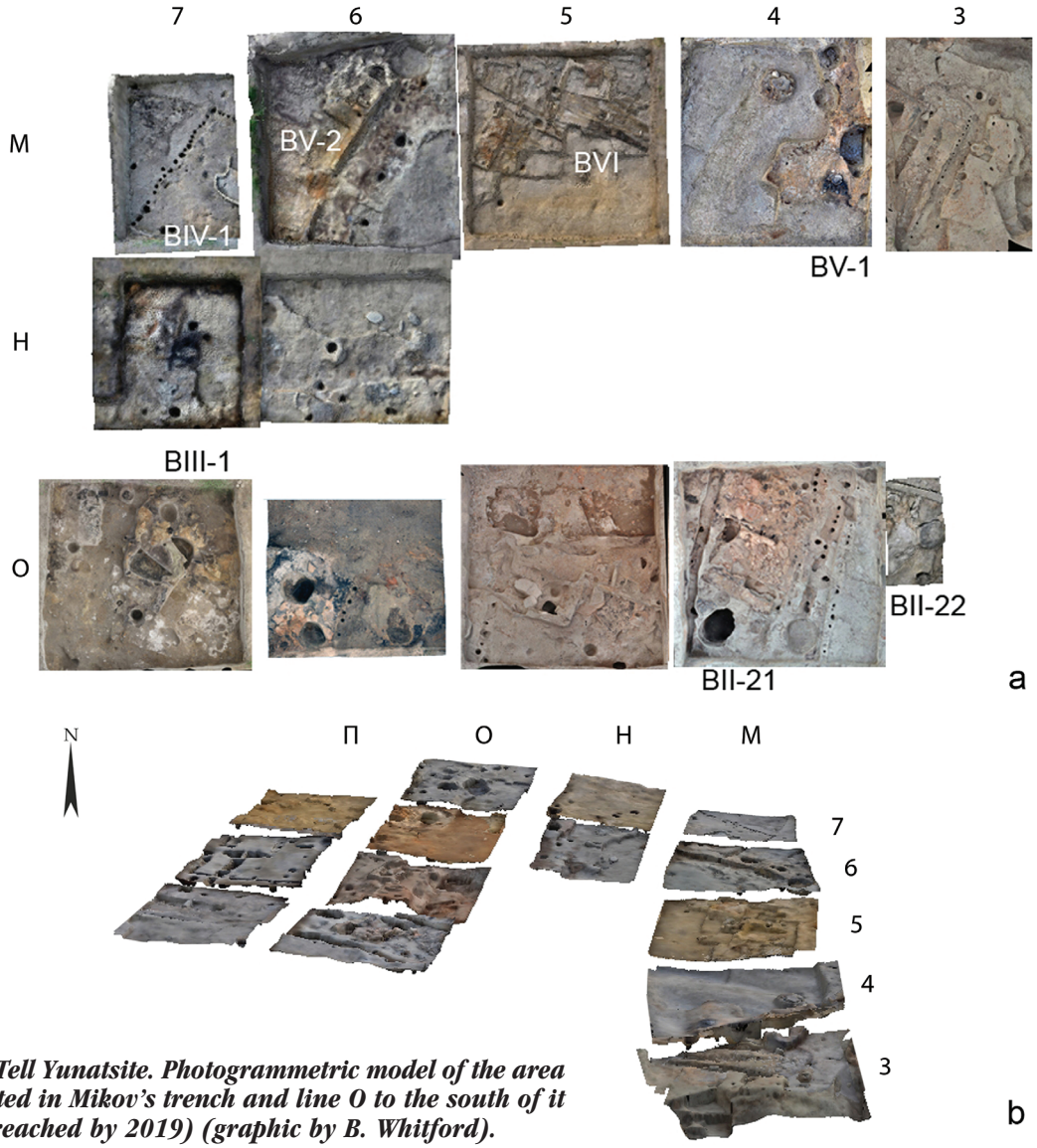


Fig. 5. Tell Yunatsite. Photogrammetric model of the area excavated in Mikov's trench and line O to the south of it (level reached by 2019) (graphic by B. Whitford).

rifying the stratigraphic connection between Mikov's trench from 1939 and the recently excavated area to the south. The southern half of the building was uncovered under the base of building BII-20 (in sq. O6-O7), while its northern half was documented in the western part of Mikov's trench (sq. H6-H7). North of the building, in sq. M7, a concentration of animal bones was found. Under it and the northernmost debris of building BIII-1 a levelling layer of greenish clay was attested (the base of level BIII). It covered the remains of building BIV-1 from level BIV (Fig. 7).

Building BIII-1 consisted of two rooms – a southern and a northern one. Several reconstruction events were documented in both rooms, which were independent of one another. In the northeastern part an oven was found, which was built on sediments on top of the earliest floor level. Later, the oven was abandoned and covered with a thin clay plaster and a wooden construction was installed east of it. The building was destroyed by fire.

Two ^{14}C dating samples were taken. The sample Poz-109084 (5730±40 BP) was taken from a concentration of charred grain found under the burnt debris of the building BIII-1 (context 90) in the southwestern part of the northern room (NW corner of sq. O7). It dates the burning event of the house and the end of level BIII. The bone sample (*Bos taurus* phalanx) Poz-108885 (6130±40 BP) was taken from an earlier layer of the building – context 278 in sq. H6. Compared to the other dates from the site, it is clearly too old for the layer and was excluded from the analysis.

In the area east of Mikov's trench (sq. Л3-М3) the remains of a building with six consecutive floor plas-

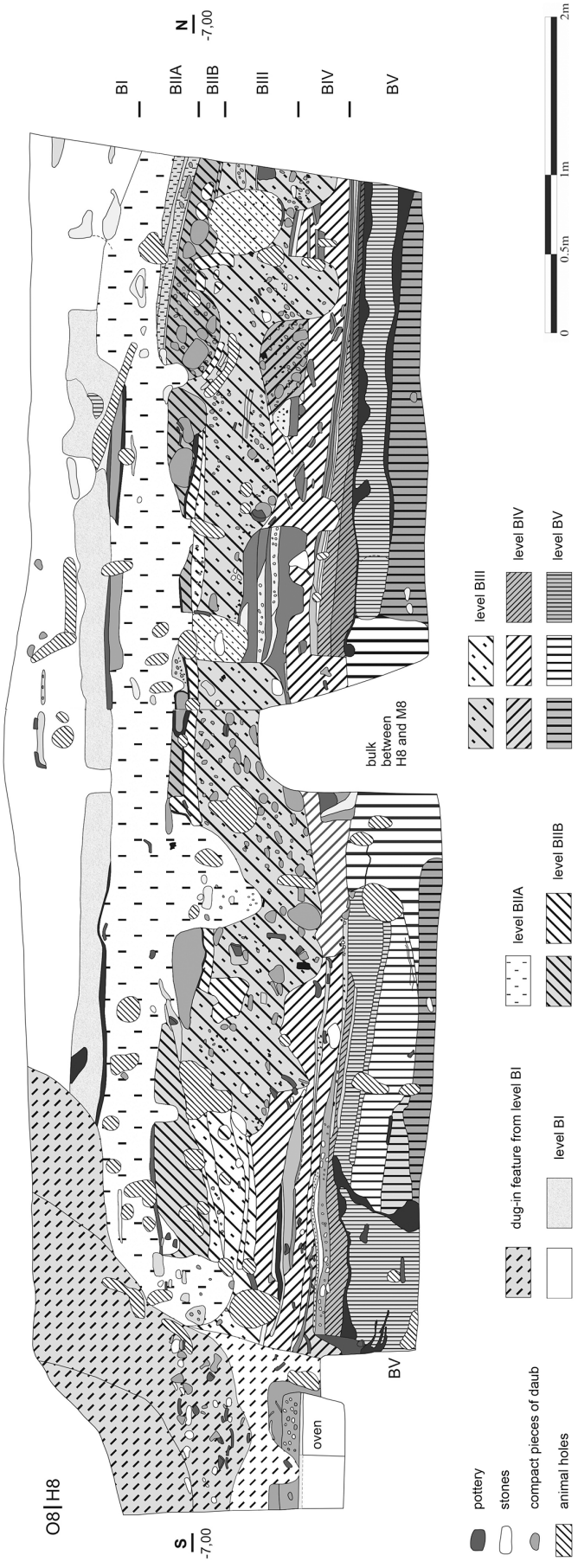


Fig. 6. Tell Yunatsite. West profile of Mikov's trench, sq. M8-H8 (graphic by K. Boyadzhiev).

ters belong to building level BIII. The remains of a base of an oven or fireplace were found (*Boyadzhiev* et al. *2015.95–96*).

Building level BIV

Building level BIV has been studied in two small areas, in the western part of Mikov's trench (sq. M7 and partly in M6) and in the small area east of Mikov's trench (sq. Λ3-M3).

In squares M7 and M6 the remains of building BIV-1 have been partially excavated. The southern part of the building is preserved under the northern part of building BIII-1 and is not yet excavated. Its 'western' and 'northern' walls were identified by 0.20m wide ditches. The orientation of the house is NE to SW.

The osteological material from the building is scanty and very fragmented. Two bone samples were selected from the heavy fraction of the flotation of a clayish layer that is located on top of the floor in the southeast part of sq. M7 (Poz-108886 (5630±40 BP [context 230, unidentified long bone]); Poz-115801 (5730±40 BP [context 225, *Ovis/Capra* vertebra])). Both samples were obtained from flotation and should be handled with more care since they were not collected during the excavation of the features.

A small part of another building (BIV-2) was excavated in the eastern periphery of the tell, in squares Λ3-M3. A floor with five consecutive plasters was documented (Fig. 8). The base of the fired eastern wall was found, identified by two rows of mudbricks. The remains of the base of an oven or fireplace was uncovered under the oven/fireplace from building level BIII (*Boyadzhiev* et al. *2015.96; Boyadzhiev, Aslanis 2016.137*).

The bone sample (*Ovis/Capra* femur) Poz-108883 (5710±40 BP) was collected from a concentration of animal bones (context 348) east of the building BIV-2, on top of a layer of green clay marking the very base of building level BIV.

Building level BV

Two buildings from this level were partially excavated: BV-1 and BV-2. Their positions in the stratigraphic sequence are well understood (Fig. 9). Building BV-2 was uncovered under the remains of building BIV-1 in sq. M6-M7. So far, it has been excavated in sq. M6, but is also preserved to the south (sq. H6-H7) and north (outside of Mikov's trench). To the west, its destructions have been documented in the entire sq. M7. The orientation of the building is N/NE-S/SW. It was heavily burnt, which left the osteological material in poor condition. A few samples were collected for dating, but these lacked enough collagen. One bone sample (*Bos taurus* phalanx) from the destruction (context 35E, sq. M6) could be dated: Poz-109419 (5460±50 BP), but had a critically low amount of collagen (0.2%). It is the youngest date in the series of radiocarbon dates and does not fit to the documented position in the stratigraphy of the site. Therefore, it was excluded from further analysis.

Building BV-1 is situated in the eastern periphery of the tell – sq. Λ3-M3-M4. Its remains were covered by the floor of building BIV-2 and the green clay layer mentioned above. At the base of the floor, constructed using an atypical construction technique that consists of tightly placing clay lumps close to each other, two construction phases were detected. During the second phase, the oven was rebuilt in the northeast part of the building and slightly shifted in its orientation. The base of clay lumps was carefully plastered with clay to build a flat and steady floor surface. Three more 'packages' of clay plasters were preserved above this floor, testifying three more reconstruction phases. Reconstruction phases were also documented by the re-plastering of the oven and by a slight shift of the eastern wall. These reconstructions indicate a long lifespan of the building.

The bone sample (*Bos taurus* phalanx) Poz-115802 (5700±40 BP) was taken from a layer on top of the latest floor (context 396), but under the debris of the building BV-1, and it marks the final phase of the building. Chronologically its position is closer to the beginning of the building level BIV (samples Poz-108886; Poz-108883; Poz-115801), than to the beginning of level BV.

Building level BVI

This building level was preserved in the easternmost periphery of the tell. A very small part of a building BVI-1 was excavated. It was partly covered by the floor of building BV-1. The eastern part at the edge of the tell was eroded. A sequence of 14 floor plasters from BVI-1 was uncovered and was found tilting to the south and west. A few bones, including sample (*Ovis/Capra* metacarpus) Poz-108907 (5630± 40 BP), were found lying on the uppermost plaster (context 439).

Building level BVI was also attested in sq. M5, in the area between buildings BV-1 and BV-2 (Fig. 5). Four ovens with a concentration of white ash surrounding them were found in this sector just below the level reached by Mikov in 1939. The two earlier ovens have been built on platforms made of wooden beams, which were preserved unburned. Stratigraphic observations of the buildings BV-1 to the east and BV-2 to the west indicate that these ovens belong to the earlier building level (BVI), while the two later ovens are probably synchronous with the buildings from level BV. Possibly this open area between the houses was used continuously during the time of the building levels BV and BVI. Similar situations were attested in levels BI and BII as concerns the space between buildings.

The bone sample (ungulate, vertebra) Poz-115803 (5690±40 BP) was collected from a clay layer (context 118) on top of the unburnt wooden platform and is most likely related to building level BVI.

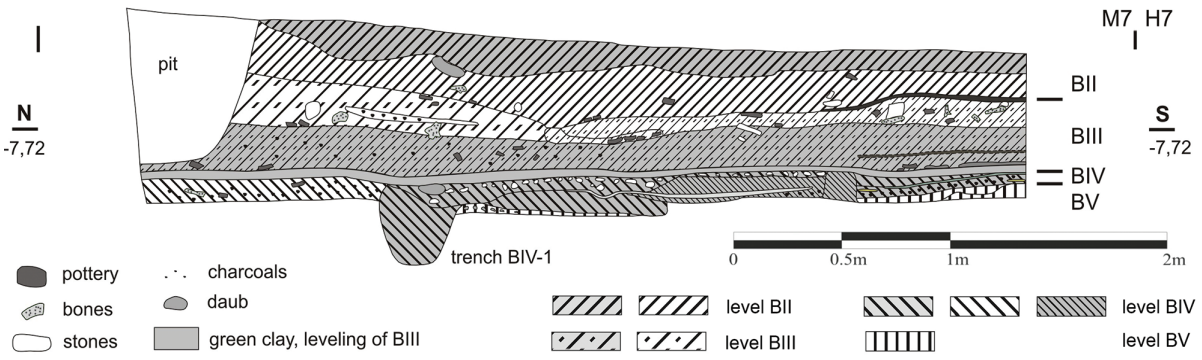


Fig. 7. Tell Yunatsite. Sq. M7, east profile (graphic by K. Boyadzhiev).

Building level BVII

To obtain additional stratigraphic information and collect samples for ^{14}C dating, a small test-trench was dug in the eastern periphery of the tell (sq. M2-M3 – Figs. 4, 8). It measured 1.30 (N-S) x 0.80m (about 1.04m^2) in the upper part and was narrowed to 0.80 x 0.30m below the depth of –8.76m. It cut the preserved parts of the layers below BVI which did not erode. The trench is stratigraphically related to the floor of building BVI-1. Under this floor a compact layer of burnt debris was exposed. About 0.40m below the debris a hard-plastered floor was found. It probably marked the lowest (earliest) floor of the building, whose destruction material was attested above. Two more probable floors were exposed 0.12m and 0.25m above the earliest floor, but under the debris. Two spots of burned clay with a diameter of about 0.50m were stratigraphically related to these floor levels. The lower one was 1.5cm thick and the upper one was 2.5cm thick.



Fig. 8. Tell Yunatsite. East profile of the Mikov's trench, sq. Λ4-M4 (photo by Y. Boyadzhiev).

Although the excavated area is very small, the stratigraphic observations indicate that these layers belong to one building with three occupational phases. Bone sample (*Dama dama* tibia) Poz-108905 (5680± 30 BP) is taken from a greenish grey layer (context 450) related to the second phase.

Building level BVIII

No remains of floors or burnt debris were excavated underneath building level BVII. Several layers with different characteristics were identified and separated into probable 'walking surfaces': trampled clay levels with horizontal concentrations of pottery sherds and other artefacts. They might mark different building levels, but the very small area of the test-trench does not provide grounds for reliable conclusions. Thus, these levels were arbitrarily labelled as BVIIIa, BVIIIb, BVIIIc and BVIIId (Fig. 10).

Level BVIIIa

The base of this level is marked by a thin layer of burned clay. A few pottery sherds and some animal bones (including sample Poz-108908 (5740± 40 BP) [*Bos taurus* costa]) were found in a grey ashy layer (context 474) on top of it. A 0.30 to 0.40m thick layer of grey-greenish soil with small pieces of daub and a lot of charcoal covered it.

Level BVIIIb

This level was approx. 0.40–0.50m thick. Its upper part is marked by a layer of grey-brown ashy soil, up to 0.25m thick to the south and thinning to the north. In the southern part of the test-trench two thin layers of yellow clay were exposed below it, and a thin layer of white ash on top of it. A very tiny level of dark soil separates the clay layers. A greenish-grey sandy layer was exposed under these layers and at its base a structure of unburnt wooden planks

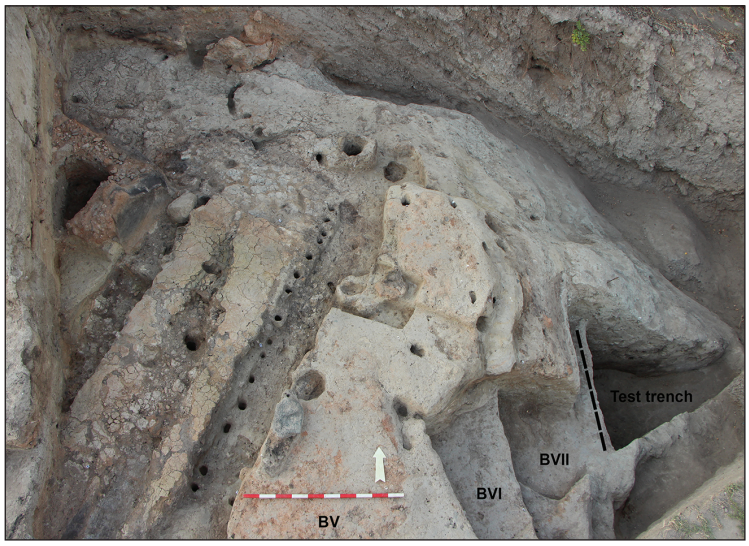


Fig. 9. Tell Yunatsite. Sq. M2-M3-Λ3: building BV-1 (level BV) and the location of the test trench in the periphery of the tell to the east of it (photo by K. Boyadzhiev).

was revealed. Four parallel horizontal planks were uncovered, which were oriented NW to SE. They were 8–10cm wide, more than 0.80m long and are still preserved in the western profile. The distance between the planks was 5–10cm. Underneath them a second layer of perpendicular planks (SW to NE) was recorded. 0.15m above the northern end of this feature, pieces of unburnt wooden planks oriented NW-SE were uncovered, as well as a preserved plank with the same orientation above them. They were divided by a thin layer of grey-greenish sandy soil (context 505). The bone sample (*Bos taurus* humerus) Poz-108906 (5810±40 BP) was taken from this place. North of these planks a vertical, 0.13m wide plank was found, placed on its longitudinal side. All wooden planks were found in or slightly below the greenish grey sandy layer.

In the northern part of the test-trench the grey-brown ashy layer was much thinner. A thick layer of grey-brown clayish and sandy soil was exposed below it (context 484). A few pieces of a broken oven or fireplace were documented inside it. In the upper part of this layer the concentration of pottery sherds was higher and the bone sample (*Bos taurus* humerus) Poz-108888 (5780±40 BP) was taken from there. It possibly marks a later 'phase' of level BVIIIb compared to Poz-108906 (5810±40 BP).

Level BVIIIc

After the documentation of the wooden construction, the research in the southern part of the test-trench was stopped to preserve the structure *in situ* and study it in the future over a larger area. Excavations continued in the northern part, covering an area of 0.80m (N-S) by 0.30m (E-W). A level of –10.72m below the highest point of the tell was reached, 0.90m below the elevation of the unburnt wooden planks. Seven layers were identified in these 0.90m. Some contained tiny layers of white ash. The overall thickness of these layers and their number indicated that they were related to at least two building levels. The upper one is marked as BVIIIc and is about 0.55–0.60m thick. A layer of hard fired clay (floor plaster?) probably marks its base.

Sample Poz-108889 (5810±40 BP [*Bos taurus* costa, hard grey clay, context 518]) was taken from a grey layer on top of this base.

Level BVIIId

The lowest level is about 0.30–0.35m thick. Three layers separated by thin layers of ash were identified. Bone sample (*Bos taurus* metacarpus) Poz-108909 (5860±40 BP) was collected from the uppermost (grey soil with some charcoal – context 521) of these layers. A second bone sample (*Bos taurus* costa) Poz-108887 (6200±40 BP) of level BVIIId has been taken from an ashy grey layer (context 523). The calibrated date is the oldest radiocarbon date from the site, comparable with the sample Poz-108885. It is obviously too old for the dated layer and therefore has been excluded from further analyses.

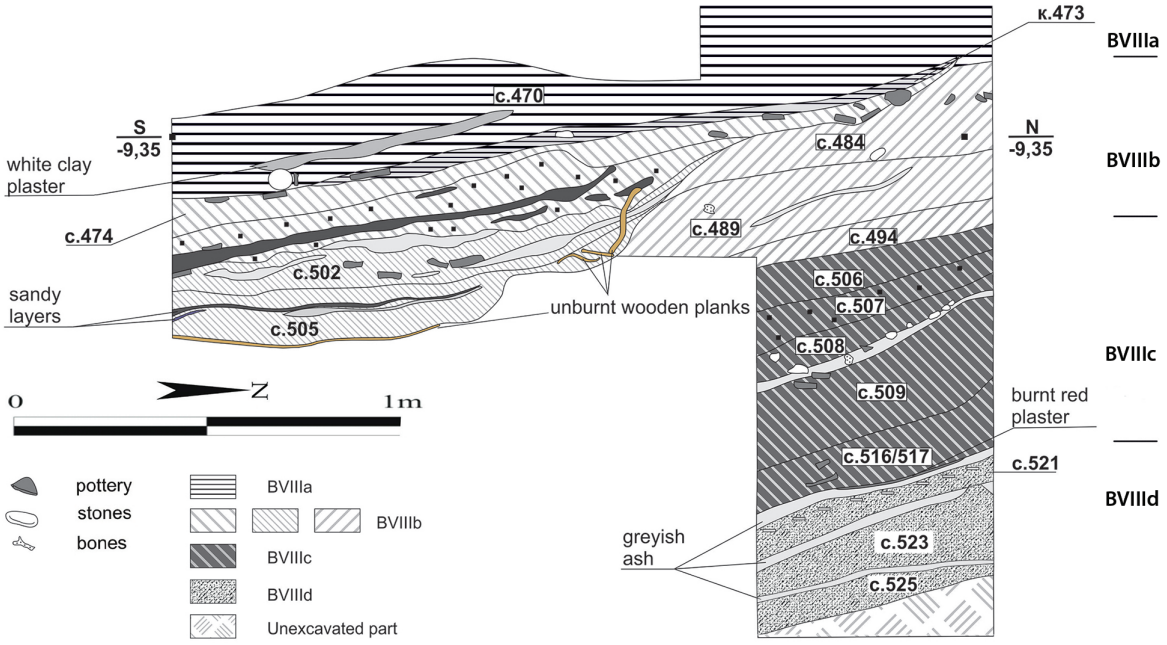


Fig. 10. Tell Yunatsite. Sq. M2-M3: profile of the test trench in the eastern periphery of the tell (graphic by S. Ivanov).

The highest point of the Chalcolithic layer in this part of the tell is defined by the burnt debris of building BI-2 from level BI (in sq. Л-К/5-4) and was measured at –5.25/–5.35m (below the highest point of the tell). The lowest depth reached in the test-trench is –10.72m, proving a thickness of at least 5.20m for the Chalcolithic layers. The sterile soil has not been reached and at least 11 building levels were identified.

Relative chronology of the Chalcolithic building levels

The main material to build up a relative chronology of the Chalcolithic building levels is ceramic. Unfortunately, the assemblage of the levels below BV is very scanty, as they have been excavated over a very small area. In the analysis of the pottery style of Yunatsite, a general conservatism can be observed resulting in the long, continuous existence of distinct shapes, decoration styles and motifs.

Building levels BVIIId – BVI

The ceramic assemblage from levels BVIIId-BVI is too scanty for detailed analysis and conclusions. It may be generally related to the Early Chalcolithic, Maritsa culture. Only the pottery associated with the platform of unburnt wooden planks and ovens in sq. M5, which was stratigraphically assigned to level BVI, was more numerous. It carries some typical features of phase III of the Maritsa culture.

Building level BV

The assemblage from level BV fits well with the characteristics of phase III of the Maritsa culture (*i.e.* the end of the Early Chalcolithic), as defined by Henrieta Todorova (*1986.101*). Among the typical shapes are dishes with slightly inward-curved rims and graphite decoration on both sides, S-shaped dishes and bowls and lily-shaped dishes. The latter two types are usually painted with graphite on both sides. Dishes with incisions on the rim have also been found. Bowls and jars are predominantly represented with rounded shapes. The common decoration techniques are graphite painting (usually covering large parts of the vessels or even their entire surface) and incised decoration. The so-called 'ladder-like' incised ornament is attested.

Building level BIV

The pottery from level BIV is quite scanty (less numerous than the collection from BV), and few shapes could be distinguished reliably. In general, the assemblage shares many of the typical characteristics of level BV. Simple conical dishes and dishes with inward-curved rims dominate. The latter are usually decorated with graphite on both sides. Bowls and jars are predominantly preserved with rounded shapes, sometimes with abundant graphite decoration. Fragments of three-partite bowls with an outlined middle part were also attested, and their upper part is decorated with graphite. This shape developed further in the Late Chalcolithic. A few sherds of jugs with vertical handles and graphite paint were found. One fragment of a jug with a horizontal handle on the neck is documented. Among the decorated fragments, graphite paint dominates. It seems that it covered a large part of the vessels and both sides of dishes and bowls. Incised decoration is less frequent and usually found on sherds of storage vessels.

The specifics of this assemblage suggest its dating to the transition from the Early to Late Chalcolithic, or to the so-called Middle Chalcolithic (phase IV of the Maritsa culture).

The most interesting find from level BIV is a small golden bead. It can be related to the earliest golden artifacts known worldwide – beads from the burials of Varna II and the cemetery of Durankulak (*Todorova, Vaisov 2001.13*). They are assigned to the Middle Chalcolithic as well.

Building level BIII

The ceramic assemblage from level BIII (mainly building BIII-1) shows continuity with the pottery from the lower levels. Some typical characteristics from levels BIV and BV are still present in the collection: dishes with inward-curved rims and rounded bowls, rich graphite decoration, incised decoration, as well as most of the motifs. New shapes that are considered typical for the Late Chalcolithic appear: biconical bowls with carination, dishes with an inverted rim or with an inward thickened rim. Shell impressions are also attested.

Additionally, a few flat bone figurines were found in building BIII-1 (*Boyadzhiev* et al. *2017.112, obr. 2*). In general, the earliest known figurines of this kind appeared in the Middle Chalcolithic, but their large-scale distribution is assigned to the Late Chalcolithic (*Boyadzhiev 2007.89–91*).

Building level BII

The pottery assemblage of level BII resembles the characteristics of a 'developed' Late Chalcolithic or phase II of the Karanovo VI horizon. Biconical bowls are more abundant. New shapes appeared and de-

veloped in level BI: 'elaborate' bowls and amphora-like vessels. Shell impressions are used more widely. Graphite painting was still the most common decoration technique and covered a large part of the vessels and the inner surfaces of some types of dishes. In the case of bowls, the decoration is now reduced only to their upper surface.

A golden 'ring-shaped idol' was found in building BII-21.

Building level BI

The ceramic assemblage from the last Chalcolithic habitation layer at Tell Yunatsite includes a large number of complete or restored vessels, which have already been published (*Mazanova 1992; Todorova, Mazanova 2000; Todorova 2003*). The specific characteristics of this complex include new forms, such as biconical cups with two vertical handles and new decoration techniques, such as the use of red[4] and yellow paste or high percentages of positive graphite decoration, which find analogies in the Krivodol culture and indicate contacts to the west (*Mazanova 1992; Todorova, Mazanova 2000.338–341; Todorova 2003.307*).

More than 20 copper artifacts have been found, including two hammer-axes of the Pločnik type (*Mazanova 2004*; new finds from the recent excavations).

Building level BI is dated to the final phase (III) of the Karanovo VI culture. It was destroyed by an enemy attack, the inhabitants were killed, and the buildings were burnt down.

After this event, the tell was abandoned for at least 1000 years. During this long period a hiatus layer accumulated. Due to a tilt of the surface to the south as well as the remains of the Chalcolithic fortification wall, which stopped the erosion of the sediment, this layer is best attested in the southern periphery of the tell, where it is up to 0.40m thick.

Modelling of the radiocarbon dates

To achieve greater precision compared to single measurements, the available stratigraphic information was employed to model the new set of radiocarbon dates. These models were analysed using 'Gaussian Monte Carlo Wiggle Matching' (GMCWM) and Bayesian Sequencing. Both approaches were performed, analysed and compared.

Selection of the radiocarbon samples

The material for radiocarbon measurements was carefully selected in 2018 from reliable contexts excavated between 2014 and 2018 (Tab. 2, see Appendix). The material from building levels BII to BVI was excavated by context over a large surface area. Material from BVII to BVIIId was selected from the small test-trench in sq. M2-M3, where the depositional processes were harder to observe. Samples visibly affected by bioturbation were excluded. Only short-lived plant material and animal bones were considered suitable for measurements. The species of the bone samples were determined, and where possible bones from herbivores were chosen. In some rare cases a determination was not possible or omnivores, mostly pigs, had to be picked.

The quality of the samples from different building levels varied enormously. No new measurements have been made for level BI, since there are already reliable dates available from short-lived materials (Tab. 1, see Appendix) (*Boyadzhiev, Aslanis 2016; Mathieson* et al. *2018*). Three samples from human bones and teeth (Ly-5999/SacA-15568, MAMS-28134, MAMS-28135), as well as one sample from charred grain (Ly-5997/SacA-15566), were included. There are some charcoal samples from BI that fit well with the other samples, but they were excluded from the analysis to reduce further uncertainty, especially since these samples define the end of the Chalcolithic habitation at the site.

The samples from level BII seem to be reliable and fit well between BI and BIII. They include samples made of charred lentils (Poz-109086) and cattle bones (Poz-108890; Poz-108910).

There is only one sample (Poz-109084) from level BIII. It was measured from charred grain found in the destruction of house BIII-1. Even if the unmodelled date seems rather late, it should be considered as reliable given the clear context and material. Due to the character of the highly burned debris of the houses from level BIII, no collagen could be extracted from any other bone sample.

The sample Poz-108883 was taken from a concentration of bones covering building BV-1. Since there were no other bones from reliable contexts from the wider excavations recorded, the samples Poz-108886 and Poz-115801 were measured from animal bones taken from the heavy fraction of the flotation of a

4 However, the use of red paint is attested in the lower levels as well.

floor layer covering the house BIV-2. These samples are less reliable.

The sample Poz-115802 was found under the debris of building BV-1 and is the only sample from level BV. The debris of buildings BV-1 and BV-2 was heavily burned and no collagen could be extracted for further measurements. Compared with the age of the samples Poz-109084 (debris of BIII-1) and Poz-108883 (reliable context covering BV-1) the unmodelled date might seem too young. In the future further measurements should be done for this building level.

The sample Poz-115803 was collected from a layer covering the wooden planks assigned to level BVI. This area was left open in the building levels BV and BVI and the sample was assigned to level BVI. A second sample Poz-108907 was taken from a concentration of bones covering the uppermost plaster of a sequence of 14 plasters belonging to the building BVI-1, which was partly covered by a floor of the building BV-1.

The samples from the levels BVII to BVIIId were obtained from the small test-trench in squares M2/M3. The size of the trench was about 1m^2, which made observations limited. Samples were taken from layers that were interpreted as floors. Further excavations over a larger surface area will clarify these preliminary observations.

Lab Code	BP date	Phase	unmodelled date cal BC (2σ)	modelled date cal BC
Ly-5997/SacA-15566	5560 ± 30	I	4399 ± 53	4395 ± 19
Ly-5999/SacA-15568	5560 ± 45	I	4415 ± 79	4403 ± 18
MAMS-28135	5578 ± 23	I	4403 ± 49	4411 ± 16
MAMS-28134	5632 ± 24	I	4452 ± 85	4419 ± 15
Poz-109086	5590 ± 40	II	4423 ± 76	4427 ± 13
Poz-108890	5620 ± 40	II	4448 ± 89	4438 ± 12
Poz-108910	5660 ± 40	II	4485 ± 119	4449 ± 10
Poz-109084	5730 ± 40	III	4573 ± 115	4460 ± 8
Poz-115801	5730 ± 40	IV	4573 ± 115	4492 ± 4
Poz-108886	5630 ± 40	IV	4451 ± 90	4502 ± 4
Poz-108883	5710 ± 40	IV	4566 ± 113	4513 ± 4
Poz-115802	5700 ± 40	V	4564 ± 115	4524 ± 6
Poz-108907	5630 ± 40	VI	4451 ± 90	4556 ± 10
Poz-115803	5690 ± 40	VI	4542 ± 135	4572 ± 13
Poz-108905	5680 ± 30	VII	4527 ± 80	4588 ± 15
Poz-108908	5740 ± 40	VIIIa	4581 ± 120	4620 ± 21
Poz-108888	5780 ± 40	VIIIb	4614 ± 109	4652 ± 27
Poz-108906	5810 ± 40	VIIIc	4665 ± 118	4684 ± 32
Poz-108889	5810 ± 40	VIIIc	4665 ± 118	4700 ± 35
Poz-108909	5860 ± 40	VIIId	4723 ± 113	4716 ± 38

Tab. 3. Results of the GMCWM model 01 for the Chalcolithic layers of Tell Yunatsite.

Gaussian Monte Carlo Wiggle Matching (GMCWM)

The methodology of wiggle matching was first applied by Charles W. Ferguson, Bruno Huber and Hans E. Suess (*1966*). Gordon W. Pearson (*1986*) described it first in mathematical detail, while Bernhard Weninger (*1986*) used it for sequenced archaeological data. A detailed comparison of wiggle matching methods was published by Christopher Bronk Ramsey *et al.* (*2001*). The GMCWM approach used in this article is an extension to the Wiggle Matching method and was outlined by Weninger (1997) and Reinhard Jung (*Weninger, Jung 2009*) to refine the method and widen its possible use. It is integrated in the program CalPal (*Weninger, Jöris 2008*).

In principle the method is using χ^2-tests to match the best-fit between two datasets (the calibration curve data and the archaeological test sample) performing an optional number of runs. To achieve this, an equidistant model, a model with fixed distances between the samples, is needed. The method was specially designed for archaeological applications and is explained in detail by Weninger (*Horejs, Weninger 2016.135*). The aim of this approach is to identify the overall best-fitting archaeological timespan for the series of radiocarbon dates.

The technical parameters for each model used in this study were the same. Each Wiggle Matching run was performed 1000 times, each time only storing the result of the best fit of 50 replications, where phase-internal changes of the position of the single radiocarbon dates were allowed. Offsets of the calibration curve and a measurement error of the BP-date were included in the modelling by applying Gaussian variability of ±10 years for both parameters. The data fitting was performed using the 'non central Chi-squared' method, described in (*Krauß* et al. *2017.294*). All age-calibrations and analyses employed the presently recommended IntCal20 data (*Reimer* et al. *2020*).

GMCWM model 01

All Chalcolithic contexts exposed by the end of 2018 were grouped into 11 phases (BI–BVII; BVIIIa–d) according to their stratigraphic position and assigned building level. The 16 new ^{14}C-samples were assigned to these

phases. Additionally, four samples from short-lived material (Ly-5997/SacA-15566, Ly-5999/SacA-15568, MAMS-28134, MAMS-28135) from the uppermost building level (BI) were integrated in the models (*Boyadzhiev, Aslanis 2016; Mathieson* et al. *2018*). For statistical analyses, an equidistant model was used, which assumed phases with an equidistant length independent from the thickness of the layers or the recorded absolute depth of the sample. The levels BI-BVII and BVIIIa-BVIIId were treated equally and it was assumed that they cover the same duration of time. Based on the hypothesis of 11 equidistant phases, GMCWM was performed. Three dates were sorted out according to low collagen (Poz-109419) or because they were obviously too old and dislocated (Poz-108885, Poz-108887).

Based on these assumptions the analysis was performed (Fig. 11, Tab. 3). The 11 phases cover the timespan between 4750 and 4375 cal BC, with an approximate duration of 32 years per phase. Especially at the beginning and the end of the habitation, the dates fit quite well with the calibration curve.

Bayesian Sequence model 01

Bayesian chronological modelling (*Buck* et al. *1996*) has become a standard tool for analysing radiocarbon samples from archaeological sequences (*Bayliss 2009; 2015; Hamilton, Krus 2018*). The Bayesian chronological model was calculated using the program OxCal, version 4.4 (*Bronk Ramsey 2009a*) and the integrated IntCal20 calibration curve (*Reimer* et al. *2020*).

The same assumptions used for GMCWM model 01 were applied to the Bayesian sequence model (Fig. 12). The 20 radiocarbon dates were grouped into 11 phases and separated by boundaries. Some of the building levels had been exposed to fire and therefore some bone samples containing lower amounts of collagen had to be included. Samples below 1% of collagen have been omitted (Poz-109419). To accom-

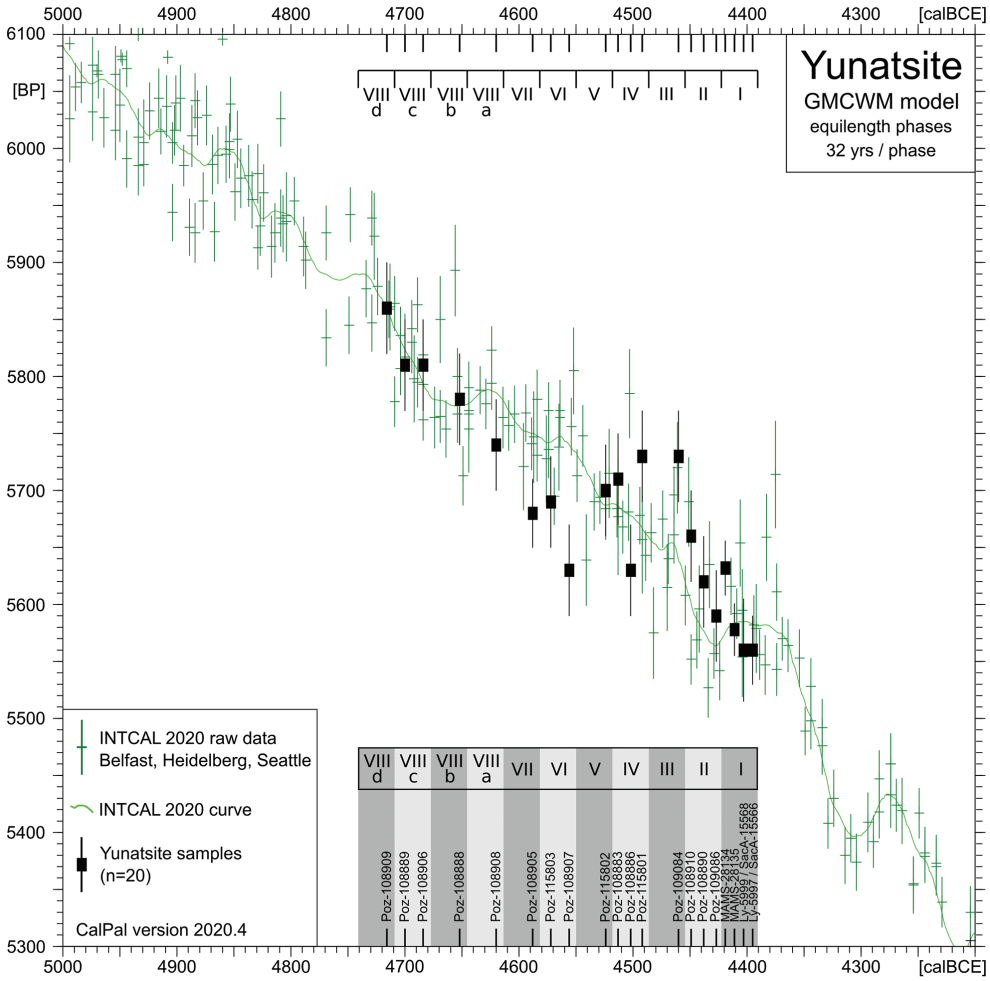


Fig. 11. GMCWM model 01 for the Chalcolithic layers of Tell Yunatsite (Gaussian Monte Carlo Wiggle Matching, using the program CalPal 2020.4 (*Weninger, Jöris 2008*) on the IntCal20 calibration curve (*Reimer *et al.* 2020*).

modate the different amounts of collagen and therefore the different reliability of the sample an r-type Outlier model has been included in the sequence (*Bronk Ramsey 2009b.1038*). The prior probabilities that bone samples with a lower amount of collagen are misleading were set according to the study from Meadows *et al.* (*2019.1660–1662, Tab. 4*), which was performed using samples with low collagen preservation, mostly measured in Poznan. Prior probabilities for collagen yield between 1–2% were set to 0.4, for 2–3% collagen to 0.2 and for >3% collagen to 0.1. Prior probabilities were not applied to the samples from short-lived plant remains. The model has an overall agreement of A=93.4,

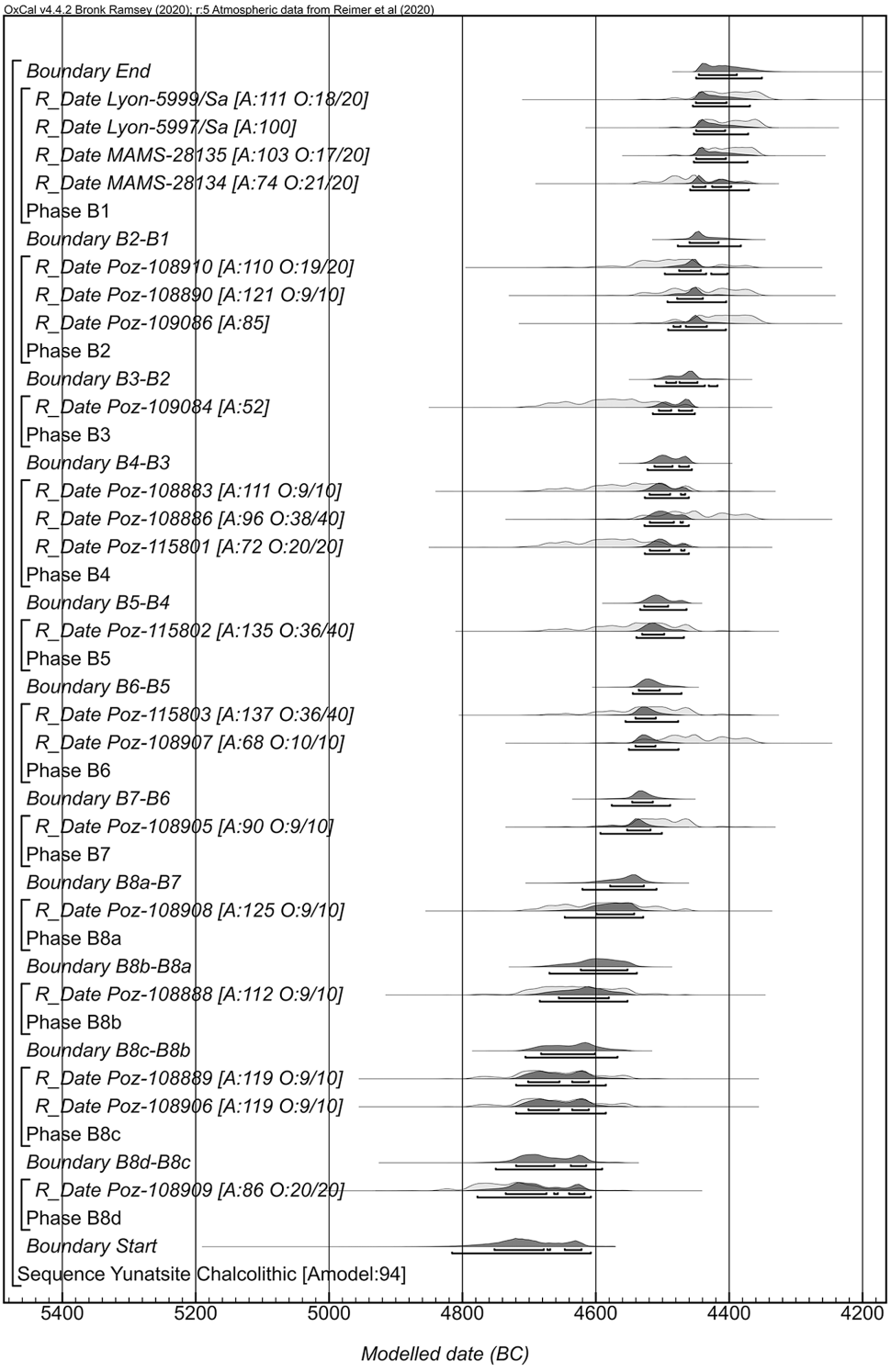


Fig. 12. Bayesian Sequence and Outlier model for the Chalcolithic layers of Tell Yunatsite (using the program Oxcal 4.4 (*Bronk Ramsey 2009a*) on the IntCal20 calibration curve (*Reimer *et al.* 2020*)).

which is robust. Only one probe failed the needed agreement of A=60: Poz-109084 (A=51.5) from building level BIII. This sample was assigned as reliable and the rejection might be caused by possibly relocated or contaminated samples, like Poz-108886 and Poz-108907. Considering the massive cuts und remodelling events at the site, and the layout of the model without any specific filtering or exclusion of radiocarbon dates, the results are good.

GMCWM model 02

Based on the radiocarbon data from level BVI-BVIIId and typological observations at different Chalcolithic sites in Thrace, one can assume a model with a length of 60 years per phase. This hypothesis (Fig. 13) has been tested by fixing the timespan of every building level to 60 years and modelling it for the best fit. Due to the higher number of dates from layer BI–BIV the model matches best with the younger samples of the data series (level BI–BII), while being unable to match the earlier dates with the calibration curve.

GMCWM model 03

As mentioned before there were problems regarding the low collagen preservation of some bones from burned structures. In particular, building BV-2 and the bones from level BV were affected. Additionally, the samples from BIV and BVI were less reliable and material of lower quality had to be chosen for dating. This is visible in the longer timespan of the samples from these levels as well as in the summed probability chart (Fig. 14).

To understand the different bias of the series of dates and deal with the problem of the distribution of the samples in the Middle and Late Chalcolithic, an additional model was carried out. The dates were grouped in two different series. The first includes all samples from levels BVI–BVIII(a-d), which refer to the Early Chalcolithic (based on pottery styles). The dates from this period from other tell-sites in Bulgaria correspond well to the calibration curve. The second series with all the samples from the levels BI-BV covers the Middle and Late Chalcolithic sequence. In other sites from these periods in Bulgaria a discrepancy between archaeological data (stratigraphic sequence and relative chronology) and the radiocarbon dates has been observed. The samples in the second series were attained from the excavations in the larger area (squares M-O 5-7), and those in the first were mainly sampled from the small test-trench in squares M2/3. Both series were modelled independently using an approach with equidistant phases. The results were plotted in one graph (Fig. 15.a-b) and compared.

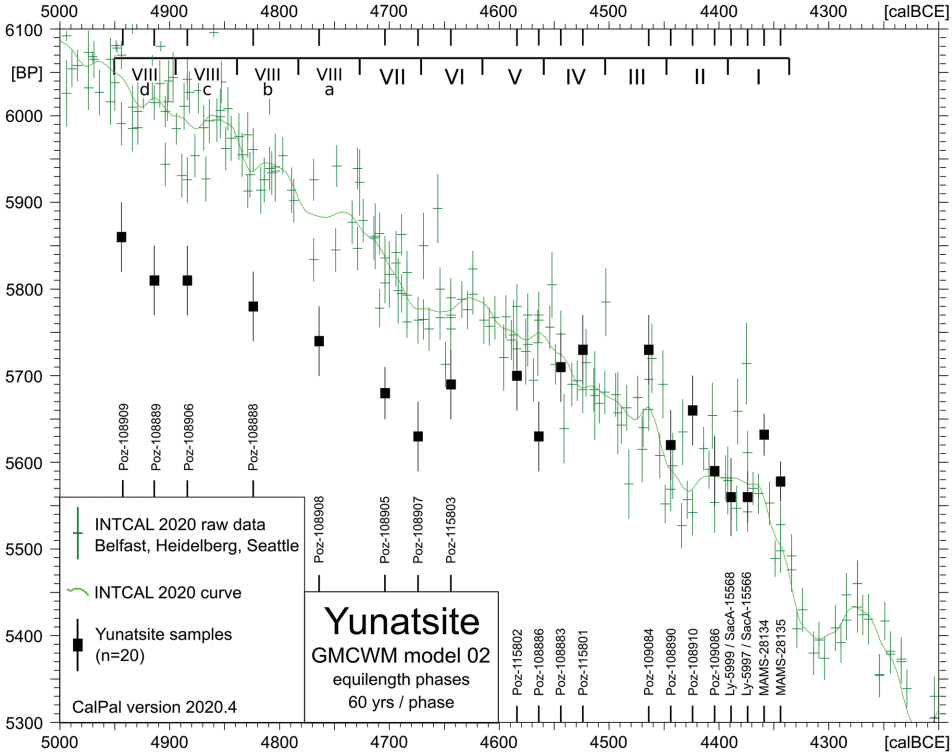


Fig. 13. GMCWM model 02 for the Chalcolithic layers of the site Yunatsite (Gaussian Monte Carlo Wiggle Matching, using the program CalPal 2020.4 (*Weninger, Jöris 2008*) on the IntCal20 calibration curve (*Reimer *et al.* 2020*).

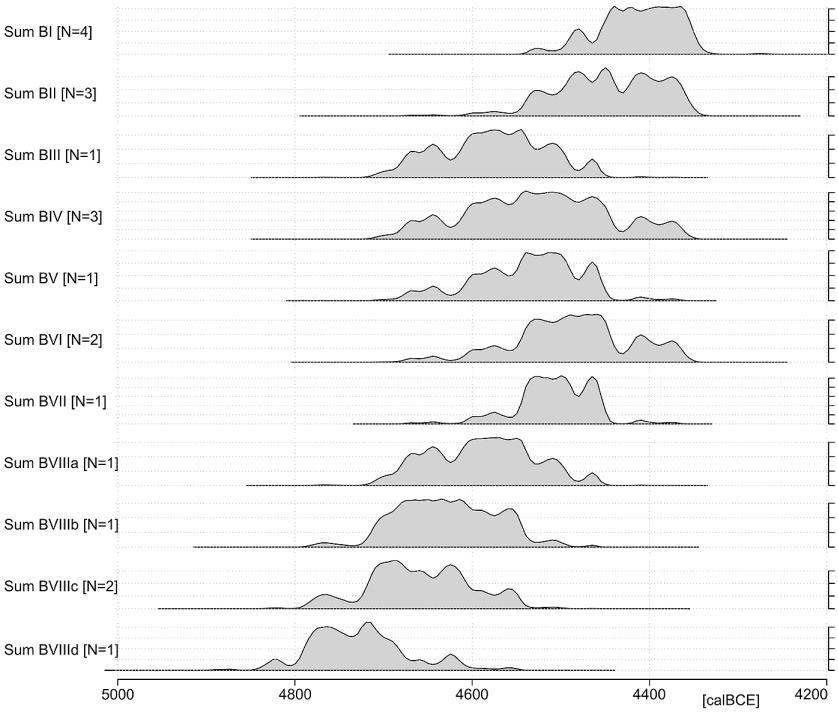


Fig. 14. Chart of summed probability distributions for each phase (using the package oxcAAR in R (*Hinz *et al.* 2018*; R Core Team 2020*), OxCal 4.4 (*Bronk Ramsey 2009*) on the IntCal20 calibration curve (*Reimer *et al.* 2020*).

While modelling the set from the levels BVI–BVIIId showed a clear result of 50 years/phase (Fig. 15.a-b – black), the results from the levels BI–BV were blurry and differed in length between 14 years/phase (Model 03a – Fig. 15.a) and 78 years/phase (Model 03b – Fig. 15.b). Both results seemed unreasonable but lack better alternatives. The single radiocarbon measurements used for modelling are located in a plateau of the calibration curve and have standard deviations between 150 and 230 years.

The duration of the two independent models resample the picture from GMCWM model 01, where the samples from levels BI/BII and BVII/VIII mark the beginning and end of the habitation. The samples from the levels in-between are overlaying due to the layout of the calibration curve.

Discussion and conclusions

These models provoke different conclusions and interpretations. Considering the complicated formation of layers at Tell Yunatsite, as well as the challenging preservation, the results are better than expected. While summed distributions for the different levels present unrealistic long durations (Fig. 14), modelling this data strictly according to stratigraphic deposition provides a solid model for the habitation of the site. Still these results should be treated as preliminary, as future excavations surely will provide more dates, especially for the early levels. Based on the initial assumptions, different chronological trajectories can be made.

Using the current IntCal20 calibration curve, GMCWM model 01 (Fig. 11) would be the best fit. The beginning and end of the series of radiocarbon dates of the Chalcolithic habitation at Tell Yunatsite are at 4750 and 4375 cal BC, respectively. The difficult depositional processes at a tell settlement as well as the general nature of a radiocarbon date are visible in the distribution of the single dates plotted on the calibration curve. Modelling the dates in phases using their stratigraphic information provides a solid way to deal with this data.

This hypothesis was also tested by applying a Bayesian chronological outlier model (Fig. 12) using the stratigraphic sequence. Even without filtering less reliable samples the model agreement is Amodel= 93.4 and solid.

The model suggests an overall chronological duration of 375 years and an average timespan of 32 years/phase (considering 11 building levels or consecutive settlements). These results are in line with published durations of building levels from other tells in the region: Uivar (10–50 years/phase) (*Drașovean* et al. *2017.643, Fig. 7*), Vinča (from a few up to 50 years/phase) (*Tasić* et al. *2016.823, Fig. 14*), Pietrele (40–50 years/phase) (*Reingruber, Rassamakin 2016.281, Fig. 5*), Okolište (30 years/phase) (*Hofmann 2013.473*) or Karanovo (35–40 years/phase) (*Reingruber, Thissen online*). However, such a timespan can be viewed as too short considering some archaeological data from Yunatsite and other Chalcolithic tell-sites in Bulgaria.

First, the correlation of ^{14}C dates series from Early Neolithic multilayered sites with the calibration curve shows average timespans for Early Neolithic building levels (settlements) of about 60–70 years

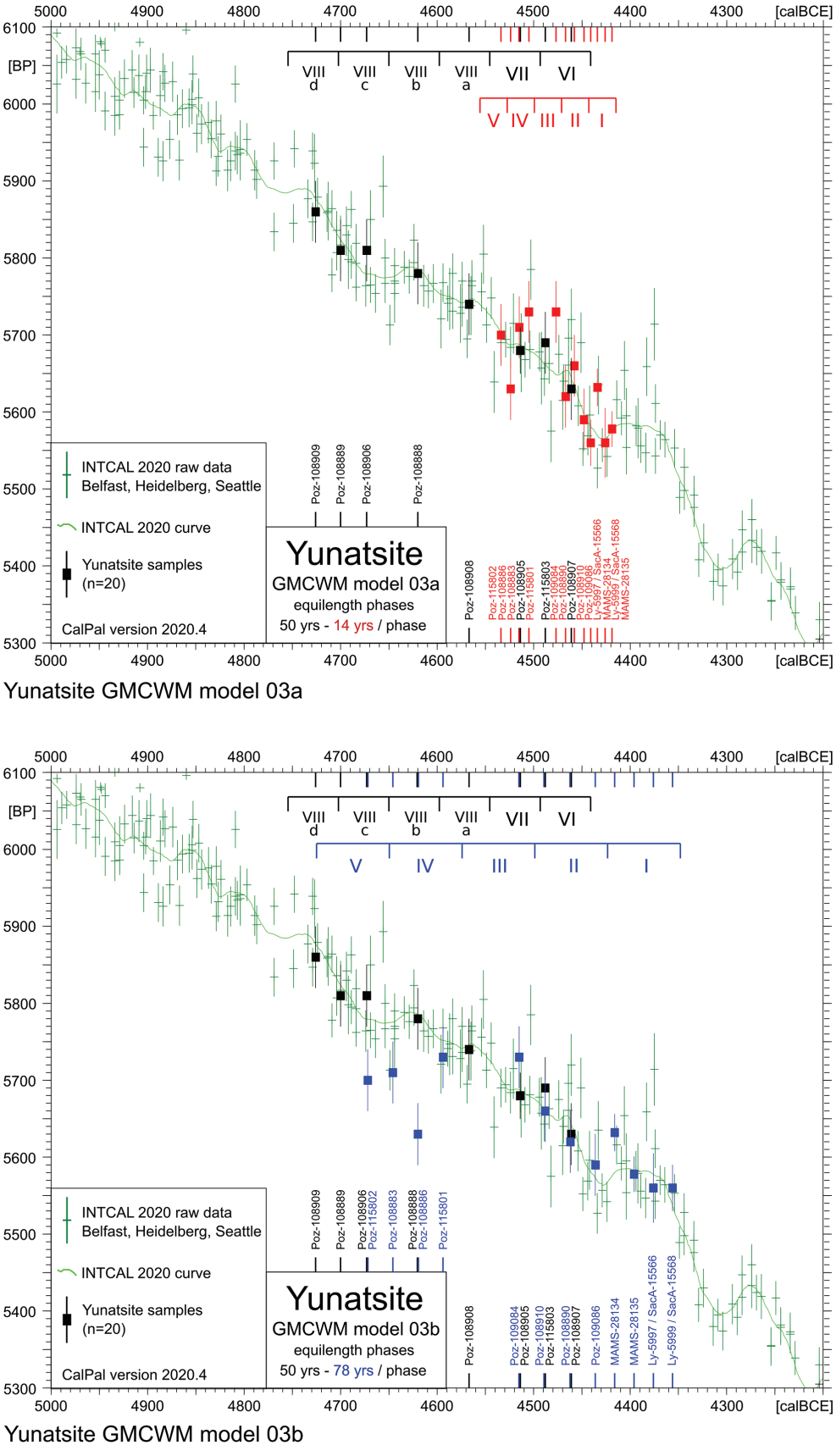


Fig. 15. GMCWM model 03a/b for the Chalcolithic layers of Tell Yunatsite (Gaussian Monte Carlo Wiggle Matching using the program CalPal 2020.4 (*Weninger, Jöris 2008*) on the IntCal20 calibration curve (*Reimer *et al.* 2020*).

(*Boyadzhiev 1995; Gösdorf, Weninger 1992*). The construction of the buildings, as well as the average thickness of the building's levels, are similar or identical in the Neolithic and Chalcolithic times. We may thus assume that the average timespan of a Neolithic building level was similar to that of a Chalcolithic one.

Second, if we accept this chronological frame for the Chalcolithic levels at Tell Yunatsite we face a large disproportion between the duration of the entire Late Chalcolithic (about 100–120 years, similar situation is attested in Thrace and Northeast Bulgaria) and the final phase of the Chalcolithic. The latter is represented by a small number of thin-layered (one or two building levels) settlements, mainly in Western Bulgaria and the Rhodope mountains. In such a scenario these sites would cover a period of 600 years (4400/4350–3800/ 3750 cal BC; *Boyadzhiev 2015*).

Another option would be to question the layout of the current calibration curve for the period between 4600/4550–4100/4000 cal BC in the region, which is archaeologically identified as the Late Chalcolithic in Bulgaria. For this case, the GMCWM model 02 was designed, which tries to find the best fit on the calibration curve and the test data, accepting a duration of 60 years/phase or 660 years of duration. As discussed above, a time-span of 60 years/phase was chosen based on the durations of multi-layered Neolithic settlements.

This model (Fig. 13) shows considerable deviation between the dates from the early building levels (VIIId to VI) and the calibration curve and fit at the end of the Chalcolithic habitation at the site. The result can be explained by the higher number of dates for the younger levels, which ties the whole series to this part of the calibration curve. The obvious deviation between the calibration curve and the earlier Chalcolithic dates must lead to a rejection of this model.

The third model (GMCWM model 03a-b; Fig. 15) consists of two independently modelled data series: the dates from the Early Chalcolithic (levels BVIIIa-d to BVI) and the dates from the end of the Early, the Middle and the Late Chalcolithic (levels BV-BI). The series from the early levels (BVIIId – BVI) fits very well with the calibration curve in the period between 4725 and 4460 cal BC. The dates from levels BV-BII fit to the calibration curve in the period 4550–4420 cal BC (model 3a; Fig. 15.a) or the period 4680–4350 cal BC (model 3b; Fig. 15.b), but largely coincide with the earlier series. Only the samples from the final phase at Yunatsite (level BI) are later than those from BVI. This situation corresponds well to the ^{14}C series from other Chalcolithic tell sites in Bulgaria: the Early Chalcolithic dates fit well with the calibration curve, but 'drop back' towards the end of the period, leading to overlapping dates between the Early and Late Chalcolithic data series (*Boyadzhiev 1988; 1995.167–173, 182–185; Görsdorf, Bojadžiev 1996.144– 152*).

As described by Yavor Boyadzhiev and Ioanis Aslanis (*Boyadzhiev, Aslanis 2016.165*), the deviation of dates from the Middle and Late Chalcolithic in Bulgaria from the calibration curves may possibly be caused by a local anomaly in the concentration of ^{14}C in the atmosphere. The presence of such an anomaly, as well as its territorial and chronological span, may be ascertained (or not) with series of dates from consecutive levels in multilayered sites, covering all stages of the Chalcolithic period, *i.e.* Maritsa I-IV and Karanovo VI in Thrace and synchronous groups in the neighbouring regions. This phenomenon is not fully understood yet and needs more analyses. The sequence from Yunatsite is hopefully viewed as a reason to intensify this research.

The results from the models draw very different conclusions for the absolute duration of the different building levels of the site Yunatsite, but also show the potential of a dating strategy combining detailed excavations by context and dating of stratified short-lived material. Especially the multilayered tells in the Balkans provide good grounds for modelling approaches using Gaussian Monte Carlo Wiggle Matching and Bayesian statistics.

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Appendix

Tab. 1. List of radiocarbon dates for Tell Yunatsite (*Görsdorf, Boyadzhiev 1996; Boyadzhiev 2015; Boyadzhiev, Aslanis 2016; Mathieson *et al.* 2018*).

Lab.-No.	BP_Date	cal BC (1σ)	cal BC (2σ)	Material	Building level	Context	Literature
ИГАН-2802	6050±140	5207–4792	5311–4616	charcoal	EC – final	central profile 8.55-8.59m	*Boyadzhiev 2015*
ИГАН-2801	5890±90	4898–4616	4992–4543	charcoal	LC – BIII	central profile 7.08-7.40m	*Boyadzhiev 2015*
ИГАН-2800	5460±170	4455–4054	4696–3955	charcoal	LC – BI	central profile 5.37-5.41m building 12	*Boyadzhiev 2015*
ИГАН-2796	5650±90	4583–4362	4700–4342	decayed wood	LC – BI	central profile 5.30m; building 12	*Boyadzhiev 2015*
ИГАН-2797	5560±70	4455–4341	4545–4258	decayed wood	LC – BI	central profile 5.52m; building 12	*Boyadzhiev 2015*
ИГАН-2793	5410±70	4345–4076	4361–4049	decayed wood	LC – BI	central profile 5.45m; building 12	*Boyadzhiev 2015*
ИГАН-2943	5520±160	4546–4071	4712–3991	bone	LC – BI	skeleton 66	*Boyadzhiev 2015*
ИГАН-2944	5380±130	4341–4052	4493–3952	bone	LC – BI	skeleton 72	*Boyadzhiev 2015*
Ly-14792	5610±40	4488–4365	4536–4354	charcoal	LC – BI	T6 – occupation level close to outer wall	*Boyadzhiev, Aslanis 2016*
Ly-14793	5515±35	4442–4333	4446–4271	big charcoal	LC – BI	F9 – pit next to platform	*Boyadzhiev, Aslanis 2016*
Ly-14794	5725±40	4650–4499	4685–4457	big charcoal	LC – BI	S6–occupation level close to outer wall	*Boyadzhiev, Aslanis 2016*
Ly-5996/ SacA-15565	5630±30	4498–4371	4537–4365	small charcoal	LC – BI	beginning of burnt daub	*Boyadzhiev Aslanis 2016*
Ly-5997/ SacA-15566	5560±30	4443–4355	4451–4346	grains	LC – BI	top part of burnt daub	*Boyadzhiev, Aslanis 2016*
Ly-5998 SacA-15567	5585±35	4448–4364	4493–4348	charcoal	LC – BI	E8 – northern part of the tell	*Boyadzhiev, Aslanis 2016*
Ly-5999 SacA-15568	5560±45	4445–4353	4493–4336	bone and teeth	LC – BI	skeleton 82–on top of burnt daub	*Boyadzhiev, Aslanis 2016*
MAMS-28134	5632±24	4499–4401	4537–4367	bone	LC – BI	skeleton 78–I0781	*Mathieson* et al. *2018*
MAMS-28135	5578±23	4446–4363	4451–4354	tooth	LC – BI	skeleton 99–I0785	*Mathieson* et al *2018*
Poz-108890	5620±40	4493–4368	4537–4359	animal bone	LC – BII	P5–feature 222–structure B2-21	this study
Poz-109086	5590±40	4451–4362	4498–4347	seeds	LC – BII	O4–feature 385–structure B2-21	this study
Poz-108910	5660±40	4539–4451	4603–4366	animal bone	LC – BII	O7–feature 48–on top of structure B3-1	this study
Poz-109084	5730±40	4654–4501	4688–4458	seeds	LC – BIII	O7–feature 90–structure B3-1	this study
Poz-108885	6130±40	5207–4996	5210–4952	animal bone	LC – BIII	N6–feature 278–under structure B3-1	this study
Poz-108886	5630±40	4500–4369	4541–4361	animal bone	LC – BIV	M7–feature 230–on top of structure B4-2–flotation	this study
Poz-115801	5730±40	4654–4501	4688–4458	animal bone	LC – BIV	M7–feature 225–on top of structure B4-2–flotation	this study
Poz-109419	5460±50	4353–4254	4445–4170	animal bone	LC – BV	M6–feature 35–structure B5-2–poor collagen	this study
Poz-115803	5690±40	4581–4455	4676–4407	animal bone	LC – BVI	M5–feature 118–on top of wooden planks	this study
Poz-108883	5710±40	4606–4463	4678–4453	animal bone	LC – BIV	M3–feature 348–on top structure B5-1	this study
Poz-115802	5700±40	4596–4458	4678–4449	animal bone	LC – BV	L3–feature 396–structure B5-1	this study
Poz-108907	5630±40	4500–4369	4541–4361	animal bone	LC – BVI	M3–feature 439–8.18m	this study
Poz-108905	5680±30	4542–4458	4606–4447	animal bone	LC – BVII	M3–feature 450–9.07m	this study

Lab.-No.	BP_Date	cal BC (1σ)	cal BC (2σ)	Material	Building level	Context	Literature
Poz-108908	5740±40	4676–4538	4700–4461	animal bone	LC – BVIIIa	M3–feature 474–9.45m	this study
Poz-108888	5780±40	4691–4554	4723–4505	animal bone	LC – BVIIIb	M3–feature 484–9.37m	this study
Poz-108906	5810±40	4718–4609	4783–4547	animal bone	LC – BVIIIc	M2–feature 505–9.67m	this study
Poz-108889	5810±40	4718–4609	4783–4547	animal bone	LC – BVIIIc	M2–feature 518–10.4m	this study
Poz-108909	5860±40	4787–4694	4836–4610	animal bone	LC – BVIIId	M3–feature 521–10.4m	this study
Poz-108887	6200±40	5213–5066	5300–5032	animal bone	LC – BVIIId	M2–feature 523–10.32m	this study
ИГАН-2794	4380±70	3259–2904	3333–2889	charcoal	BA – XVII/XVI	central profile – 5.00m	*Boyadzhiev 2015*
ИГАН-2795	4090±60	2851–2501	2872–2476	charcoal	BA – XVII/ XVI–XV	central profile – 5.00m	*Boyadzhiev 2015*
Ly-14795	4280±40	2925–2876	3016–2707	grains+ chaff	BA – XV	K7–8 – building 34 – 4.64m	*Boyadzhiev, Aslanis 2016*
Bln-3677	4080±70	2852–2495	2873–2471	grains	BA – XV	building 34	*Görsdorf, Boyadzhiev 1996*
Bln-3678	4050±50	2661–2475	2858–2466	grains	BA – XV	building 34	″
Bln-3675	4280±60	3011–2778	3091–2671	grains	BA – XV	building 31	″
Bln-3676	4030±70	2836–2466	2868–2348	grains	BA – XV	building 31	″
Bln-3672	4040±50	2623–2475	2857–2462	charcoal	BA – XIII	building 22	″
Bln-3672A	4040±50	2623–2475	2857–2462	charcoal	BA – XIII	building 22	″
Bln-3671	4180±50	2882–2675	2896–2586	grains	BA – XIII	building 22	″
Bln-3673	3990±60	2620–2357	2842–2296	grains	BA – XIII	building 20	″
Bln-3674	4020±60	2626–2466	2858–2347	grains	BA – XIII	building 20	″
Bln-3670	3990±50	2576–2462	2828–2307	peas	BA – XI	square C 7/C 8 – building 11	″
Bln-3679	4000±70	2629–2352	2857–2294	peas	BA – XI	C 7/C 8 – building 11	″
Bln-3668	3830±60	2435–2151	2466–2066	lentils	BA – X	C 8–building 10	″
Bln-3669	4090±50	2849–2503	2872–2489	grains	BA – X	U 8	″
ИГАН-2799	4070±150	2874–2467	3011–2150	charcoal	BA – X–IX	central profile – 3.30–3.60m	*Boyadzhiev 2015*
Bln-3665	4100±50	2851–2575	2874–2494	wood	BA – IX	P 7	*Görsdorf, Boyadzhiev 1996*
Bln-3666	4070±60	2847–2492	2868–2470	grains	BA – IX	K 8	″
Bln-3667	4050±50	2661–2475	2858–2466	charcoal	BA – IX	L 9	″
ИГАН-2798	4180±250	3283–2352	3508–2047	charcoal	BA – IX–VIII	central profile – 3.30m	*Boyadzhiev 2015*
Bln-3663	4100±50	2851–2575	2874–2494	grains	BA – VIII	O 8/M 6	*Görsdorf, Boyadzhiev 1996*
Bln-3664	4140±50	2866–2631	2879–2579	grains	BA – VIII	O 8/M 6	″
Bln-3662	3910±60	2469–2297	2570–2204	acorns	BA – VII	O 9	″
Bln-3660	3970±50	2573–2354	2621–2298	charcoal	BA – VI	3 9/K 6	″
Bln-3661	4060±60	2840–2476	2868–2467	charcoal	BA – VI	3 9/K 6	″
Bln-3658	3780±50	2292–2136	2434–2034	acorns	BA – V	O 6/O 8	″
Bln-3659	3700±50	2195–1986	2276–1946	acorns	BA – V	O 8/O 9	″
Bln-3657	3760±50	2282–2050	2343–1985	acorns	BA – IV	3 9–1.70m	″
Bln-3656	3760±50	2282–2050	2343–1985	acorns	BA – III	K 6	″

Tab. 2. Context and laboratory information as well as taxonomic determinations on the radiocarbon dates published in this study.

Lab.-No.	BP date	context	square	depth (below site datum)	building level	species	fragment	collagen (%)	N (%)	C (%)	layer description
Poz-108883	5710±40	348	M3		BIV	*Ovis/Capra*	femur	4.3	2.0	6.5	pile of bones on top greenish clay leveling on top of the oven/building BV-1
Poz-108885	6130±40	278	N6	7,75	BIII	*Bos taurus*	phalanx	2.4	0.5	3.9	claylayer under destruction of building BIII-1 over the oven – lower layer
Poz-108886	5630±40	230	M7		BIV	n.d.	longbone	1.4	1.5	5.3	clayish layer on top of floor of building BIV-2 – from floatation
Poz-108887	6200±40	523	M2	10,32	BVIIId	*Bos taurus*	costa	3.9	1.6	8.7	grey ashy layer
Poz-108888	5780±40	484	M3	9,37	BVIIIb	*Bos taurus*	humerus	3.0	3.4	9.5	grey brown layer with concentration of pottery
Poz-108889	5810±40	518	M2	10,4	BVIIIc	*Bos taurus*	costa	6.4	3.0	8.9	hard grey clay
Poz-108890	5620±40	222	P5	7,15	BII	*Bos taurus*	phalanx	3.7	0.9	7.3	building BII-21
Poz-108905	5680±30	450	M3	9,07	BVII	*Dama dama*	tibia	3.2	2.8	8.2	grey-greenish layer
Poz-108906	5810±40	505	M2	9,67	BVIIIc	*Bos taurus*	humerus	5.4	3.5	9.6	grey non-homogenous layer - unburned wooden planks
Poz-108907	5630±40	439	M3	8,18	BVI	*Ovis/Capra*	metacarpus	3.1	2.8	8.2	floor level
Poz-108908	5740±40	474	M3	9,45	BVIIIa	*Bos taurus*	costa	5.7	3.9	9.8	grey ashy layer
Poz-108909	5860±40	521	M3	10,4	BVIIId	*Bos taurus*	metacarpus	2.7	4.0	11.0	grey layer with some charcoals
Poz-108910	5660±40	48	O7		BII	*Bos taurus*	phalanx	2.1	7.6	19.7	Phase 2 on top of building BIII-1 – homogeneous layer of clay surfaces
Poz-109084	5730±40	90	O7	7,21	BIII	grains					concentration of grains in burnt destruction of building B3-1
Poz-109086	5590±40	385	O4	7,53	BII	lentils					Burnt destruction of building B2-21 (in pot 10 under feature 385)
Poz-109419	5460±50	35	M6		BV	*Bos taurus*	phalanx	0.2	1.6	5.8	destruction of building BV-2 – low collagen
Poz-115801	5730±40	225	M7		BIV	*Ovis/Capra*	vertebra	2.8	2.6	8.9	clayish layer on top of floor of building BIV-2 – from floatation
Poz-115802	5700±40	396	L3		BV	*Bos taurus*	phalanx	1.2	0.7	4.4	lower floor level of building BV-1
Poz-115803	5690±40	118	M5	8,15	BVI	ungulate	vertebra	1.0	1.2	5.4	claylayer on top of unburned wooden planks

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Combining relative chronology and AMS ^{14}C dating to contextualize 'megasites', serial migrations and diachronic expressions of material culture in the Western Tripolye culture, Ukraine

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ABSTRACT – *Scholarship regarding the Eneolithic Cucuteni-Tripolye cultural complex of Romania, Moldova and Ukraine has recently focused on 'megasites' of the Western Tripolye culture (WTC) in Central Ukraine. However, in order to properly contextualize such unusual phenomena, we must explore the broader typo-chronology of the WTC, which is suggestive of a high degree of mobility and technological transfer between regions. We report 28 new AMS ^{14}C dates from sites representing diagnostic types and propose a high-resolution chronological sequence for the WTC's development. Our results support the relative chronology and offer an opportunity to propose a new chronological synthesis for the WTC.*

KEY WORDS – *Eneolithic; Cucuteni-Tripolye; migration; chronology; radiocarbon*

Združevanje relativne kronologije in AMS ^{14}C datumov pri kontekstualizaciji 'mega-najdišč', zaporednih migracij in diahronih izrazov materialne kulture na območju zahodne kulture Tripolje v Ukrajini

IZVLEČEK – *Študije eneolitskega kulturnega kompleksa Cucuteni-Tripolje, ki se razprostira na območju Romunije, Moldavije in Ukrajine, so se nedavno osredotočile na 'mega-najdišča' kulture zahodnega Tripolja (ang. kr. WTC) na območju osrednje Ukrajine. Da bi lahko ta nenavaden pojav postavili v ustrezni kontekst, moramo najprej preučiti širšo tipo-kronologijo WTC, ki kaže na visoko stopnjo mobilnosti in prenosa tehnologij med regijami. V članku predstavljamo 28 novih AMS ^{14}C datumov iz najdišč, ki predstavljajo diagnostične tipe. Predlagamo kronološko visoko ločljivo sekvenco razvoja. Naši rezultati podpirajo relativno kronologijo in nudijo priložnost za vzpostavitev nove kronološke sinteze kulture WTC.*

KLJUČNE BESEDE – *eneolitik; Cucuteni-Tripolje; migracije; kronologija; radiokarbonski datumi*

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Introduction

Large settlements (known in the literature as 'giant-settlements' or 'megasites') belonging to the Cucuteni-Tripolye cultural complex (CTCC) have in recent years become the focal point of international interest in Ukrainian archaeology. Previously known to Western readers mainly through a selection of regional-scale archaeological monographs (*e.g., Anthony 2007; Fletcher 1995; Kohl 2007*), these sites now attract international attention through the results of Swiss-Ukrainian, British-Ukrainian, German-Ukrainian, and US-Ukrainian projects conducted over the last dozen years (*e.g., Gaydarska 2020; Menotti, Korvin-Piotrovskiy 2012; Müller* et al. *2016; Ohlrau 2020*).

The largest CTCC settlements, which reached sizes of 100–320ha and date to *c.* 4100–3400 BC, are located in the Southern Bug-Dnieper Interfluve (SBDI; the Cherkassy and Kirovograd oblasts of modern-day Ukraine). According to the CTCC taxonomy, they belong to the Western Tripolye culture (WTC). Studies of the archaeological materials and population dynamics of these settlements indicate that they were formed as the result of populations migrating along the forest-steppe corridor, which extends across Central Ukraine from the Dniester to the Dnieper River valleys (*Diachenko 2012; Diachenko, Menotti 2017; Harper 2016; 2019; Harper* et al. *2019; Ryzhov 1993; 1999; 2003; 2015*). Similar hierarchies in settlement size have also been noted in other regions and among other cultures within the CTCC, but these settlements did not reach such extreme dimensions as those in Central Ukraine. For instance, in the Prut-Dniester and Dniester-Bug interfluves, as well as in the Middle Bug region, the largest WTC sites did not exceed a size of *c.* 60ha (*Diachenko 2016a; 2016b; Diachenko, Zubrow 2015; cf. Rud* et al. *2019b*).

It is of little surprise that reconstructions of the demographic development, economy, and social structure of the inhabitants of the WTC giant-settlements, *i.e.* the largest settlements of Neolithic and Eneolithic Europe, inspire controversy. To a great extent, these reconstructions and interpretations stem from different understandings of the durations of the giant-settlements and their internal chronologies. As in any discussions of archaeological time, construction of a temporal framework for the giant-settlements may vary greatly depending on the weight assigned to relative versus absolute dating techniques. Relative approaches are usually criticized for the host of other stylistic and cultural factors that may influence pottery seriation beyond a strictly temporally derived typo-chronology (*e.g., Gaydarska, Chapman 2016*). Meanwhile, absolute dates are only as good as the contexts and materials from which they are taken. Common discussions of ^{14}C dates may often appear imprecise due to reliance on 2σ (or 95%) uncertainty ranges and the popular misconception that these ranges signify duration or intensity of occupation, rather than the range of probable occurrence for a discrete event (*Carleton, Groucutt 2021*).

Current demographic and socio-economic reconstructions suggested for the WTC giant-settlements are grounded in three major approaches to their duration and micro-chronology. The first approach proposes the sequential functioning of structures at the settlements, which were inhabited for several centuries and all existed synchronously (*Ohlrau 2020; cf. Palaguta 2020*). The second approach places settlement duration at *c.* 200 years but assumes only seasonal occupation of the majority of dwellings (*Chapman 2017*). Both temporal frameworks are mainly based on consideration of the 2σ ranges of large datasets of radiocarbon data. Our paper contributes to further development of a third approach, which combines highly targeted AMS ^{14}C dating with the traditional relative chronology to create a chronological synthesis. This approach supports the idea that giant-settlements existed more or less sequentially with each being inhabited for around 80 to 100 years (*Diachenko 2012; Harper 2016*).

However, our project goes well beyond the giant settlements and addresses a far broader spatial and chronological range, examining material from diagnostic sites throughout Western and Central Ukraine and generating 28 new AMS ^{14}C dates from eight sites (Fig. 1). Of these, three sites lie within the SBDI, four in the Dniester Basin, and one in Eastern Volhynia. Despite being an archaeological culture that originates in the Prut-Dniester region, the sample of known WTC sites has an extensive space-time bias towards the area of giant-settlement development owing to scholarly priorities since the early 1970s. Consequently, knowledge of the origins of the WTC is confined to just a few studies (*e.g., Ryzhov 2007*), and the Republic of Moldova and Ukraine are home to thousands of Eneolithic sites that remain unpublished or as-yet unstudied.

By dating sites and examining settlement data from outside the SBDI we strive to recontextualize the development of the WTC towards its point of origin,

in regions and micro-regions at the other end of the forest-steppe corridor. Our results, in concert with other recent AMS ^{14}C dates from throughout the WTC, aid in resolving the chronology of both the giant-settlement phenomenon and the CTCC as a whole. Notably, we establish new temporal termini: five new dates from Kosenovka provide a *terminus ante quem* for the Vladimirovskaya-Tomashovskaya giant-settlement sequence, while two dates from Golyshev indicate the end of Tripolye CII in Western Volhynia. Evaluation of settlement data, organized according to a new chronology that synthesizes relative and absolute dating, allows for the examination of rates of change in material culture and the serial movement of populations across the landscape. These are issues that affect our understanding of CTCC ways of life at both large and small settlements alike.

The Cucuteni-Tripolye cultural complex

Taxonomy and chronology

The CTCC (*c.* 5050–2950 BC) forms the north-eastern periphery of the Neolithic and Eneolithic cultural complexes of Southeast Europe ('Old Europe'). Sites attributed to this complex extend west-to-east from the Carpathian Mountains to the eastern bank of the Dnieper River, and north-to-south from Volhynia to the coast of the Black Sea. Cucuteni-Tripolye pottery is represented by a diverse selection of vessel forms and decorative motifs. During the early and middle twentieth century, specialists began to make coarse typological distinctions relying on the presence of incised ornamentation, painting, or a combination of the two, stylistic trends which vary through space and time. The identification of these trends enabled the gradual development of a taxonomy of divisions within the CTCC, and eventually led to fine-grained schemes of relative chronology at local and regional levels.

Earlier CTCC ceramics display incised decoration, and are sometimes painted after firing, while later ceramics are painted prior to firing. Considering these differences in ornamentation styles, Vladimir Dumitrescu suggested that the complex be divided along chronological lines, between the Precucuteni and Cucuteni-Tripolye cultures. He also underlined significant differences in ornamentation schemes between the Cucuteni and Tripolye components of the overall complex, arguing that Cucuteni and Tripolye should be distinguished from one another (*Dumitrescu 1963*).

The periodization of the Cucuteni sites, constructed from stratigraphic observations at multi-layer sites, is based on the scheme of Hubert Schmidt. Schmidt combined the sites into three sequential periods: Cucuteni A, AB, and B (*Schmidt 1932*). Further contributions allowed for the subdivision of these periods into smaller phases. These are the Cucuteni A1, A2, A3, and A4, Cucuteni AB1 and AB2, and Cucuteni B1, B2, and B3 phases (*Cucoș 1999; Dumitrescu 1945; Mantu 1998; Nițu 1984*).



Fig. 1. Geographic reference, showing the northern extent of the CTCC with major regions labelled, as well as ^{14}C-dated sites and other major type-sites mentioned in the text.

The periodization of the Tripolye sites, which is still used in a corrected and elaborated form, was proposed by Tatiana Passek (*1935; 1949*). She divided sites into three chronological groups: Early (A), Middle (B), and Late (C and γ). The Middle Tripolye settlements were further distinguished into the Tripolye BI and BII periods. Later research by Natalia Vinogradova suggested that an additional transitional period, Tripolye BI-II, should be placed between Tripolye BI and BII and synchronized with Cucuteni A-B (*Vinogradova 1982*). In the case of Late Tripolye sites, Passek's scheme was extended by spatial division. Sites located in the north – in Volhynia

and the Middle Dnieper region – were labelled 'Tripolye C', while sites located in the south – in the Prut, Dniester, and Lower Southern Bug regions – were labelled 'Tripolye γ'. This resulted in the subdivision of Late Tripolye into Tripolye CI, γI, CII, and γII (*Passek 1949*). Contemporaneous sites in Romania are referred to as Horodiștea-Folteşti or, more recently, Horodiș tea-Erbiceni or Horodiș tea-Erbiceni/Gordinești. These sites were at first considered to be a separate chronological horizon and later as an individual culture or cultures (*Dumitrescu 1963; Lazarovici 2010; Nestor 1950; Petrescu-Dîmboviţa 1950; Sîrbu 2019*).

Tamara Movsha (*1972*) proposed replacing the term 'Tripolye CI' with 'Tripolye BIII', and related only Tripolye CII sites (after Passek *O.c.*) to the latest period of the culture. Vladimir G. Zbenovich (*1974*) and Valentin Dergachev (*1980*) also noted that Tripolye CI (after Passek *O.c.*) settlements, dwellings, and ceramics are more similar to Tripolye BII materials than to those of Tripolye CII. Hence, Dergachev claimed that Late Tripolye corresponds exclusively to Tripolye CII/γII in Passek's scheme (*Dergachev 1980*). Late Tripolye sites were further divided into two sub-periods labelled simply '1' and '2' according to chronological ordering (*Dergachev 1980*). Taras Tkachuk, and Sergei Ryzhov, considering different issues with the transition from Tripolye CI to Tripolye CII (after Passek *O.c.*), used more neutral terms like "*late Tripolye CI–early Tripolye CII sites*" or "*Tripolye CI-II*" (*Ryzhov 2007; 2012; Tkachuk 2005; 2011*). To some extent, these neologisms were caused by different rates of development in the material culture in different regions of the CTCC, which we attempt to address in the analysis presented here.

More recently, Ryzhov (*2007; 2012; forthcoming*) proposed applying a modified version of Movsha's changes to the Tripolye periodization. According to him, most of the Tripolye CI sites should equate to the Tripolye BIII period, while a new period designated CI should be limited to sites previously attributed to the final phases of Tripolye CI and the early phases of Tripolye CII; *i.e.* the sites of the Badrazhskaya, Koshilovetskaya, Lukashevskaya, and Kosenovskaya local groups and those contemporaneous with them (*Ryzhov 2012; forthcoming*). Tkachuk continues to use the term "*late Tripolye CI–early Tripolye CII*" (*e.g., Tkachuk 2011*). The idea of separating the latest Tripolye local groups into individual cultures was also suggested recently (*e.g., Burdo 2007; Petrenko 2009*). However, it was not accepted by all experts. Here we promote the use of the periodization developed by Ryzhov, which current research shows to be the most apt for describing continuities and discontinuities in Tripolye material culture.

Further work on pottery seriation identified the Ariușd culture in Transylvania, while the Tripolye component of the cultural complex was subdivided into two cultures. These are the Eastern Tripolye culture (ETC) and Western Tripolye culture (WTC). ETC materials are distinguished based on ceramics with mostly incised ornamentation, as well as certain diagnostic types of clay figurines and dwellings (*Tsvek 1980; 2006*). Tripolye sites with ceramic assemblages characterized by painted ornamentation are associated with the WTC (*Ryzhov 2007; 2012; forthcoming*).

The current view of the CTCC is of a large taxonomic unit subdivided into five smaller taxa: Precucuteni, Ariușd, Cucuteni, ETC, and WTC. Sites within cultures that have similar ceramic assemblages are further grouped into types. These types of sites compose the local groups that in turn form the 'genetic' lines of development of the culture (*Dergachev 1980*; note here that the term 'genetic' refers not to biology, but exclusively to trajectories in the development of pottery technology, morphology, and ornamentation). We use the term 'Tripolye' when the ETC and WTC are simultaneously considered or apply it in respect to the periodization of sites, for example, 'Tripolye BII', 'Tripolye CII'.'

Until recently the synchronization of the Cucuteni and Tripolye periodizations was based on a linear (though not consciously recognized as such) concept of cultural evolution, presuming that changes in pottery shapes and decoration were rapidly disseminated as regional archaeological horizons that displaced previous materials. However, mathematical modelling, partly confirmed by radiocarbon chronology, indicates a delay in the development of the eastern part of the CTCC in comparison to its western part. The same trend is also assumed for cultural units of lower orders in the taxonomic hierarchy (*e.g., Diachenko, Menotti 2015*). In the case of the ETC, the formation of site clusters was initially characterized by different ceramic traditions coexisting within the same micro-regions, while further interactions between populations of these clusters resulted in rapid change of pottery assemblages. Synchronous long-distance migrations of sub-populations bringing new pottery styles to new areas and further re-colonization of already populated niches

created a complex patchwork of cultural change, featuring the simultaneous use of old and new stylistic traditions within the same cultural complex (*Harper* et al. *forthcoming*). The WTC presents a similarly complex mosaic of differential rates of material change.

Local groups of the Western Tripolye culture

The WTC formed in the Middle Dniester and Upper Dniester regions and its ceramics, while exhibiting a diversity of forms and decoration, share a common and readily recognizable stylistic lineage (Fig. 2). Its roots are visible in the late Tripolye BI sites, from which emerged the sites of the Kadievtsy type. However, precise distinction of the earliest WTC sites requires further accumulation of empirical data and their analysis (*Ryzhov 2007*). The relative chronology of early sites is intensively debated (compare *Ryzhov 2007; 2012; Tkachuk 2019*). The earliest WTC local groups, Zaleschitskaya and Solonchenskaya, along with the Polivanov Yar-type sites, are ascribed to Tripolye BI-II (*Ryzhov 2007*), a nebulous period with comparatively few sites that has recently appeared to be a stylistic variant of Tripolye BI rather than a period unto itself (*Diachenko 2016b; Harper* et al. *forthcoming; Palaguta 2007*). We tentatively assign these sites, which lack any absolute dates, to the range of 4250–4100 BC. It seems probable that this range will narrow once absolute dates are obtained for these sites.

The Solonchenskaya group, through the sites of the Nezvisko III type, formed the genesis of the Shipinetskaya local group in the Upper Dniester region, while the Zaleschitskaya local group formed the basis for the Rakovetskaya group in the Middle Dniester region (*Ryzhov 2007*). This transition is dated to the beginning of Tripolye BII. There are two major views on the taxonomy of the WTC during the first part of Tripolye BII: Ryzhov (*2003*) follows Vladimir Sorocin (*1990*) and subdivides the Rakovetskaya group into two subsequent site-types, Rakovetskij and Mereshovskij. An alternative view considers these two units as distinct local groups (*Diachenko, Sobkowiak-Tabaka forthcoming; Levinzon 2019; Tkachuk 2015*).

The formation of WTC settlements in the western part of Eastern Volhynia and in the Middle Bug region, where complexes of this kind were not known previously, marks the migration of Rakovetskaya and Mereshovskaya group populations to the north and east (*Kruts, Ryzhov 2000*). The migration of Rakovetskaya and Mereshovskaya group populations resulted in the formation of the Voroshilovskaya group in the Middle Bug region and Vladimirovskaya group in the SBDI around 4100 BC (*Ryzhov 2015*). The subsequent migration wave of Mereshovskaya and Shipinetskaya group populations to the east is dated to *c.* 3950–3900 BC. This migration is reflected in the rapid transformation of ceramic styles and abnormally high population growth reflected by settlements of the first phase of the Nebelevskaya group in the SBDI and, probably, the Nemirovskaya group in the Middle Bug region (*Diachenko 2016a; Gusev 1995; Harper 2016; Ryzhov 1993*).

Mereshovskaya group sites were the basis for the formation of the Petrenskaya local group in the Middle Dniester area at the end of Tripolye BII (*Ryzhov 2003; Sorocin 1990; Tkachuk 2019*). However, the late Mereshovskaya group sites located to the north and east of the Dniester represent a certain 'delay' in ceramic assemblages in comparison to the contemporaneous pottery sets coming from the early settlements of the Petrenskaya group. The earliest Petrenskaya group sites are dated to the range of *c.* 3950–3900 BC (*Diachenko, Sobkowiak-Tabaka forthcoming*).

Tripolye BIII in the Dniester-Bug region corresponds to the development of the Chechelnitskaya local group. The mechanisms of its formation and the attribution of the earliest sites to the group are debated (*Ryzhov 2007; Tkachuk 2005*). The WTC settlements of Tripolye BIII in the Middle Bug region are assigned to the Gorodischenskaya group (*Gusev 1995*).

The transition from Tripolye BII to Tripolye BIII in the SBDI corresponds to the early sites of the Tomashovskaya local group, which formed *c.* 3850–3800 BC from a portion of the sites of the Nebelevskaya local group. It should be noted that settlements of both groups existed synchronously in neighbouring micro-regions during the range of 3850–3700 BC (*Diachenko, Menotti 2012*). Similar to the formation of the Nebelevskaya local group, the formation of the Tomashovskaya local group corresponds to a shift in pottery assemblages and an increase in population indicative of elements of the Shipinetskaya local group migrating east (*Ryzhov 2003*).

Settlements of the Petrenskaya local group in the Middle Dniester region developed in the range of 3950–3700 BC. However, the continued functioning of the latest sites of this group in peripheral areas somewhat later than 3700 BC is not excluded (*Diachenko, Sobkowiak-Tabaka forthcoming; Tkachuk*

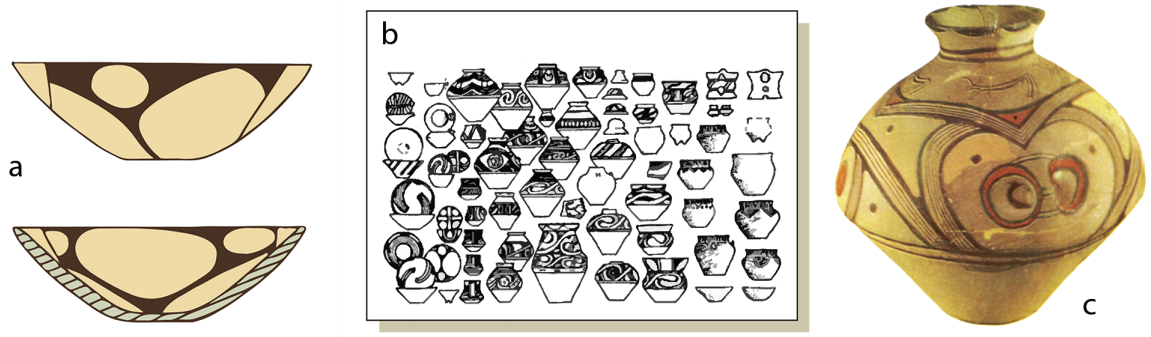


Fig. 2. Examples of WTC ceramics:* a *bowl from Mereşeuca-Cetățuia, Mereshovskaya phase 2 (*Sorocin 1990*);* b *Nebelevskaya phase 2 ceramic forms and ornamentation (*Ryzhov 1993*);* c *vessel with painted 'owl face' scheme and bull decorations from Vărvăreuca 15 (*Markevich 1981*).

2008). Considering the presence of imports from settlements belonging to the second phase of the Tomashovskaya local group at Bernashevka 2 (*Ryzhov 2003; Tkachuk 2008*), we suggest the subdivision of the second stage of the second phase of the Petrenskaya group into two sub-stages. In the core area of the Prut-Dniester interfluve, Petrenskaya group sites were replaced by settlements of the Vărvăreuca 15 type and Badrazhskaya local group *c.* 3700–3650 BC. It is important to note that Vărvăreuca 15-type sites and the Badrazhskaya local group belong to Tripolye CI, while pottery assemblages of synchronous cultural units to the east and north of the Dniester are attributed to late Tripolye BIII.

Sites of the Lomachintsy-Vyshneva type were spread between the Prut and Dniester during late Tripolye BIII to early Tripolye CI. This site-type became the base for the formation of the Tripolye CII Brynzenskaya group in the Prut-Dniester interfluve, and, through long-distance migration, the Tripolye CII Khorjev group in Volhynia and the Tripolye CI Kosenovskaya group in the SBDI (*Dergachev 1980; Ryzhov 2007*). Further development of the WTC in the Prut-Dniester interfluve corresponds to two 'genetic' lines starting with, respectively, the Vykhvatinskaya and Brynzenskaya local groups (*Dergachev 1980*). The Brynzenskaya local group influenced the formation of the Tripolye CI Koshilovetskaya group in the Upper Dniester region (*Ryzhov 1998; 2007; cf. Tkachuk 1998; 2005*). The Kocherzhintsy-Shulgovka type dates from Tripolye CI to the very beginning of the Late Tripolye period in the SBDI and arose from the Kosenovskaya local group (*Dergachev 2004; Ryzhov 2002; cf. Tkachuk 2008*). The co-existence of Tripolye CI and CII local groups and site types indicates uneven rates of cultural change in different regions. Generally, the highest rates of change are observed in the core area of the WTC's development, the Prut-Dniester interfluve.

The Brynzenskaya local group became the basis for the formation of the Late Tripolye Gordineshtskaya and Horodiștea groups as well as several types of sites in the Upper Prut region, Upper and Middle Dniester, the northern part of the Southern Bug region and the SBDI (*Dergachev 1980; 2004; Ryzhov 2007; cf. Tkachuk 2011; 2014*). According to Viacheslav Bicbaev (*1994*), the transition from the Brynzenskaya to Gordineshtskaya local groups included an intermediate chronological step represented by sites of the Kirilen type. More recently, it has been suggested that this site type is synchronous with sites of the early Gordineshtskaya local group (*Sîrbu 2019*). The Vykhvatinskaya local group provided the basis for the formation of the Usatovskaya group in the North Pontic region and the Folteşti group in Romanian Moldavia. However, early sites of the Usatovskaya group are generally synchronous with early sites of the Vykhvatinskaya group, with only a short delay in development (*Dergachev 1980; 2004*).

The final picture of the relative development of the WTC is extremely complex, an interwoven mass of stylistic changes that has been pieced together over decades of careful study by ceramic specialists. However, the interrelationships among the various local groups and site types provides a structure for guiding strategies of absolute dating, which may in turn be used to test the accumulated assumptions of the relative chronology.

Methods

AMS radiocarbon dating and analysis

We produced 28 AMS dates on faunal bones at the Penn State Accelerator Mass Spectrometry Laboratory (PSUAMS) in 2018. Samples were taken from the collections of the Institute of Archaeology of the National Academy of Sciences of Ukraine in Kiev, Ivan Franko National University in Lviv, and the Tri-

polye Culture Museum in Lehedzyne. They originate from sealed contexts at eight well-studied WTC type-sites, mostly from within or underneath the archaeological remnants of burned houses (known as *ploshchadki* in Ukrainian and Russian). These sites were excavated between 1959 and 2017 in campaigns led by Sergei Ryzhov, Elena Tsvek, Dmitriy Chernovol, Pavlo Nechitailo, Vladimir Kruts, Vladislav Chabaniuk, Valentina Shumova, Tamara Movsha, Mikhail Makarevich and Nikolai Peleschishin.

Bone collagen for ^{14}C and stable isotope analyses was extracted and purified at the Pennsylvania State University using a modified Longin method with ultrafiltration (*Kennett* et al. *2017*). With an X-acto blade, bones were cleaned of adhering sediment and the exposed surfaces removed. Samples consisting of 600–1000mg of finely cut fragments were demineralized for 24–36 hours in 0.5N HCl at 5°C. Residue from this process was rinsed to neutrality in multiple changes of Nanopure H_2O, and then gelatinized for 10 hours at 60°C in 0.01N HCl. The resulting gelatine was lyophilized, weighed, and visually inspected to determine the percent yield as a first evaluation of the degree of bone collagen preservation, with yields in the 0–3% range generally being rejected. Following this, the gelatine was rehydrated into a solution and pipetted into pre-cleaned Centriprep (*McClure* et al. *2010*) ultrafilters (retaining ≥30kDa molecular weight gelatine) and centrifuged 3 times for 20 minutes, diluted with Nanopure H_2O, then centrifuged 3 more times for 20 minutes to desalt the solution. Carbon and nitrogen concentrations and stable isotope ratios were measured at the Yale Analytical and Stable Isotope Center with a Costech elemental analyser (ECS 4010) and Thermo DeltaPlus analyser. Sample quality was evaluated by examining the % crude gelatine yield, %C, %N, and C:N ratios prior to being sent on to AMS ^{14}C dating. C:N ratios for the 28 dated samples fell between 3.12 and 3.49, indicating acceptable collagen preservation (*Van Klinken 1999*). In those cases where ultrafiltration returned an unacceptably low gelatine yield, samples were processed according to the XAD amino acid purification method (after *Lohse* et al. *2014*).

Having passed demineralization and quality control measures, the purified collagen samples proceeded to the gas line, where they were combusted for three hours at 900°C in vacuum-sealed quartz tubes with CuO and Ag wires. Sample CO_2 was reduced to graphite at 550°C using H_2 and an Fe catalyst, with reaction water drawn off with $Mg(ClO_4)_2$ (*Santos* et al. *2004*). Graphite samples were then transferred to the AMS, pressed into targets in Al cathodes and loaded on the target wheel. Received ^{14}C ages were corrected for mass-dependent fractionation with measured $\delta^{13}C$ values (*Stuiver, Polach 1977*) and compared with samples of Pleistocene whale bone (backgrounds, 48 000 ^{14}C BP), late Holocene bison bone (*c.* 1850 ^{14}C BP), late AD 1800s cow bone and OX-2 oxalic acid standards for calibration.

The reported uncertainty of the dates ranged from 15–35 ^{14}C years, with the majority falling at ±20. All calibrated ^{14}C ages were calculated using OxCal version 4.4 (*Bronk Ramsey 2020*) using the IntCal20 northern hemisphere curve (*Reimer* et al. *2020*). Results are reported in Table 2 (see also Supplementary Data, Table S1).

Aside from two obvious outliers dating to the Middle Bronze Age (PSUAMS-4627) and Medieval period (PSUAMS-4452), data were placed into a Bayesian sequence consisting of ten phases (Supplementary Data, Tables S3, S4). Boundaries were entirely delineated by site, presumed habitational layer and ^{14}C ages, agnostic of extensive *a priori* assumptions about the relative sequence of sites. Layers are indicated by sequential Roman numerals within parentheses, such as (I) or (II), and are not indicative of official nomenclature or previously applied numbering schemes. A further two minor outliers, PSUAMS-4589 and PSUAMS-5096, were removed due to poor model agreement (the manual outlier detection method, after *Bronk Ramsey 2009*). The intent of this exercise was twofold: to test whether calibrated ^{14}C probability distributions that have a high degree of overlap, especially during the periods of Tripolye BII and BIII, may be arranged into a sequence resembling the *c.* 50–100 year resolution prescribed by the relative chronology; and to highlight two situations (Lipchany and Konovka I) in which the received data disagree with the material classification of the sites.

Consideration of calibrated radiocarbon dates and derivative statistics (like summed probability distributions) is prone to all manner of ill-considered and dubious popular applications, such as ascribing habitational periods or 'intensity' to calibrated ranges. Similarly, Bayesian sequencing may often be poorly designed and implemented in a manner that locks in the confirmation bias of researchers, rather than for its intended purpose of resolving sequences of dates and testing chronological assumptions. The fourth millennium BC is characterized by several ca-

libration curve plateaus that causes radiocarbon probability distributions to assume wide, bi- or tri-modal appearances, rendering calibrated 2σ ranges imprecise and often overlapping despite dates having quite distinct ^{14}C ages. It is important to remember that ^{14}C dates represent singular events (the time at which an organism died and ceased carbon fixation) and that consideration of the mean (μ) calibration, as well as the duration of modelled phases, should also feature heavily in interpretation of results.

Analysing the diachronic spatial distribution of WTC local groups

In order to understand the space-time development of WTC local groups, we analysed a dataset of 158 settlement sites with well-defined chronological assignments and site size data (Supplementary Data, Table S5) in QGIS software. The chronology of the sites was determined according to our past projects in regional analysis (*e.g., Diachenko 2012; 2016b; Harper 2016; Harper* et al. *2019*) and updated according to the new ^{14}C dates presented in this study. These sites were divided into three main analytical groups based on their geographic positioning: the Prut and Dniester Basins, the Southern Bug Basin, and the Southern Bug-Dnieper Interfluve (Fig. 3). It should be noted that the sites of the Dniester-Bug interfluve have their own specific ceramic assemblages (*e.g., Rud* et al. *2019b; Ryzhov 2007*), so this region is usually treated separately. However, given the size and geographic distribution of the sample, we divided these sites for the purposes of this study. Excluding the SBDI, which has been subject to extensive study elsewhere (*Diachenko 2012; Diachenko, Menotti 2012; Diachenko, Zubrow 2015*), these groupings were then subdivided into a further seven micro-regions. The intent is to explicate large-scale trends in population development, while also being able to highlight individual settlement events and population movements on the local scale.

Population estimates are generated according to Harper's (*2016*) variant of the SARP model for estimating archaeological populations (originally pro-

Lab ID	Site	Process	^{14}C age	δ^{13}C	δ^{15}N	%C	%N	C:N	cal BC (2σ)	cal BC (μ)
PSUAMS-4590	Golyshev (I)	UF, >30kDa gelatin	5255±25	–21.0	7.5	38.8	13.8	3.28	4230–3980	4075
PSUAMS-4453	Lipchany	UF, >30kDa gelatin	5220±20	–21.8	9.9	43.2	15.2	3.32	4050–3970	4015
PSUAMS-4451	Lipchany	UF, >30kDa gelatin	5200±25	–22.0	7.2	43.9	15.5	3.31	4045–3965	4005
PSUAMS-4450	Lipchany	UF, >30kDa gelatin	5075±25	–21.0	7.7	44.0	15.5	3.32	3960–3795	3870
PSUAMS-5095	Peshchanoe	XAD amino acids	5045±20	–17.5	9.6	38.5	14.4	3.12	3945–3785	3870
PSUAMS-5094	Peshchanoe	XAD amino acids	5045±20	–18.7	7.7	13.1	4.8	3.21	3945–3785	3870
PSUAMS-4589*	Rubanyj Most	UF, >30kDa gelatin	5040±20	–21.2	7.9	46.8	16.9	3.24	3945–3775	3870
PSUAMS-4587	Rubanyj Most	UF, >30kDa gelatin	5015±20	–19.6	6.8	46.1	16.3	3.30	3940–3710	3825
PSUAMS-4630	Rubanyj Most	UF, >30kDa gelatin	4995±20	–20.0	5.4	55.7	19.8	3.27	3910–3705	3770
PSUAMS-5097	Kam.-Podolskij (Polskij Rynok)	XAD amino acids	4990±25	–19.9	11.0	19.2	7.1	3.14	3915–3700	3770
PSUAMS-4454	Konovka (I)	UF, >30kDa gelatin	4975±20	–20.9	8.3	42.9	15.2	3.31	3795–3700	3745
PSUAMS-5096*	Peshchanoe	XAD amino acids	4960±20	–19.9	7.0	23.7	8.6	3.21	3790–3665	3735
PSUAMS-4629	Rubanyj Most	UF, >30kDa gelatin	4955±25	–21.6	10.2	82.9	29.2	3.32	3785–3660	3730
PSUAMS-4584	Konovka (I)	UF, >30kDa gelatin	4950±20	–21.1	6.7	41.5	14.4	3.36	3780–3660	3725
PSUAMS-4588	Rubanyj Most	UF, >30kDa gelatin	4950±20	–21.5	9.9	42.1	14.6	3.36	3780–3660	3725
PSUAMS-4695	Kam.-Podolskij (Polskij Rynok)	XAD amino acids	4910±20	–20.5	8.8	21.6	7.8	3.23	3710–3645	3680
PSUAMS-5106	Kosenovka	UF, >30kDa gelatin	4810±20	–20.8	8.3	39.8	14.5	3.21	3650–3530	3580
PSUAMS-5105	Kosenovka	XAD amino acids	4760±20	–20.8	7.4	33.4	12.5	3.13	3640–3515	3570
PSUAMS-5104	Kosenovka	UF, >30kDa gelatin	4750±20	–21.7	8.8	46.5	17.0	3.20	3640–3380	3565
PSUAMS-4628	Konovka (II)	UF, >30kDa gelatin	4725±20	–21.0	9.9	43.2	14.8	3.41	3635–3375	3515
PSUAMS-5103	Kosenovka	XAD amino acids	4720±20	–21.0	11.0	22.2	8.2	3.17	3635–3375	3500
PSUAMS-5107	Kosenovka	UF, >30kDa gelatin	4690±35	–21.2	7.5	42.7	15.5	3.22	3630–3365	3470
PSUAMS-4586	Stena 2	UF, >30kDa gelatin	4465±20	–19.0	7.7	39.9	14.3	3.25	3335–3025	3205
PSUAMS-4585	Stena 2	UF, >30kDa gelatin	4465±20	–20.3	7.3	41.5	14.8	3.27	3335–3025	3205
PSUAMS-4696	Golyshev (II)	XAD amino acids	4440±20	–21.3	5.5	14.4	5.2	3.25	3330–3010	3115
PSUAMS-4697	Golyshev (II)	XAD amino acids	4400±20	–21.2	5.5	23.9	8.3	3.35	3095–2925	3010
PSUAMS-4627*	Konovka	UF, >30kDa gelatin	3640±20	–21.7	7.0	42.7	14.3	3.49	2125–1940	2005
PSUAMS-4452*	Lipchany	UF, >30kDa gelatin	470±15	–21.1	5.5	41.8	14.7	3.31	AD 1420–1450	AD 1435

* omitted outliers

Tab. 2. PSUAMS radiocarbon dates and stable isotope measurements for eight WTC sites.

posed by *Ammerman* et al. *1976*). While SARP is a general model in its operating principles, this variant has been specifically developed and adapted for parsing large quantities of settlement data pertaining to the Neo-Eneolithic period in Eastern Europe (*Harper 2016; forthcoming*). The model calculates the population at a given time reference (t) by assigning settlement area (a) to an appropriate value of t for all settlements k. Time references correspond to the 50-year intervals prescribed by the regional relative chronology, and in this particular case the analytical window is defined as 4200–3300 BC (roughly from the beginning of Tripolye BII to the end of Tripolye CI). Data were selected on the basis of having reliable chronological assignments, but in those cases where ambiguity exists or phases occupy multiple 50-year intervals, the model divides a equally over multiple values of t.

While values of a are known for *c.* 73% of the sampled sites, there are a number of cases where a site's chronology is well-known while its morphological characteristics are not. In these situations, the model notes all incidences where values of a are equal to zero and imputes a size value (u) based on the median settlement size at the appropriate value of t. Distributions of settlement size values, both theoretically and observationally, assume a descending log-normal trend and therefore must be log-transformed, analysed, and then back-transformed to generate accurate statistical data. Values of u applied here are based on previous calculations made for settlements found over the entire area of Romania, Moldova, and Ukraine (*Harper 2016*; see also Supplementary Data, Table S6).

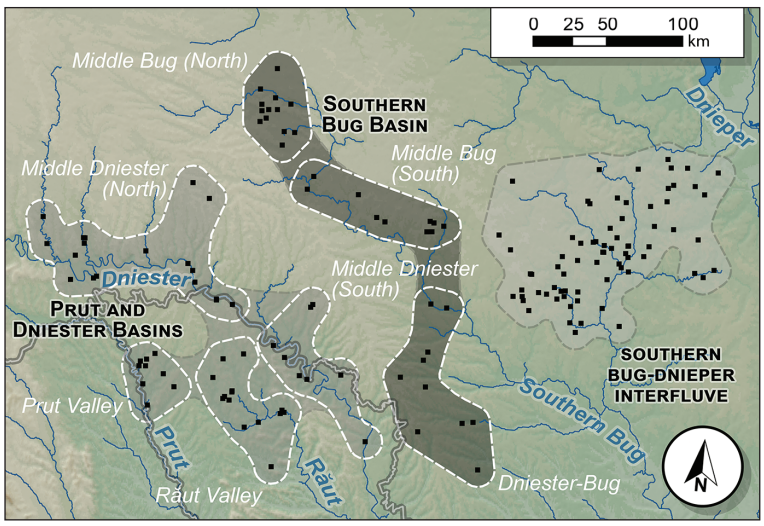


Fig. 3. Extent of the demographic analysis. Major regions are shaded, and micro-regions indicated by white outlines. Point data represent the locations of the 158 settlements analysed.

Results

The absolute sequence of WTC sites

The AMS ^{14}C dates obtained by our project generally correspond well to the relative sequence of sites and are in agreement with comparable AMS ^{14}C dates on bone samples (Fig. 4). The earliest date obtained at the multilayer site of Golyshev (PSUAMS-4590), originating from the excavations of Nikolai Peleschishin (*1998*), is represented by the ranges of 4230–3980 cal BC (2σ) and 4105–4035 cal BC (modelled). Sławomir Kadrow (pers. comm., 3 May 2021; see also *Pozikhovskyj 2010*) contends that this is indicative of a distinct occupation belonging to the Rzeszów phase of the Malice culture. Our date fits the chronology of this cultural unit and suggests that Western Volhynia was inhabited by its population during the time range corresponding to late Tripolye BI and early Tripolye BII (*Kadrow 2013*). This synchronization is also corroborated by Malice imports and influences on WTC pottery assemblages (*e.g., Skakun, Starkova 2003; Tkachuk 2019*).

The next site in our sequence, the Middle Dniester site of Lipchany, is one case in which ^{14}C dates and relative chronology do not correspond to each other. The three dates (PSUAMS-4450, -4451, -4453) from Ploshchadka 1 (*Zbenovich, Shumova 1989*) are substantially older than we expected from the site's dominant pottery assemblage, which is identified as Phase 3 of the Petrenskaya local group. However, during excavations at Lipchany considerably older pottery sherds were also found below Ploshchadka 1. Taking into account the site's modelled range of 4090–3895 cal BC, we assume that the bones recovered from Ploshchadka 1 are most likely indicative of a Mereshovskaya local group occupation, which is as-yet poorly understood. The dates are comparable to recent AMS dates from Trostianchik, which dates to Mereshovskaya phase 2, stage 1 (*Rud* et al. *2019a*). The translation of much of the Petrenskaya local group relative sequence (*Ryzhov 2003*) into a framework of absolute calendar dates is enabled by recently obtained dates for the Late Mereshovskaya site of Kamenets-Podolskiy (Tatarysky) (*Diachenko, Sobkowiak-Tabaka 2020*). The ceramic assemblage of this settlement indicates its synchronicity with the Early Petrenskaya group sites in Northern Moldova,

which similarly exhibit synchronicity with the settlements of Mereshovskaya phase 2 in the Middle Dniester and settlements of Nebelevskaya phase 1 in the SBDI (*Diachenko, Sobkowiak-Tabaka, forthcoming*).

While the fine-grained Tripolye relative chronology is mostly composed of units with a duration of 50 years (*Kruts 1989; Markevich 1981*), it is important to note that this is a partial abstraction and that the lifetimes of settlements exhibit some local and regional variability, seldom adhering exactly to ceramic phases. The settlement of Peshchanoe in the SBDI (3950–3780 cal BC on 2σ; 3895–3790 cal BC [modelled]) is one case in which radiocarbon data are a close but inexact match to those expectations. Our dates are taken from Ploshchadka 2, excavated in 2005 (*Chernovol, Ryzhov 2006*). In terms of relative chronology Peschanoe is assigned to phase 1 of the Nebelevskaya local group (*c.* 3950–3900 BC), and shares a very similar ceramic assemblage with the eponymous giant-settlement of Nebelevka. However, the ^{14}C data are somewhat later than expected, coinciding with our expectations for Nebelevskaya phase 2, stage 1 (compare with *Diachenko, Menotti 2012*). The dates from Peshchanoe are in close agreement with the general ^{14}C sample from Nebelevka (*Chapman* et al. *2018; Millard 2020*), though it may be that Nebelevka was founded first and Peshchanoe was established later yet retained 'conservative' ceramic traditions for a time amid the development of Nebelevskaya phase 2 settlements. It should be noted that Ryzhov (*1993*) and Tkachuk (*2005*) do not exclude the possibility that Peschanoe is a somewhat younger settlement than Nebelevka. These results highlight the fact that rates of change in material culture scale to all levels, from the super-regional to the local.

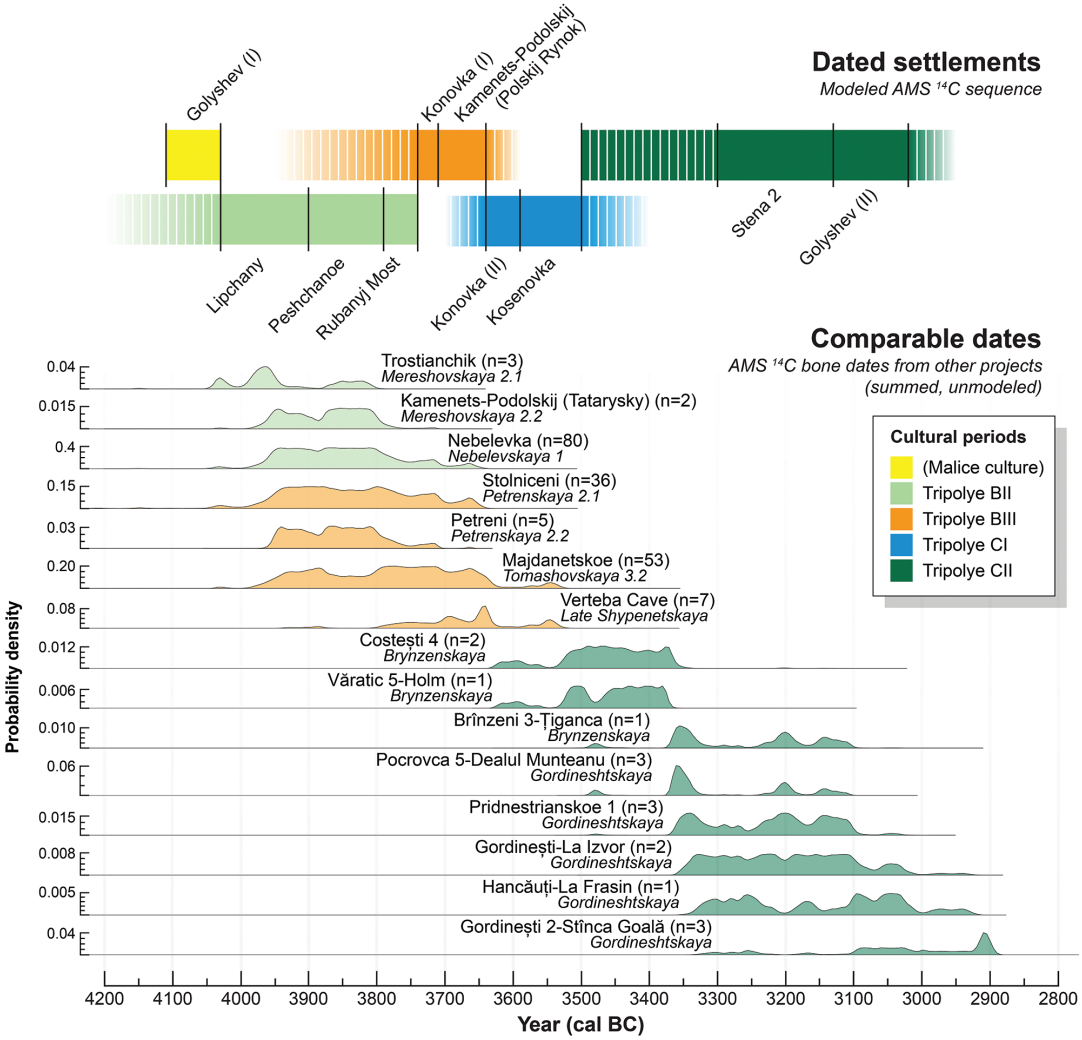


Fig. 4. A Bayesian sequence of sites dated in this study, shown in relation to the periodization of the Tripolye culture (above). The duration ascribed to each site is determined as the span between the mean values of the model boundaries (black lines; see Supplementary Data, Tables S3, S4). The received dates are comparable to other recent AMS ^{14}C bone dates from WTC sites (below, see Supplementary Data, Table S2).

The first occupational event identified by the dates from the site of Konovka-Putsyta originates from Ploshchadki 3 and 12 (*Shmaglij* et al. *1985*), which contain ceramic assemblages matching the earlier part of the Shipinetskaya local group (Tripolye BII). The absolute dating of the Shipenetskaya local group is mostly unknown, though we may compare our results against seven AMS dates on human remains from Verteba Cave (*Lillie* et al. *2017*), which are associated with Late Shipinetskaya (Tripolye BIII) pottery that Tkachuk synchronizes with the earliest phases of the Badrazhskaya local group (*Tkachuk 1998*). However, the ^{14}C results are still far younger than expected (3800–3650 cal BC on 2σ; 3740–3710 cal BC [modelled]), closer in age to middle-late Tripolye BIII. In this respect, we assume that there is further occupation at this site dated to the middle of Tripolye BIII. However, this assumption requires further confirmation.

Our five dates from Rubanyj Most all come from Ploshchadka 1, excavated in 1989 (*Tsvek, Movchan 1990*). Results from this site (3945–3710 cal BC on 2σ; 3790–3740 cal BC [modelled]) correspond almost exactly with the presumed position and duration of the settlement's relative chronological phase (Nebelevskaya phase 2, stage 3; *c.* 3800–3750 BC). This confirms the previously suggested overlap between the late settlements of the second phase of the Nebelevskaya local group to the earlier sites of the Tomashovskaya group in the SBDI, including the giant-settlement of Dobrovody (*Diachenko, Menotti 2012*). This assumption is also supported by finds of Tomashovskaya group ceramics at this site.

The dominant ceramic assemblage of the giant-settlement of Majdanetskoe belongs to Tomashovskaya phase 3 stage 2 and showcases numerous influences from the Chechelnitskaya local group, as well as similarities that allow synchronization of this site to the early Badrazhskaya group settlements (*Tkachuk 2008*). While there are numerous AMS dates from Majdanetskoe, these occupy an exceedingly broad temporal range (*e.g., Olhrau 2020*) and date a diverse set of features. Majdanetskoe is a highly unusual site in terms of its layout and developmental trajectory, and may indeed include multiple phases of occupation. However, further consideration of the chronology of this site requires extensive study of its ceramic inventories. The influences seen in ceramics of Tomashovskaya phase 3 stage 2 are crucial for the inter-regional synchronization of the WTC settlements located in the Dniester region and the SBDI and necessitate a date of *c.* 3700–3650 BC. Consequently, we follow the observations of Taras Tkachuk (*2008*), who underlines the synchronous development of the Late Petrenskaya, Early Badrazhskaya and Late Tomashovskaya group sites.

Two dates were obtained from Ploshchadki 2 and 3 at Kamenets-Podolskiy (Polskij Rynok), a recently excavated site (unpublished excavations by D. Chernovol and P. Nechitailo). Our results (3935–3680 cal BC on 2σ; 3710–3645 cal BC [modelled]) confirm the chronological position of phase 3 of the Petrenskaya local group and associated site types, confirming earlier chronologies made based on material culture exchange and older ^{14}C dates (*Diachenko, Harper 2016; Diachenko, Menotti 2015; Diachenko, Sobkowiak-Tabaka forthcoming; Ryzhov 2003; Tkachuk 2008; cf. Markevich 1981*). Two sites in Kamenets-Podolskiy (Tatarysky and Polskij Rynok) have now been dated, both of which help to situate the relative chronology of the Petrenskaya group sites (*Ryzhov 2003*), especially with regards to charting the development of the Pentrenskaya phase 2 sites. Available relative chronological data suggest that these sites developed sequentially during the period of *c.* 3900–3700 BC, indicative of two stages within this phase (most notably represented by the sites of Stolniceni and Petreni, respectively). AMS radiocarbon data from Stolniceni and Petreni agree with this interval, though remain somewhat ambiguous as to the sequence of the sites (*Hansen, Uhl 2016; Țerna* et al. *2019*). Our dates from Polskij Rynok establish a *terminus ante quem* for the Petrenskaya local group as a whole. Confirmation of this group's sequence is crucial for its support of the concept that the development of the CTCC was defined by multilinear cultural evolution (with different rates of cultural change characterizing different groups), as well as the ramifications it has for the proper reconstruction of migratory behaviour and cultural transmission in the WTC. This chronology is also supported by the date obtained from Ploshchadka 2 at Konovka-Putsyta (II) (3630–3375 cal BC on 2σ; 3645–3585 cal BC [modelled]), which confirms assumptions for the chronology of the Badrzazhskaya local group, which replaced the Petrenskaya group in the Middle Dniester region (*Diachenko, Harper 2016; Diachenko, Menotti 2015; Tkachuk 2008*). The core area of the WTC experienced different rates of cultural change, with a far earlier transition from Tripolye BIII to Tripolye CI in the Middle Dniester region in comparison to the Middle Bug region and SBDI.

Until now, chronologies assumed the presence of a hiatus between the settlements of the Tomashovska-

ya and Kosenovskaya local groups, owing to a poor understanding of the development of Tripolye CI and a reliance on older conventional ^{14}C dates from the eastern part of the complex (*e.g., Diachenko, Harper 2016; Kruts 1989; Ryzhov 2007; cf. Tkachuk 2008*). We obtained five new dates from the site of Kosenovka, from materials excavated from two ploshchadki in 1984 and 2004 (*Movsha 1987; Kruts* et al. *2005*). According to these results (3645–3365 cal BC on 2σ; 3585–3500 cal BC [modeled]), belonging to the first phase of the Kosenovskaya local group, we may amend the chronology of the SBDI so that the Kosenovskaya local group directly follows the end of the Tomashovskaya local group. This substantially revises the latter part of the giant-settlement sequence in the region and prompts a reassessment of the scale of migrations from the Dniester Valley to the east.

Finally, turning to the Tripolye CII sites dated by our project, we have two dates from the 1959 excavations at Stena 2 (*Makarevich 1960*) and a further two dates from Golyshev taken from samples uncovered in 1972–1973 (*Peleschishin 1998*). The chronology of Stena 2 (3335–3025 cal BC [2σ]; 3300–3135 cal BC [modeled]) and Golyshev (II) (3330–2920 cal BC on 2σ; 3135–3025 cal BC [modeled]) fit our views on the position of the Gordineshtskaya local group (*Diachenko, Harper 2016; cf. Videiko 1999*). Our dates are corroborated by AMS dates on Late Tripolye sites in the Dniester region, which are beginning to present a coherent chronology for the Brynzenskaya and Gordineshtskaya local groups. While our project lacks absolute dates for the Brynzenskaya local group, four recent dates from Costești 4, Văratic 5-Holm, and Brînzeni 3-Țiganca (*Rybicka 2019; Sîrbu* et al. *2020*) fill in this gap very well. We omit one anomalously old outlier from Brînzeni 11(9) (*Sîrbu* et al. *2020*); while this site is ascribed to the Brynzenskaya local group, multiple habitational layers exist there, and the results of its ceramic assemblage have never been formally published (*Țerna, Heghea 2017*). Our dates for the Gordineshtskaya local group are directly comparable to other AMS bone dates from mortuary sites like Pocrovca 5-Dealul Munteanu and Gordinești-La Izvor (*Sîrbu* et al. *2020*), the kurgan complex at Pridnestrianskoe (*Klochko* et al. *2015*), as well as the settlements of Hancăuți-La Frasin and Gordinești-Stînca Goală (*Rybicka 2019; Sîrbu* et al. *2020*).

Taken as a whole, the chronology of the WTC Late Tripolye groups agrees with our previous assessment, made before the availability of AMS-dated materials, that the Brynzensakaya and Gordineshtskaya local groups existed during the periods of *c.* 3500–3300 and 3300–3000/2950 BC, respectively (*Diachenko, Harper 2016*). The neighbouring Vykhvatinskaya and Usatovskaya local groups, located in the lower reaches of the Dniester and the steppe of the northwestern Black Sea littoral, are not as well dated. However, they more or less correspond with these same periods (*Dergachev 1980*), albeit with a lightly later transition. It is important to stress that, due to the presence of numerous Funnel Beaker and Baden-style influences in its ceramic complex, Golyshev is considered as the latest known Tripolye settlement in Western Volhynia (*Pozikhovskyj 2019*). Along with other recent radiocarbon dates, its chronology adds to the contention that *c.* 2950 BC constitutes the younger limit for the CTCC.

Diachronic change in WTC local group populations

On the regional level, the influence of giant-settlements of the SBDI is immediately and obviously discernible (Fig. 5). However, it is just as interesting (if not more so) to direct our attention to the serial settlement and abandonment seen within micro-regions along the forest-steppe corridor (Fig. 6). Our sample is biased towards the SBDI, so our results should be considered not in terms of definitive population sizes in different regions but taken as a general representation of demographic trends.

Several important observations can be made from this analysis:

❶ The Middle Dniester region is characterized by a permanent increase in population during Tripolye BII and Tripolye BIII, which explains why migrations were not directed to this area. Instead, migrants preferred regions to the east and north of the Dniester.

❷ The trend towards population decline in the Dniester region *c.* 4100–4000 BC corresponds to a demographic increase to the east. This trend corresponds to the spread of Rakovetskaya and Mereshovskaya-group ceramic traditions in the Dniester-Bug interfluve, the Middle Bug region and the SBDI (*Ryzhov 2007*). At the same time, migrants colonized the western part of Eastern Volhynia (*Kruts, Ryzhov 2000*). As shown by our dating of the Malice culture occupation at Golyshev, this territory was settled by post-Linear Pottery groups and the Lublin-Volhynian culture before it was further occupied by the WTC and Funnel Beaker-culture populations (*Kadrow 2013*).

❸ Two abnormally high increases in population in the Middle Bug region and SBDI are correlated with significant influences from Shipenetskaya group pottery traditions on the formation of ceramic styles of the Nemirovskaya and, later, Kurilovskaya local groups in the Middle Bug region and, respectively, Nebelevskaya and Tomashovskaya groups in the SBDI (see *Ryzhov 2007* for a detailed discussion of changes in these ceramic complexes).

❹ Demographic trends obtained for the Prut and Răut regions are inverse to each other, suggestive of west-east migration between these sub-regions. Further archaeological investigations in these areas are warranted, to examine whether our results are suggestive of trends of significant changes in pottery styles.

❺ The population decrease in the Dniester-Bug region after 3700 BC corresponds to an increase in population in the SBDI, suggesting another west-east migration wave. In terms of material culture, this event is also visible in significant amount of influences from the Chechelnitskaya group pottery traditions on Tomashovskaya group ceramic assemblages from the second stage its third phase (*Rud 2007; Ryzhov 2007; Tkachuk 1990*).

❻ The increase in population between 3650 and 3600 BC in the southern part of the Middle Bug region corresponds to a demographic decrease in the SBDI and northern part of the Dniester region. This trend corresponds to the formation of syncretic complexes combining Chechelnitskaya, Petrenskaya, Kurilovskaya, and Tomashovskaya group pottery styles in the Middle Bug region (*Ryzhov 2007*).

Discussion

The obtained dates make a significant contribution to the understanding of diachronic changes in WTC ceramic styles and enable us to make several modifications to the current periodization and chronology (Fig. 7). The dates obtained for Tripolye BII sites continue to blur the transition between Tripolye BI and BII, indicating that the turn of the 4th millennium BC saw a great diversity in ceramic forms. While it was previously assumed to be a meaningful chronological category throughout the Tripolye culture, Tripolye BI-II ceramic assemblages should now be reconsidered only as regionally dispersed continuations of Tripolye BI stylistic traditions, synchronized with the latest sites of Tripolye BI and earliest sites of Tripolye BII (*Diachenko 2016a; Palaguta 2007; Tkachuk 2019*). This assertion fits with previous observations regarding the relative rarity of settlements attributed to this 'period' (*Dergachev 2007; Rassamakin 2012*) and is consistent with analysis of ETC settlements in the SBDI, which form a distinct cultural sequence overlapping with the WTC giant-settlement phenomenon. ETC sites ascribed to Tripolye BI-II exhibit a high degree of variability in terms of radiocarbon dating, indicative more of stylistic lineages than an archaeological period (*Harper* et al. *forthcoming*). In the WTC and ETC alike, our chronological revisions support a return to Passek's (*1949*) general classifications for Tripolye BI and BII.

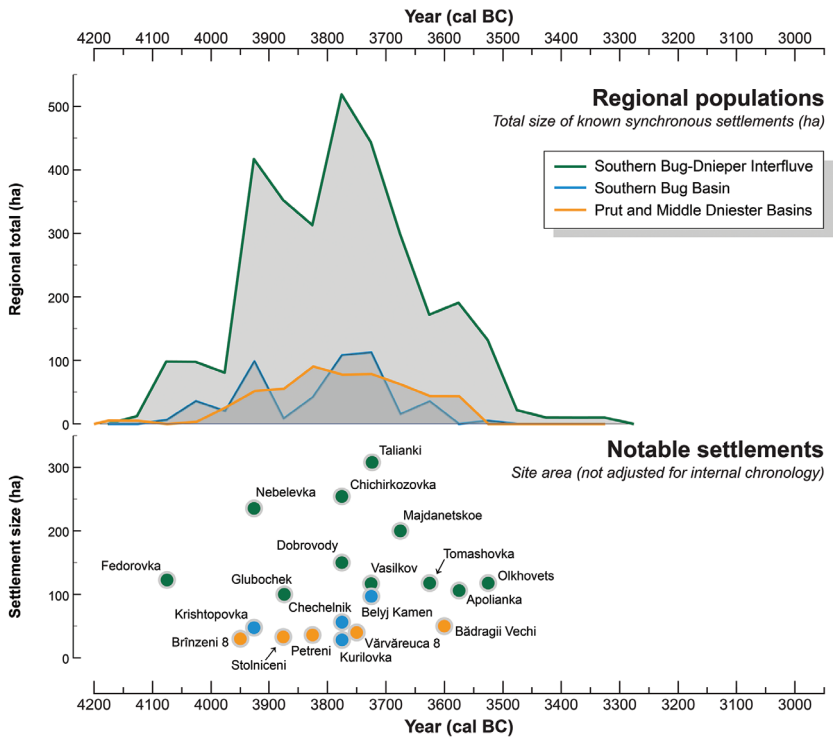


Fig. 5. Population trends across the three major regions of the study area, as calculated by Harper's derivative of the SARP model. The settlements of the SBDI are substantially larger than those of other WTC- inhabited regions, with few settlements outside this region even approaching the 'giant' category.

Different regions and sub-regions inhabited by WTC populations demonstrate a chronological overlap with earlier

and later traditions, which confirms previous relative synchronizations made based on material exchange. These overlaps are characterized by decreasing rates of cultural change from west to east in the years preceding 3300 BC, as was suggested by mathematical simulations (*Diachenko, Menotti 2015*). More specifically, the beginning of Tripolye BIII in the Dniester region is dated to 3900 BC (the early settlements of the Petrenskaya local group being characterized by ceramic traditions of Tripolye BII; see *Ryzhov 2003*), while in the Middle Bug region it is dated to 3850 BC. Pottery assemblages from the early sites of the Tomashovskaya local group demonstrate the synchronous presence of Tripolye BII and BIII styles, with the beginning of Tripolye BIII in the SBDI dated to 3800 BC.

The transition from Tripolye BIII to Tripolye CI ceramic styles is even more complex. In the southern part of the Dniester region this transition is dated to 3700 BC, when Tripolye BIII traditions were still dominant among ceramic assemblages at late Petrenskaya group sites in the northern part of the Dniester region. Considering the newly obtained dates for Kosenovka, the transition from Tripolye BIII to Tripolye CI in the SBDI is dated to 3600 BC. Approximately at the same time, *c.* 3600 BC, ceramic assemblages of the Dniester region are characterized by the transition from Tripolye CI to Tripolye CII. The Kocherzhintsy-Shulgovka-type sites of the SBDI indicate the transition from Tripolye CI to Tripolye CII in the region *c.* 3400–3350 BC (see also *Diachenko, Harper 2016; Kushtan 2015; Rassamakin 2012*).

The population model presented in this paper expounds on previous studies of demographic development and migration of the WTC populations, which found strong correlations between migratory behaviour, transformations in ceramic assemblages, and ecological and climatic factors (*Diachenko 2012; 2016a; 2016b; Diachenko, Menotti 2012; 2017; Diachenko, Zubrow 2015; Harper 2016; 2019; Harper* et al. *2019; Weninger, Harper 2015*). Our analysis indicates a constant increase in population in the core area of the WTC (the Dniester region), with the colonization of the areas to the east and north of the Dniester being the result of long-distance migrations. The latter are represented quantitatively as shifts from zero population to certain numbers indicating the colonization of new areas, and also as abnormally high increases in population (which also correspond to changes in pottery assemblages). Therefore, population pressure in the core area is considered the main factor in the dispersal of WTC populations to Central Ukraine. The mechanism is quite

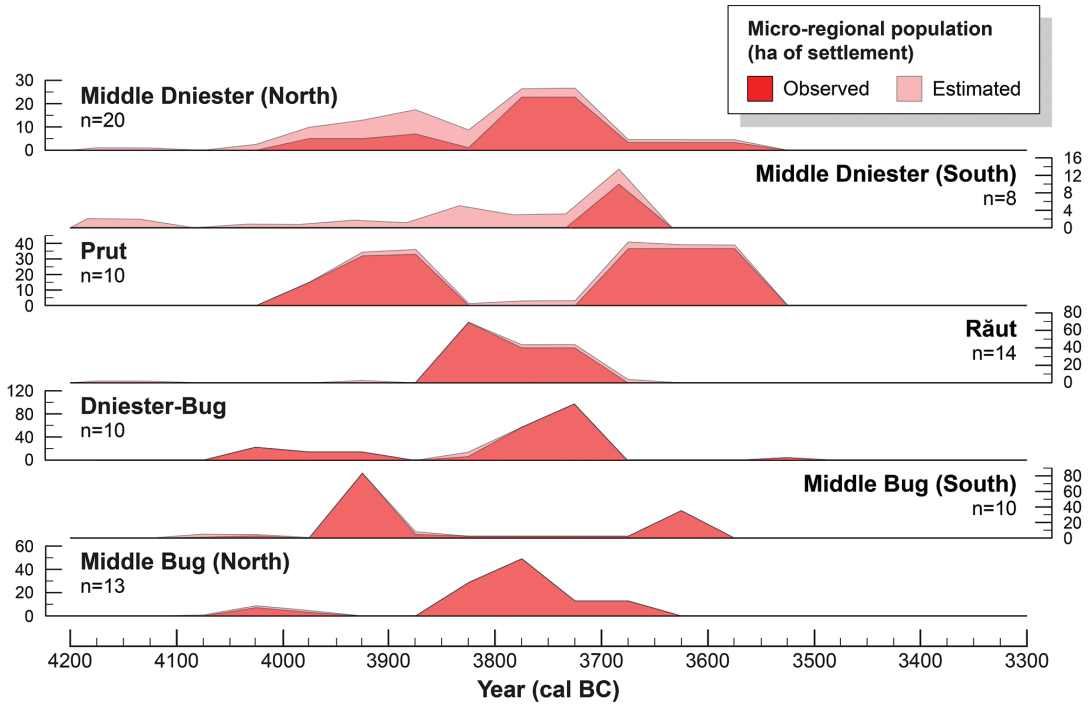


Fig. 6. Distributions of population development in seven micro-regions in Moldova and Ukraine, expressed according to the total area of synchronous settlements. Dark shading indicates the contribution from settlements with known size, while light shading indicates the estimated population from settlements with unknown size parameters.

similar to that seen for ETC migrants to the SBDI and Middle Dnieper regions. The high mobility of the ETC populations led to the first agrarian colonization of this area (*Harper* et al. *forthcoming*), while subsequent WTC populations came in repeated 'recolonizations' that targeted different micro-regions.

In the broader regional context, the beginning of the development of the WTC post-dates the famous Varna I Necropolis (*c.* 4590–4340 cal BC; *Krauß* et al. *2017*), as well as the vast majority of tell settlements of the Kodjadermen-Gumelnița-Karanovo VI (KGK VI) complex. In Romania, two 'collapses' can be perceived: the first at the end of Gumelnița A2 (*c.* 4100 BC) and the second at the end of Gumelnița B (*c.* 3900 BC; *Harper 2016*). The first instance is of particular interest to the expansion of the CTCC, as the territory of the Stoicani-Aldeni variant of the Gumelnița-culture (which previously extended into Romanian Moldavia) was subsumed by the expansion of groups bearing Cucuteni material culture (Cucuteni A4 and AB) at the same time that the WTC was developing and expanding into Ukraine. The later, final extinction of tell settlements in the Danube Valley during Gumelnița B (synchronous with the giant-settlement phenomenon of Tripolye BII and BII) came at a time when European settlement systems, and climatic systems, were in a state of flux. The upland settlements of the subsequent Cernavodă I culture represent a fundamental shift in economic practices and settlement location (*e.g., Anthony 2007; Weninger, Harper 2015*). It is not known whether the gradual collapse of settlement systems associated with the KGK VI complex influenced the massive population increases perceived in the WTC, or whether such divergent patterns are simply representative of regionally variegated responses to changing climate (*Harper 2019; Harper* et al. *2019*).

Conclusions

The results presented in this paper build upon others presented from our project (*Harper* et al. *forthcoming*) in supporting and building upon a syncretic relative chronology established for groups throughout the CTCC. High-resolution AMS dates and Bayesian sequencing support the general principle that ceramic types are highly predictive of the chronological age of settlements. In those situations where some data diverged from relative expectations, such as the sites of Lipchany and Konovka, our results may guide reanalysis and fieldwork in contexts that

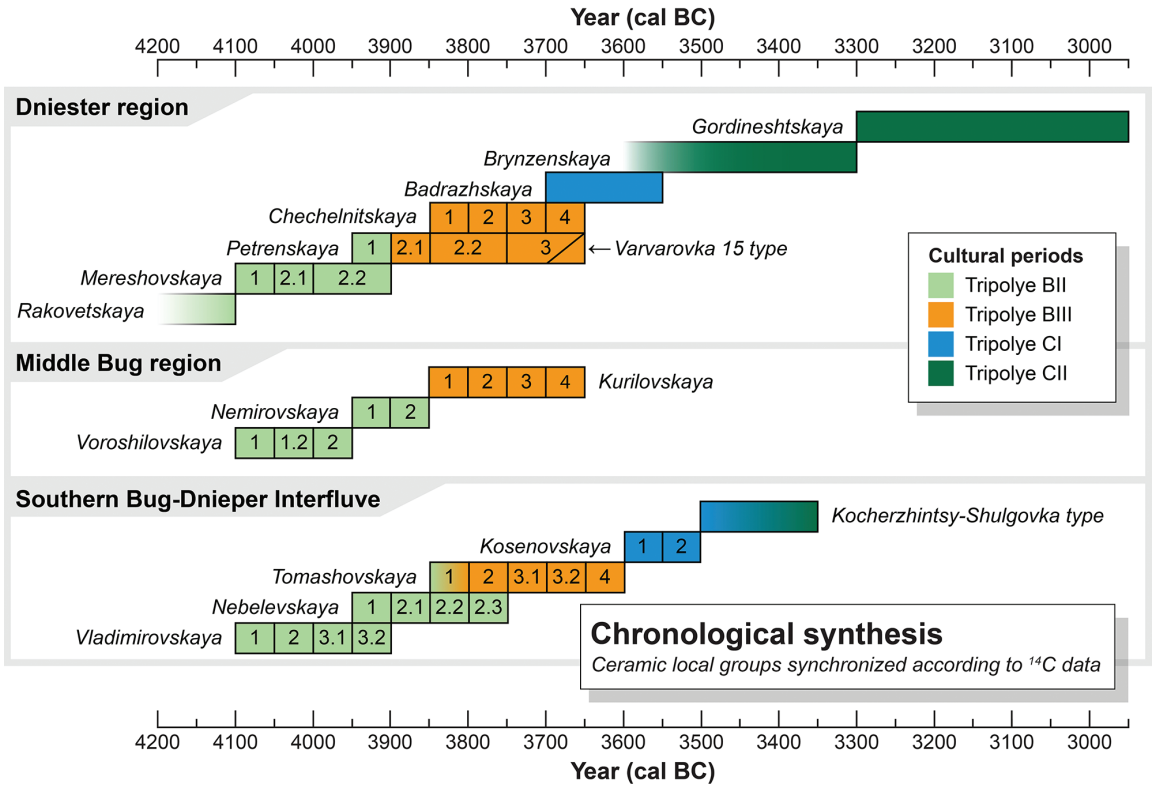


Fig. 7. Our new chronological synthesis for the WTC. Labels in italics beside boxes indicate the names of relevant local groups and site types. Numbers indicate phases and stages. It is important to note the prominent lag times (c. 50–200 years) in the development of Tripolye BIII, CI, and CII when looking west-to-east across the WTC, contradicting the traditional concept of rapidly disseminated cultural horizons.

were traditionally considered to be single-habitation and excavated with the assumption that multiple layers would not be encountered.

Through the creation of a new chronological synthesis, we may hone our existing settlement archaeology data and their derivative models, enabling more precise consideration of the intersection between human settlement, subsistence, climate, and ecology at the north-eastern frontier of 'Old Europe'. We highlight the substantial bias that exists between data in the SBDI and other regions of the WTC, and consider that continued improvement of these datasets should be undertaken with colleagues working in the Dniester region of Ukraine and Prut-Dniester region of Moldova. However, the available data still enable us to explicate the highly targeted and ephemeral nature of Eneolithic settlement, which was characterized by both punctuated settlement and abandonment on the local level and more gradual diffusion of material culture traits on the regional level.

Our dates are important for the delineation of major archaeological phenomena. Important for the consideration of the CTCC as a whole, our Tripolye CII dates from Golyshev reinforce the viewpoint that the transition to the Early Bronze Age was rapid and occurred no later than 2950 cal BC. These results agree with other recent AMS dates from the latest sites of the Tripolye culture and related Terminal Eneolithic contexts, and may put to rest the anomalously young results obtained from conventional ^{14}C dates using liquid scintillation and gas proportional counting methods.

In the case of the SBDI, we provide the first high-resolution dates for the Kosenovskaya local group, establishing a *terminus ante quem* for the giant-settlement phenomenon at *c.* 3500 cal BC. In concordance with our dates from Peshchanoe and Rubanyj Most, as well as consideration of sites AMS-dated by other projects, we confirm the validity of the relative sequence of sites, which proscribes short (at most, *c.* 80-year) habitational periods for most settlement sites. In response to assertions to the contrary, we would continue to assert the importance of considered and scientifically grounded ^{14}C analysis, as well as pottery seriation, that considers the whole cultural and chronological context of these sites.

Supplementary materials are available at http://dx.doi.org/10.4312/dp.48.11.

Author contributions

T. K. Harper and A. Diachenko designed research; T. K. Harper, A. Diachenko, and L. R. Eccles performed analysis; T. K. Harper, A. Diachenko, Y. Y. Rassamakin, D. K. Chernovol, V. A. Shumova, P. Nechitailo, V. V. Chabaniuk, E. V. Tsvek, N. M. Bilas, Y. V. Pohoralskyi, and S. N. Ryzhov contributed data; T. K. Harper created the figures; D. J. Kennett supervised research; T. K. Harper and A. Diachenko wrote the text, with input from S. N. Ryzhov, Y. Y. Rassamakin, L. R. Eccles, and D. J. Kennett.

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Early Neolithic ritual funerary behaviours in the Westernmost regions of the Mediterranean: new insights from Dehesilla Cave (Southern Iberian Peninsula)

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ABSTRACT – *An intact archaeological context named Locus 1 has recently been discovered at Dehesilla Cave (southern Spain). The ritual funerary deposition consists of a complete pottery jar with part of a human calvarium over the mouth, and was occulted by large stone blocks. This paper offers a presentation of the new data provided mainly by the stratigraphic, osteological, pottery, lithic and radiocarbon analyses. A systematic review of the relevant evidence in the Iberian Peninsula during the Early Neolithic (*c. *5600–4800 cal BC) provides a context for this finding and supports its interpretation with reference to several possible anthropological scenarios.*

KEY WORDS – *Neolithic; ritual; human skull; pottery jar; residue analysis*

Zgodnje neolitski pogrebni obredi v najbolj zahodnih regijah Sredozemlja: nova spoznanja iz jame Dehesilla (južni Iberski polotok)

IZVLEČEK – *Nedavno so v jami Dehesilla (južna Španija) odkrili nepoškodovan pogrebni kontekst Locus 1. Gre za v celoti ohranjen keramičen lonec z delom človeškega lobanjskega svoda nad usti, ki je bil prekrit z večjimi kamnitimi bloki. V prispevku predstavljamo nove podatke, ki smo jih pridobili na podlagi stratigrafske in osteološke analize, analize keramike in kamnitih orodij ter z radiokarbonskim datiranjem. Najdbo postavljamo v kontekst s pomočjo sistematičnega pregleda relevantnih podatkov iz zgodnjega neolitika (ok. 5600-4800 pr. n. št.) na Iberskem polotoku in podpremo interpretacijo s sklicevanjem na različne možne antropološke scenarije.*

KLJUČNE BESEDE – *neolitik; obred; človeška lobanja; keramični lonec; analiza ostankov hrane*

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Introduction

Neolithic funerary practices in the Iberian Peninsula have caught the attention and interest of many archaeologists (*e.g., Bernabeu* et al. *2001; Rubio 2001; Pascual 2002; Gibaja 2004; Chambon 2008; Jiménez-Brobeil 2009; Bernabeu 2010; Carrasco* et al. *2010; Pérez-Fernández, Soler 2010; Garrido-Pena* et al. *2012; Alonso, Jiménez-Echevarría 2015; Rojo* et al. *2016*) as an empirical record of particular importance, as a direct means of approach to the populations of the past and, especially, to their symbolic and ritual behaviours.

In recent years, an increase can be observed in the archaeological evidence related to funerary practices during the Early Neolithic, *c.* 5600–4800 cal BC, in the Iberian Peninsula. A major body of information comes from cave sites in which disarticulated or isolated human bones are commonly found alongside other artefactual and faunal remains, admittedly as the probable result of complex cultural and post-depositional processes. When present, inhumations are usually individual, although several burials may be placed in the same area. There are also some unusual cases of secondary burials and rare multiple graves. For the same period, a smaller number of burials are known at open-air sites, where they tend to belong to individual and very rarely multiple inhumations inside pits within the living areas. The articulated bodies are generally placed in a flexed lateral decubitus position, with variable assemblages of grave goods or accompaniments, essentially of pottery, stone tools, worked bone, shell elements, and faunal remains (*Garrido-Pena* et al. *2012.145–147*).

Dehesilla Cave (Cueva de la Dehesilla), located in the foothills of the Sub-Baetic System in southwestern Spain (Fig. 1), holds one of the oldest and richest Neolithic funerary records known in the Iberian Peninsula, although apparently unevenly distributed within the cave. The excavations carried out in 1977 and 1981 documented a series of burials (c. 8) attributed to the Early Neolithic (*Acosta, Pellicer 1990*) (extended information is provided in the Discussion), while the excavation of Area C003 during the 2016 field season (*García-Rivero* et al. *2018a*) documented only a few isolated human bones in the Early Neolithic levels. Another ritual funerary context named Locus 2 has been published recently, but belongs to a later archaeological period, namely the Middle Neolithic (*García-Rivero* et al. *2020*).

During the archaeological excavation of Area C006 in 2017, a depositional context was discovered located in one of the innermost chambers of the cave, identified as Unit 10-Locus 1 (hereafter, Locus 1). This find takes on particular interest and importance, not only because of its singularity but also because it offers a unique opportunity to learn more about the ritual and funerary behaviours of the communities of the second half of the 6th millennium cal BC in the Iberian Peninsula.

The aim of this paper is thus twofold: first, to present the new finding documented at Dehesilla Cave, supported by a wide range of data provided by the technical means available today in archaeology; and second, to place this ritual funerary deposition within the broader context of the contemporaneous and comparable data known at present in the Iberian Peninsula. This comparative approach enables not

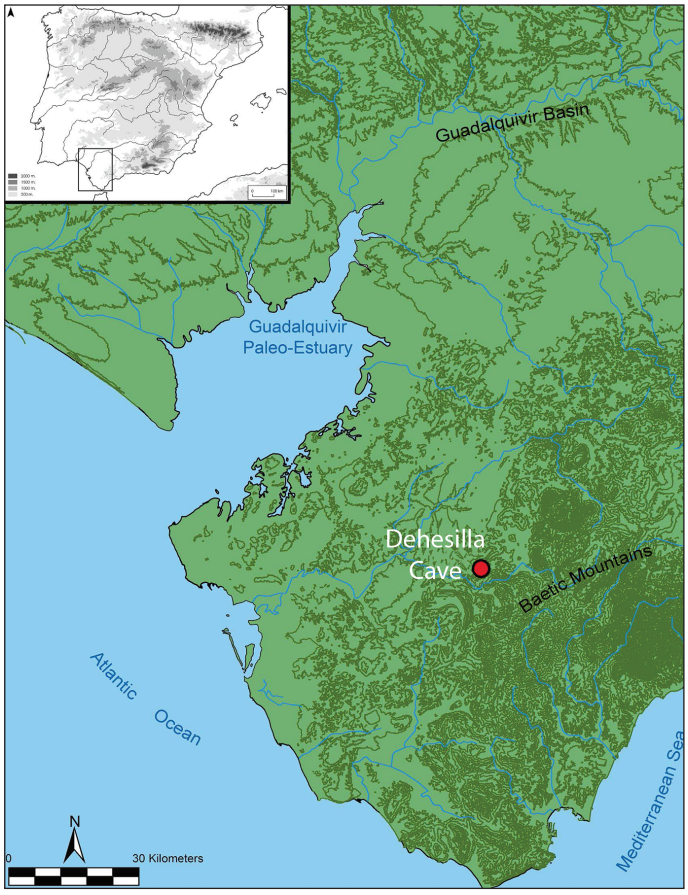


Fig. 1. Location of Dehesilla Cave (Theme map: https://www.naturalearthdata.com/ and http://www.juntadeandalucia.es/insti tutodeestadisticaycartografia).

only a systematic review of the current evidence, but also supports the formulation of a likely interpretation for the new archaeological context presented here. Moreover, it will enable us to highlight the singular characteristics of the Dehesilla Cave, Locus 1 deposition, and to shed new light on the ritual funerary behaviours during the Early Neolithic period in the Iberian Peninsula.

Materials and methods

Archaeological excavation

The unpublished context and data presented here are provided by the recent excavations carried out at Dehesilla Cave, and more specifically by the second excavation season, in 2017, and the work carried out in Area C006 located in Room 4, one of the innermost chambers of the cave (Fig. 2). The location of C006 coincides with an area in which the surface sheet of flowstone was broken and absent (Unit 0) and the irregular shape of the trench corresponds exactly with its limit. The excavated area is approx. 5m^2, with a length of 5m running parallel to the west wall of the cave and a width of 1m. The excavation confirmed that only the upper levels immediately beneath the flowstone sheet were affected by recent human and animal activities. The excavation proceeded with great care, paying particular attention to the definition of the contacts between stratigraphic units (*Harris 1991*). The elements associated with the deposition were clearly identified and documented, and all of the archaeological materials and samples were recorded accordingly. The location of the archaeological features and finds was recorded in the field using total stations and laptops with EDM Mobile software (*Dibble, McPherron 2010*). The sediment was screened and a stable proportion was processed by flotation. Unprocessed samples were set aside for further analyses.

Human remains

The human remains were analysed with the naked eye, with a magnifying glass (10x) and a Dino-Lite Edge Digital Microscope with a 30x to 70x magnification range. The state of preservation was assessed according to Jane E. Buikstra and Douglas H. Ubelaker (*1994*). Sex diagnosis, in one case, was based on the maximum length of the talus, following Silva (*1995*). The estimation of age at death considered the traits recommended by Louise Scheuer and Sue Black (*2000*) for the non-adult individual, while the closure of the cranial suture of the adult individual was assessed according to Claude Masset (*1989*). Dental wear was described following Holly B. Smith (*1984*).

Pottery analysis

The methods applied in the pottery analysis (*Shepard 1956; Sinopoli 1991; Orton, Hughes 2014; Rice 2015; Hunt 2016*) aimed to assess and reconstruct the probable nature of the depositional and taphonomic processes behind the creation of the assemblage under study, and to enable the typological (formal and decorative) characterisation of the ceramic materials. The quantification of the number of pottery fragments and the individual measurement of their size and weight helped to establish a series of reference values for the fragmentation of the deposit. After initial descriptive statistics, size was finally retained as the most appropriate proxy variable for the state of fragmentation. An exercise in cross-fitting was also completed, with the specific purpose of identifying sherds belonging to the same pots, with or without a direct physical connection.

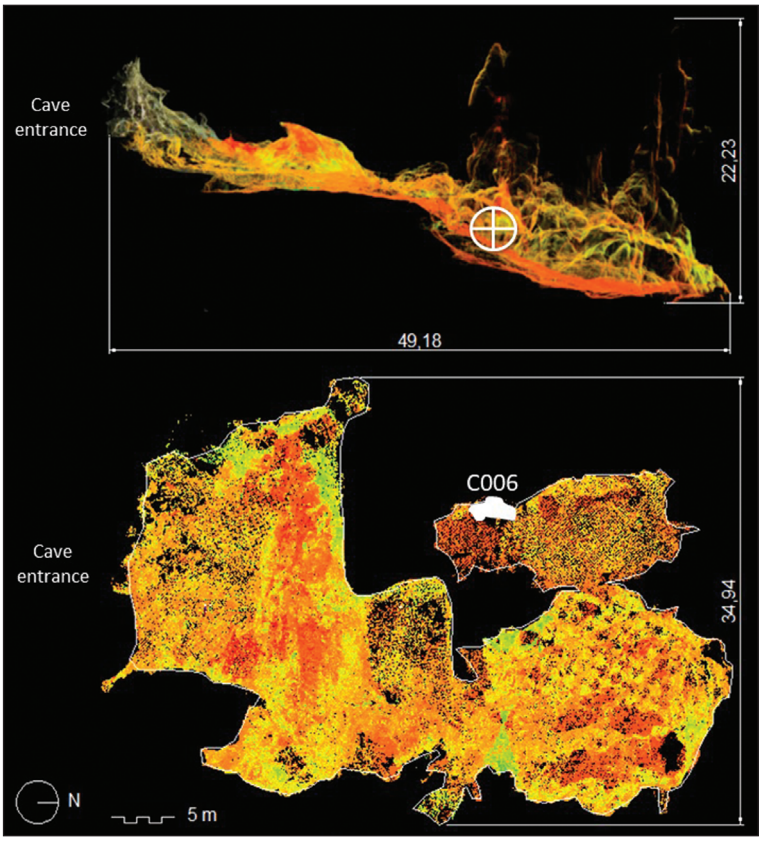


Fig. 2. Location of excavation area C006 on the 3D model of the cave.

Organic residue analysis was carried out on four pottery samples. The method applied focused on the organic residues absorbed by the clay matrix. Lipids were extracted following established protocols of one-step extraction and methylation with acidified methanol (*Craig* et al. *2011; Correa-Ascencio, Evershed 2014*). Gas Chromatography-Flame Ion Detection (GC-FID) and Gas Chromatography-Mass Spectrometry (GC-MS) were used for all samples (Appendix 1). High Temperature Gas Chromatography-Mass Spectrometry (HTGC-MS) and Gas Chromatography-Combustion Isotope Ratio Mass Spectrometry (GC-C-IRMS) were applied on the single successful sample after the previous methods (Appendix 1). Stable carbon isotope values of methyl palmitate ($C_{16:0}$) and methyl stearate ($C_{18:0}$), as derived from precursor fatty acids, were measured by GC-C-IRMS, following existing procedures (*Craig* et al. *2012*). The isotopic values of the main fatty acids (palmitic and stearic) were compared with compiled data from ruminant and non-ruminant adipose, and dairy and marine derived fatty acid resources throughout Europe (Appendix 2).

Lithics

The stone tools were counted and analysed in two main groups: knapped and ground stone. The study of the knapped materials followed the Georges Laplace's (*1966*) analytical typology for retouch and extraction techniques, while the characterisation of particular technical attributes was complemented by the classification put forward by Bernaldo-Quirós *et al.* (*1981*). The metric description of the material was based on Bernardino Bagolini (*1968*). Backing, patina and macroscopic use-wear was determined by observation with a 20x magnifying glass. The typo-technological analysis followed the main syntheses and terminological proposals for the western (*Carvalho 1998; Carvalho, Gibaja 2005*), southern (*Martínez-Fernández, Afonso 2008*) and eastern (*Juan-Cabanilles 2008*) regions of the Iberian Peninsula.



Fig. 3. Panoramic view from the centre to the South of Room 4.

The archaeological deposit Locus 1

Archaeological context

Area C006 provides valuable information on the depositional processes of Room 4 (Fig. 3), the innermost and furthest chamber from the present-day mouth of the cave. The excavation documented a complete stratigraphic sequence and has made possible a number of observations regarding the nature and use of this part of the cave.

The surface level is constituted by a sheet of flowstone (Unit 0) with microgours and a thickness between 5 and 20cm. Underneath the flowstone the sequence includes several thick layers, which appear to correspond to natural depositional events in which rocks, sediments and water may have been carried down from Room 2 or, possibly, through cracks and chimneys in the roof of the cave. These levels display a descending south to north slope, *i.e.* from the hillside to the interior of the cave, and form a wedge-shaped accumulation in the southern half of the room. The anthropic sequence is formed by a number of levels defined on the basis of their stratigraphic characteristics and archaeological materials, belonging to different Neolithic periods (Fig. 4). This sequence spans (from top to bottom) from Late Neolithic (units 0, 1 and 4), Middle Neolithic B (units 5, 6 and 6b), Middle Neolithic A (units 7, 9, Structure 1 and Locus 2), to Early Neolithic (Locus 1 and units 8, 11, 12 and 13). The upper level (Unit 8) of the Early Neolithic sequence displays a marked south to north descending slope, and contains numerous medium to large limestone blocks, some up to 70cm, possibly linked to rock fall and/or torrential events, and abundant archaeological materials.

During the formation of Unit 8, or soon after, an anthropic depositional event took place (Figs. 5 and 6.a). Locus 1 is therefore partially encased within Unit 8, although in proximity to its upper contact. The archaeological materials documented in Unit 8 are dated to the Early Neolithic, as are those of the depositional event. The deposition consists of a pottery vessel

(No. C006-244) (Fig. 6.b) placed upright, surrounded by small stones, devoid of sediment but containing a light-coloured crust (Fig. 6.c). The mouth of the jar was covered by part of a human calvarium, and other isolated human remains were found among the packing stones. Finally, it was covered by a number of larger blocks, resting on a ring of medium-sized stones placed for this purpose around the mouth of the jar and supporting a final limestone capstone. This deposition may have involved the excavation of a small negative feature, not detected between the packing materials and the surrounding sediment.

The human remains

The human cranium covering the mouth of the pottery vessel is represented by the posterior portion of the frontal bone and the anterior portion of the right and left parietal bones (Fig. 7.a), with an antero-posterior measurement of 180mm and medio-lateral of 130mm. The endocranial surface was facing down, and the frontal bone was oriented to the north.

This calvarium belonged to an adult, most probably of more than 45 years of age, based on the Stage 3 closure of the observed portions of coronal and sagittal sutures. Sex could not be determined since cranial thickness, which is average, was the only trait that could be assessed, therefore not permitting a reliable diagnosis.

The ectocranial surface displays two linear marks on the right side of the frontal bone (Fig. 7.b), both running perpendicular to the sagittal line, approx. 45 and 47mm from the coronal suture. With a length of 20 and at least 30mm, these marks are 2 to 3mm apart, almost parallel to each other. They are narrow and shallow, and display smooth (not jagged) sharp (well-defined) edges, a V-shaped cross-section and micro-striations (Fig. 7.c). The absence of bone remodelling indicates their *peri-* or *post-mortem* timing.

Several traits support the *peri-mortem* and anthropogenic nature of these marks. The colouration of the incisions, similar to the rest of the bone surface, points to marks made only a short time after death, while the bone still preserved all of its biomechanical properties. In contrast, *post-mortem* marks with a recent origin would be light in colour and have jagged edges (*Buikstra, Ubelaker 1994; White* et al. *2012; Gresky* et al. *2017*). Vascular impressions and markings from plant roots can be excluded due to the straight, linear and parallel aspect of the marks, and the presence of micro-striations. Trampling may also produce shallow striations but is expected to create marks with a random orientation (*White* et al. *2012*). The tooth marks made by carnivores are known to display a typical pattern of pitting, scoring and puncturing, particularly on the trabecular extremities of long bones (*Buikstra, Ubelaker 1994; White* et al. *2012*). However, they may also produce parallel grooves with different cross-sections depending on the tooth cusp (*Shipman 1981*), which are more difficult to distinguish from intentional marks. Rodent gnawing may also result in shallow, parallel or sub-parallel grooves, usually on bony prominences (*Buikstra, Ubelaker 1994; White* et al. *2012*). Yet, the marks produced by carnivores and rodents are square bottomed in section (*Shipman 1981; Buikstra, Ubelaker 1994; White* et

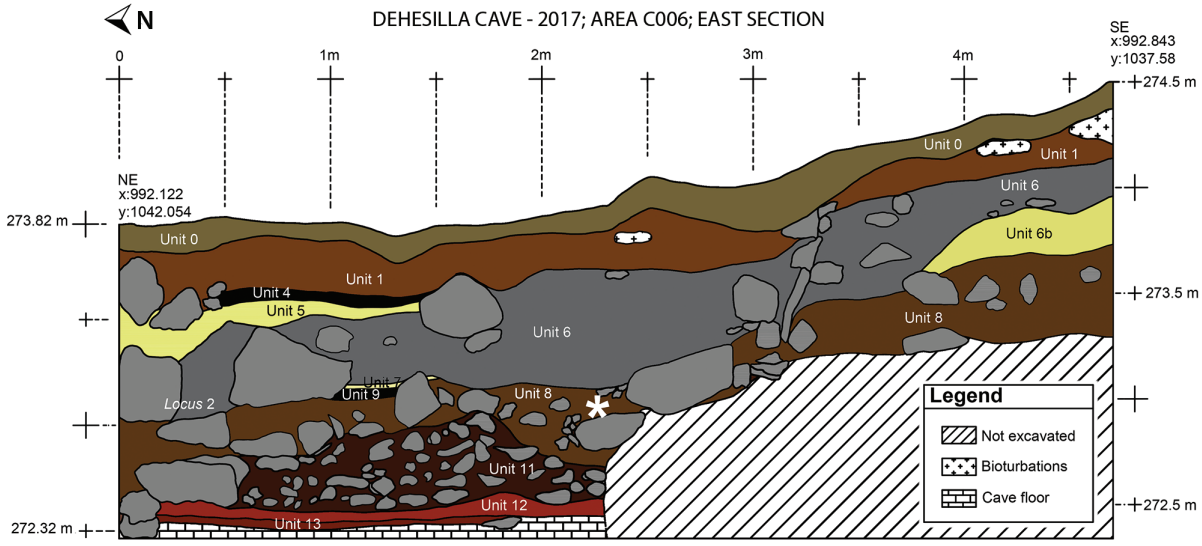


Fig. 4. East section of C006 (the white asterisk indicates the location on the section nearest to Locus 1).

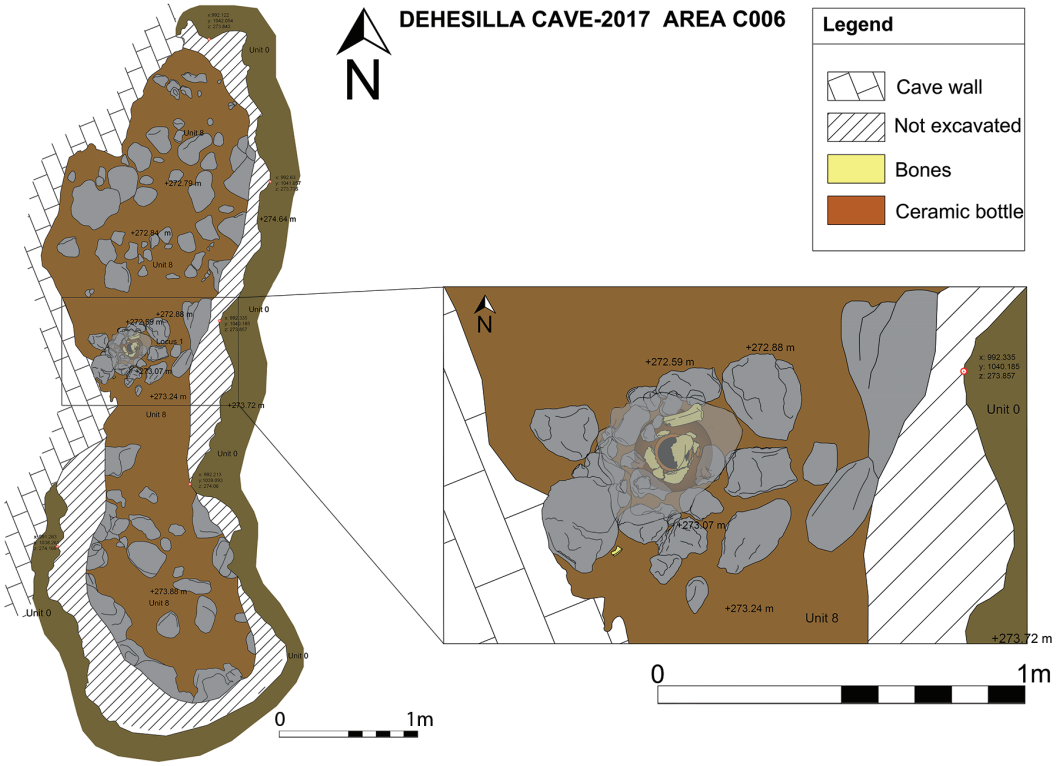


Fig. 5. Plan of the stratigraphic phase corresponding to Locus 1.

al. *2012*), a trait that is not observed in this case. The linear and parallel placement, the smooth edges and V-shaped cross-section, and the presence of micro-striations on the Locus 1 cranium are, therefore, strong evidence of the peri-mortem anthropogenic origin of the marks and are indicative of the use of a stone tool (*Shipman 1981; Bello* et al. *2016; Santana* et al. *2019*).

In addition to the cranium, another seven human bones and one tooth were recovered from Locus 1 (Tab. 1, Figs. 8 and 9). Sex determination and estimation of age at death were only possible in two cases. The complete talus (DH17-6-Locus 1–3), with a maximum length of 47.28mm, is consistent with a female individual. The thoracic vertebral neural arch (DH17-6-Locus 1–2) does not display the neurocentral fusion that usually takes place by the age of 6 (*Scheuer, Black 2000*), thus providing an upper age limit, while the lower age limit is provided by the fusion of the posterior synchondrosis that usually occurs by the age of 2 years (*Scheuer, Black 2000*). The thoracic vertebral neural arch may therefore be attributed to a child between the age of 2 and 6 years.

The poor preservation of the rest of the osteological material, characterised by small bone fragments representing less than 25% of the skeletal element, does not provide any further reliable information pertaining to sex and age at death, other than their belonging to adult individuals. The small size of the medial condyle of the femur may indicate a female or an adolescent individual. The same observation is valid for the scapula fragment from the region of the right glenoid cavity which, although incomplete, points most probably to a female. The only tooth recovered, a left mandibular first premolar, displays Grade 4 occlusal dental wear, according to Smith's (*1984*) classification.

With the exception of the thoracic vertebra from a non-adult individual, all of the other bones and the tooth could eventually belong to the same adult individual. The minimum number of individuals represented in Locus 1 would therefore be two and the maximum number eight, in the case that all of the elements belonged to different individuals. Only DNA analysis may, in time, shed light on this question. In any case, it is not clear beyond doubt that the fragmentary human remains, with the exception of the calvarium, were introduced intentionally in the deposition.

Pottery

The complete pottery jar (C006-244) deposited in Locus 1 is an ovoid form with a restricted neck and a simple rim, belonging to the type known as ampho-

roid or *botella* in common typologies (*Llobregat 1973; Bernabeu 1989*). Its surfaces are smooth, undecorated, with three approximately equidistant handles located on the gentle shoulder. It is slightly asymmetrical in the areas of the rim, neck and height of the handles (Fig. 10). The preservation of the base was compromised and could not be physically reconstructed, thus the curvature of the base and height of the vessel are estimated on the basis of the known parameters.



Fig. 6.* a *Locus 1 after removing the large limestone cover stone;* b *section of the deposition after the excavation of its northern half;* c *remains of a white crust inside the jar.

In addition to this complete jar, there is an assemblage of 50 pottery fragments with a total weight of 560g (Fig. 9). No sherds belonging to the same pots, with or without a direct physical refit, were identified. This is, therefore, a very strong suggestion that each pottery record of the Locus 1 fragmentary assemblage belongs to a different vessel, thus indicating a large number of pots although represented only by single and small fragments ($\bar{T}$ =3.7cm maximum axis).

This pattern of fragmentation and representation is in complete contrast to the physical integrity of the jar included as a central element of the deposition, thus supporting the reconstruction of a depositional event in which a single and complete pottery vessel was carefully placed. On the grounds of these observations, it is probable that the fragmentary pottery assemblage associated with Locus 1 may form part of the context merely as a component of the fill of the negative feature surrounding the deposited jar, that is as an incidental inclusion in the packing material.

The characteristics of the fragmentary pottery assemblage display strong affinities with the pottery record of Unit 8 in which the deposition was made. The formal and technological traits and the presence of characteristic decorative techniques place the context in an advanced Early Neolithic horizon, with a particularly noteworthy presence of impressed and 'almagra' wares (Fig. 11) (*Navarrete 1976; Navarrete, Capel 1980; Bernabeu 1989; Acosta, Pellicer 1990; Capel* et al. *2006; Pardo-Gordó* et al. *2021*). Applied decoration is documented in a single case in the form of a finger-impressed cordon. Incised decoration is also present, and is exclusively linked to slipped wares, mainly to the bright red 'almagra' pottery and secondarily to those of dull brownish hue.

There are eight fragments (all undecorated) with physical evidence of alteration from direct contact with heat sources, during long periods of time and/

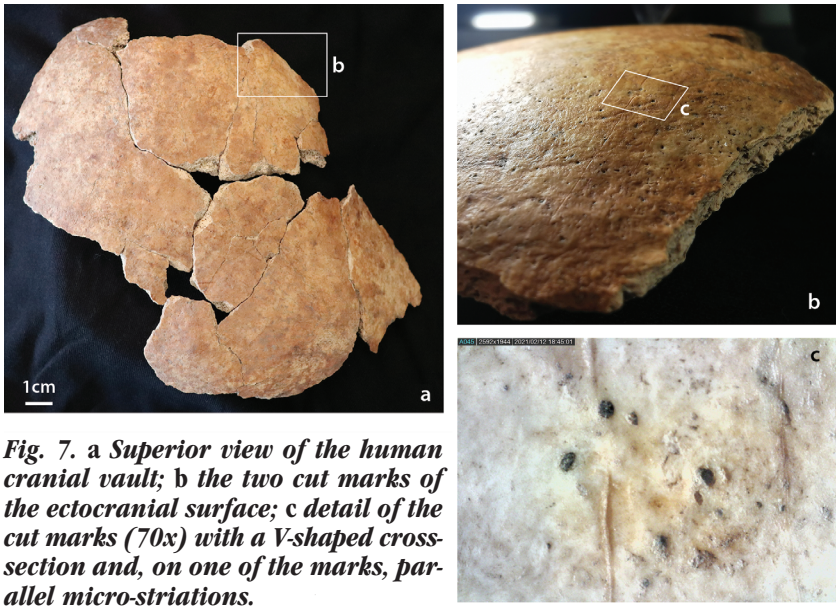


Fig. 7.* a *Superior view of the human cranial vault;* b *the two cut marks of the ectocranial surface;* c *detail of the cut marks (70x) with a V-shaped cross-section and, on one of the marks, parallel micro-striations.

or with low oxygen levels. Fragment ID-10 (C006-188) also preserves a carbonized residue and has been sampled for organic residue analysis (see below). The observed effect is the reduction-carbonization of the wall of these fragments from the internal surface of the vessel. This may indicate their use as fire holders or lamps, although not necessarily linked to the ritual deposition but explained more broadly by the location and conditions of the inaccessible chamber.

Organic residue analysis

Three samples from the pottery jar with visible remains of a white crust, and one sample from the above-mentioned fragment with carbonized residue, were analysed. Interpretable amounts of lipids (>5µg/g) were obtained from two samples (Tab. 2). However, in one of these cases the value is very close to the threshold. Low lipid preservation in the analysed samples is in accordance with other studies undertaken in the Mediterranean and southeastern Europe (*Evershed* et al. *2008; Spiteri* et al. *2016*). Just one sample LD-10 (the pottery sherd with carbonized residue, not the amphoroid jar) met the criteria in order to carry out further analysis by GC-MS and GC-C-IRMS.



Fig. 8. Assemblage of human remains from Locus 1.

The molecular composition is formed by a distribution of saturated fatty acids ($C_{14:0}$ and $C_{26:0}$), unsaturated fatty acids ($C_{16:1}$, $C_{18:1}$, $C_{22:1}$) and C_{23} alkane (Fig. 12). However, this molecular composition is limited due to the absence of specific sterols or molecular biomarkers. For that reason, we carried out the isotopic analysis ($\delta^{13}C$) of the two main saturated fatty acids ($C_{16:0}$ and $C_{18:0}$) to distinguish the resource type in comparison with modern authentic fats. As well as absolute ranges, ruminant adipose, ruminant dairy and porcine fats are distinguished according to differences in the carbon isotope values between the two main fatty acids ($\Delta^{13}C = \delta^{13}C_{18:0} - \delta^{13}C_{16:0}$) (*Copley* et al. *2002*).

Comparison of isotopic values ($\delta^{13}C$ $C_{16:0}$: –30.45 and $\delta^{13}C$ $C_{18:0}$: –30.94; $\Delta^{13}C$: 0.49) with modern European reference fats and oils (Appendix 2) suggests that the pottery vessel was probably used in the processing of mixed ruminant and non-ruminant animal resources. However, due to the low specificity of the chromatogram and the absence of any molecular biomarkers, this interpretation is based only on the isotopic signal of the palmitic and stearic acids. The result from sample LD-10, belonging to an indeterminate pottery form, is in accord with the pattern observed recurrently in the use of the

Specimen numbers	Skeletal elements	Side	Completeness	Age	Sex
DH17-6-Locus 1-2	Vertebral arch of a thoracic vertebra	–	100%	Non-adult	–
DH17-6-Locus 1-3 (C006-228)	Talus	Left	100%	Adult	Female
DH17-6-Locus 1-4 (C006-197)	Femur medial condyle	?	< 25%	Adult	Unknown
DH17-6- Locus 1-5 (C006-218)	Femur fragment from the anterior region	?	< 25%	Adult	Unknown
DH17-6- Locus 1-6 (C006-217)	Parietal bone (from the region of the sagittal suture)	?	< 25%	Adult	Unknown
DH17-6- 8-8 (C006-249)	Tibia (proximal half of the anterior and posterior region of the shaft)	Left	25–75%	Adult	Unknown
DH17-6-8-10 (C006-251)	Lower first premolar tooth	Left	100%	Adult	Unknown
DH17-6-10-1	Scapula fragment from the region of the glenoid cavity	Right	< 25%	Adult	Female?

Tab. 1. Human remains recovered from Locus 1.

earliest pottery of the Atlantic facade of the Iberian Peninsula (*Cubas* et al. *2020*).

Lithics

Locus 1 yielded a total of eight lithic elements, seven knapped and one ground (Tab. 3 and Fig. 9). The first group includes tools – blades and flakes with and without retouch – and reduction products. The second group contains only one element, identified as a fragment of a pebble used as a hammer stone as indicated by the surface scars (Fig. 13.L1-7).

The knapped lithic elements are made out of grey (3), beige (3) or brown (1) flint, and correspond to four blades, two flakes and one undiagnostic reduction flake. In addition to the traits described below, flat (2) and pointed (1) platforms and proximal truncation (2) are also documented. There is one case of a third extraction cortex and two cases of heat treatment, with and without the creation of thermal domes.

Among the tools, a sickle blade with a faceted proximal platform and abrupt, deep, and partially continuous distal retouch (Fig. 13.L1-4) and a meso-proximal blade fragment with a dihedral platform (Fig. 13.L1-1) are noteworthy, as they also display use-wear patina. The traceological analysis currently in progress on part of the Dehesilla Cave lithic assemblage confirms that the wear on the sickle blade is consistent with the cutting of cereals, with striations and abrasions in the form of pecking due to the cutting of stalks close to the ground. This type of element is similar to those documented in other Andalusian Neolithic caves, such as El Toro, Nerja, Murciélagos de Zuheros or the sites of Bajondillo and Los Castillejos (*Ibáñez, González 1996; Rodríguez 2004; Carvalho* et al. *2012; Perales* et al. *2015*).

The second element with use-wear is a fragment of a blade with a very sharp edge without retouch that, according to the traceological analysis, seems to have

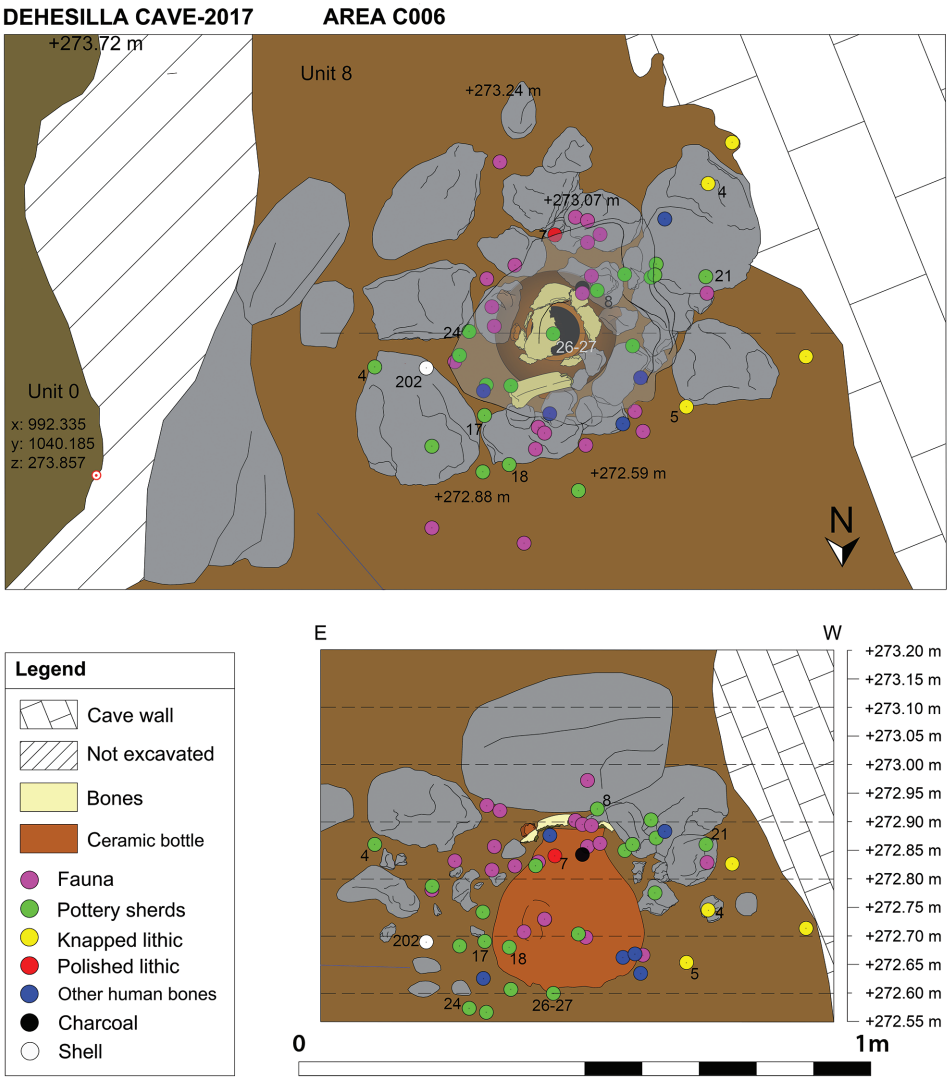


Fig. 9. Plan and section of the location of the archaeological materials documented in Locus 1.

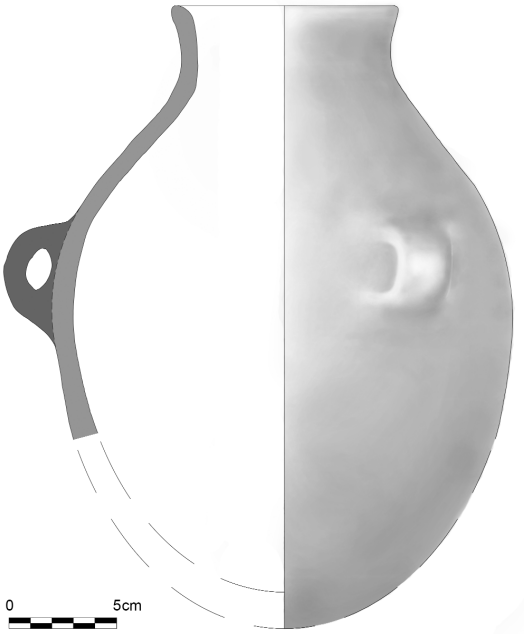


Fig. 10. Reconstruction of pottery vessel C006-244.

been used to cut an indeterminate soft material. In the context of Locus 1, it is perhaps possible to relate this instrument to the cut marks on the human calvarium and to the removal of flesh. However, as noted above regarding the accidental presence of pottery sherds, we cannot securely discard the same depositional nature of the elements of the lithic assemblage of Locus 1. Indeed, the types of elements found here are common throughout the entire stratigraphical sequence. Heat treatment, along with the presence of the sickle blade, are traits identified particularly in other Andalusian Neolithic sites (*cf. Ibáñez, González 1996; Vera 1997; Rodríguez 2004; Carvalho* et al. *2012; Morgado, Pelegrin 2013; Perales* et al. *2015; Gibaja* et al. *2017; Ibáñez* et al. *2017*).

Faunal and botanical remains

Small faunal remains were recovered from the sediment surrounding the pottery jar. Sheep or goat, suid, bovine, deer and rabbit are present, as well as some rare invertebrates. A Unionida valve, identified as *Potomida littoralis* (C006-202), was identified near the pottery vessel. The faunal assemblage of Locus 1 is identical in both taxonomical and taphonomic terms to Unit 8, surrounding the deposition, as well as to the contents of most of the levels of the same excavation area. It is therefore likely that these elements were included indirectly in the deposition. The only exception may be the freshwater mussel shell, since this kind of specimen is very unusual throughout the entire sequence.

Despite having processed a stable proportion of sediment by flotation, barely any botanical remains were recovered, with the exception of a fragment of taxonomically indeterminate carbonized seed and a few, very rare, wood charcoal fragments, including wild olive and an unidentified angiosperm. The relationship of these botanical remains with the Locus 1 depositional event cannot be safely assumed, as has been suggested with regard to other materials discussed above.

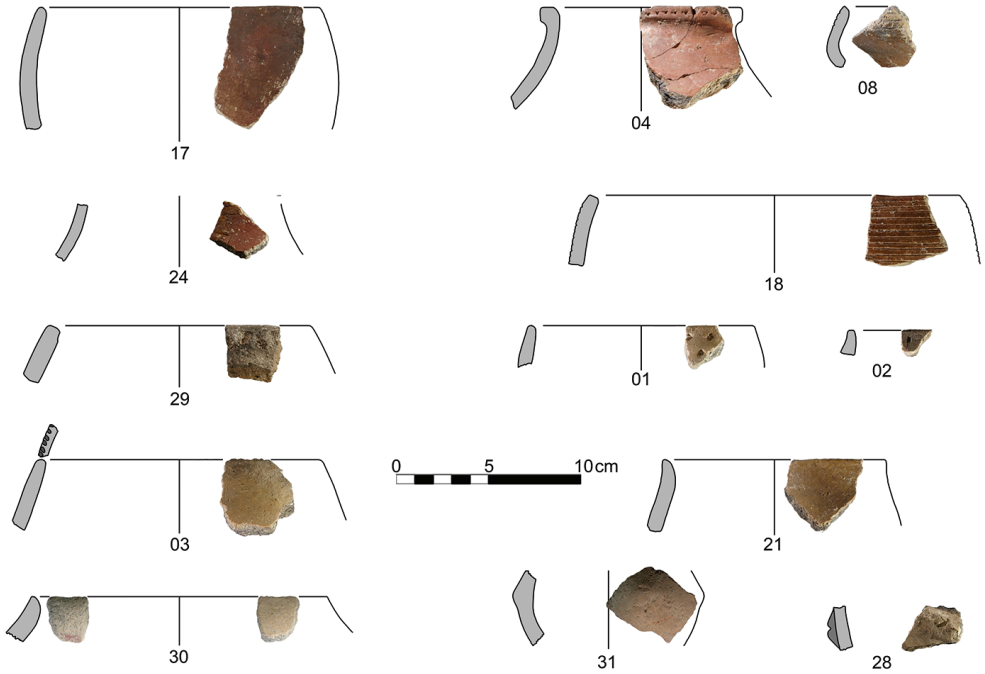


Fig. 11. Selection of the fragmentary pottery assemblage recovered from Locus 1.

Radiocarbon dating

Two samples were selected from Locus 1 for radiocarbon dating: one from the human cranium itself, and the other from the white crust from inside the pottery vessel. The latter unfortunately did not work, while the sample from the skull bone dated to 5222–5036 cal BC (calibrated to two sigmas) (Tab. 4). This date is consistent with the characteristics of the pottery assemblage.

This new date is also coherent within the current body of radiocarbon dates in the Iberian Peninsula. Recent reviews of these dates have established a fundamental chronological span for the Early Neolithic between *c.* 5600–4800 cal BC, which, in addition, supports the first Neolithic arrivals to the Iberian Peninsula by way of the Mediterranean coast (*Rojo* et al. *2012; García-Puchol* et al. *2017; Bernabeu* et al. *2018*).

The available radiocarbon dates for the Andalusian Early Neolithic indicate a maximum range *c.* 5500–4700 cal BC, but there is generally a greater density of dates in the last centuries of the 6th millennium cal BC (*Martín-Socas* et al. *2018*), as is the case here. The oldest dates come from Dehesilla Cave itself, where excavations in Area C003 documented at the very base of the sequence a stratigraphical level including impressa pottery of Mediterranean influence, followed by other levels characterized by 'almagra' wares (*García-Rivero* et al. *2018a; Taylor, García-Rivero 2021*). Other archaeological sites with similarly very old dates in Andalusia are the caves of Nerja (*Jordá, Aura 2008*) and Esqueleto (*Carrasco, Martínez 2014*). This suggests that the arrival of the first Neolithic populations took place on the coastal line.

Sample Id.	Sample mass (mg)	Lipid concentration (µg/g)
LD_1	1010	5.11
LD_2	1090	4.88
LD_3	1260	4.01
LD_10	1120	13.60*

* Sample selected for GC-MS and GC-C-IRMS analyses.

Tab. 2. Summary of the analysed samples and their lipid concentrations.

The accumulation of radiocarbon dates between *c.* 5300–5000 cal BC indicates a period of notable replication and consolidation of these populations throughout the south of the Iberian Peninsula. In contrast, a drop in radiocarbon dates can be observed around 4700 cal BC, suggesting a decrease in the human populations during most of the second half of 5th millennia cal BC (*Molina* et al. *2017; García-Rivero* et al. *2018a*).

Ritual funerary contexts in the Iberian Early Neolithic

The funerary practices of the Early Neolithic in the Iberian Peninsula have been considered previously in several specific works of synthesis (*e.g., Rubio 2001; 2004; Garrido-Pena* et al. *2012*). The general overview outlined in these works can be updated with some recently discovered contexts and new data (*Oms* et al. *2017; Gibaja* et al. *2018; Alt* et al. *2020*). Broadly, the fundamental behaviours of the Early Neolithic funerary record of the Iberian Peninsula are essentially embodied in the concept of individual burial in a flexed lateral position, with relatively few elements of material accompaniment. Burials are more abundant in caves, but also exist in open-air settlements where they may of-

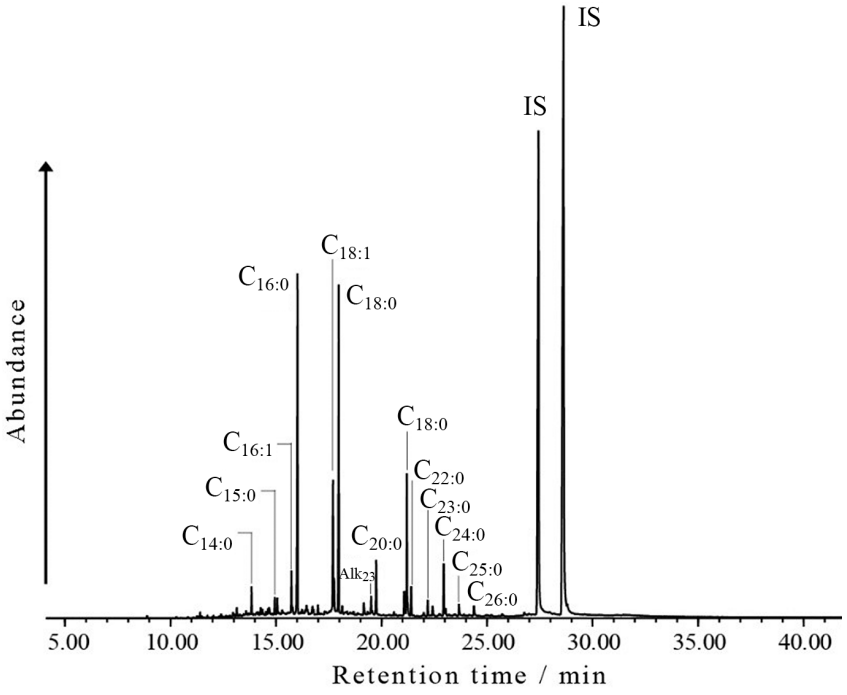


Fig. 12. Partial gas chromatogram showing the distribution of the molecular composition in sample LD-10.

Typology			f	Retouched tool	%	Use-wear	%	Total
Knapped (87.5%)	Blades	57%	4	2	50%	2	50%	7
	Flakes	28.6%	2	0	–	0	–	
	Indeterminate	14.3%	1	0	–	0	–	
Ground (12.5%)	Hammer	100%	1	–	–	1	100%	1

Tab. 3. Lithic assemblage.

ten share domestic contexts or, occasionally, be placed in distinct spaces, in some cases considered as designated burial grounds.

As well as the normative and formal primary burials, another recurring pattern is the identification of more or less isolated remains, which usually appear mixed together with pottery fragments and fauna, as well as with lithic elements and shells, in areas and levels of presumably ordinary activities. This type of finding actually constitutes the majority of the funerary record, and has generally been interpreted as evidence of secondary burials, involving ritual practices in which bones were moved and recategorized, or as a result of the common post-depositional processes that shape the stratigraphic palimpsests of caves. Even at present, it is not easy to discriminate between the two processes, and there is some uncertainty about the precise meaning of this fragmentary record and its possible cultural background.

In a separate and concise group, there is evidence of intentional depositional events of a special nature, which remain rare and incompletely understood. In order to shed light on the new discovery at Dehesilla Cave, we will focus here on the Early Neolithic ritual funerary contexts in the Iberian Peninsula that include either or both of the two main elements of the depositional context Locus 1, that is, the differential treatment of crania and/or the specific use of pottery jars. The comparative contexts have been characterized on the basis of their structural features and material markers of ritual behaviours. These archaeological contexts and traits are summarized in Table 5, and their locations in the Iberian Peninsula are shown in Fig. 14. This overview provides a broader context for the Locus 1 deposition, and aims to lay the ground for its interpretative discussion.

At Dehesilla Cave, several Early Neolithic burials were documented during the 1981 excavations (*Acosta, Pellicer 1990.57–58*): seven inhumations (four children, one juvenile and two adults, both female) and two cases of isolated skeletal elements – a cranium and a mandible – belonging to two different adult individuals were identified in Levels VI and V. These two levels contained ceramic and lithic materials consistent with the Early Neolithic period (*Acosta, Pellicer 1990*). The radiocarbon date from a charcoal fragment at the base of the burials (Layer 13 of Level VI), acting as a post quem reference, is 5468–4992 cal BC (*cf. Acosta, Pellicer 1990.87; García-Rivero* et al. *2018a.126*). The majority of the remains belong to formal burials, mostly flexed and placed on one side. The human remains were later studied from an anthropological and paleopathological perspective, and the existence of *cribra orbitalia* was noted in two of the children (*Robledo, Jiménez-Brobeil 1994*). The cranium showed signs of cremation, and was found next to a hearth with numerous *Iberus alonensis* snail shells (*Acosta,*

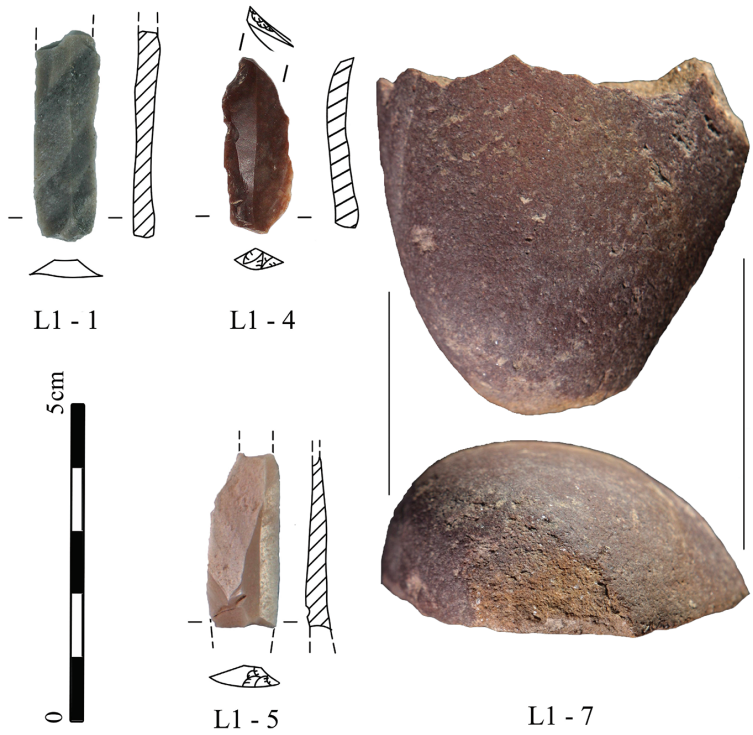


Fig. 13. Lithic assemblage documented in Locus 1:* L1-1 *meso-proximal blade fragment;* L1-4 *sickle blade (C006-247);* L1-5 *mesial blade fragment with partial retouch on the proximal break (C006-252);* L1-7 *hammer stone fragment (C006-231).

Lab. code	Sample Id.	Context	Sample	% Extract.	%C	%N	C:N	Date BP	pM	$\delta^{13}C$ ‰	Cal BC 2σ	p*=
CNA4493	DH17-21	Locus 1	*Homo* – Skull	3.9[1]	31.9	11.6	3.2	6180±30	46.31±0.18	–18.17±1.50	5222–5036	1.00
1 Method: Collagen extraction and purification. Ultrafiltration.												

Tab. 4. Radiocarbon date. The calibration is made with IntCal13.14c Northern Hemisphere atmospheric radiocarbon calibration curve in the software Calib 7.0 (*Reimer *et al.* 2013*).

Pellicer 1990.58). The mandible appeared to be an isolated element.

The presence of disarticulated and isolated jaw bones or other post-cranial remains is common and well-documented, not only in all of the prehistoric contexts known to date at Dehesilla Cave, but also in many other Neolithic caves throughout the south of the Iberian Peninsula, probably in part caused by post-depositional processes. In contrast, the case of the isolated adult cranium is relevant here, not because skulls are unusual in the archaeological record, but because their specific deposition and contexts often have an intentional dimension that must have been guided by a particular pattern of ritual behaviour. In this case, it may also be significant that the cranium was found in association with a hearth and terrestrial snail shells.

In Andalusia, the funerary record of this Early Neolithic period is characterised mainly by scattered remains, more or less isolated, and some burials, mainly documented in caves. This is the case, for example, at one of the most emblematic Andalusian sites that was discovered in the 19th century, Cueva de los Murciélagos de Albuñol, which has a substantial funerary record, including both formal burials and remains dispersed over the floor of different areas of the cave, and among which there are numerous isolated crania (*Góngora 1868; Molina* et al. *2012*). Unfortunately, the funerary record cannot be securely attributed to the different Neolithic periods, despite a radiocarbon date for the famous weaved baskets that would place at least some of the remains in the advanced Early Neolithic (*Castro* et al. *1996*).

Cueva de la Carihuela (Carigüela) also contains numerous human remains throughout its sequence (*Pellicer 1964; Navarrete 1976; Arribas, Molina 1979*), most of which are not anatomically connected, in addition to certain stratigraphic problems probably caused by the funerary use of the cave itself (*Carrasco* et al. *2010*). However, more than twenty burials have been attributed to the Early Neolithic, occasionally with signs of treatment, including defleshing, suggestive to some authors of cannibalistic practices (*Botella* et al. *2000; Carrasco* et al. *2012; Molina* et al. *2012.436*).

On the coast of Málaga, Cueva de Nerja has provided many remains of Early Neolithic burials (*Fernández* et al. *2005*). Of particular interest here are two burials from the base of the Neolithic sequence in the Sala Torca, one adult and one child, with evidence of cremation (*Pellicer, Acosta 1986.446*); and, perhaps more notably, the remains from level V of area NM-84 in the room known as Sala de la Mina, in which a juvenile cranium was found in association with typical pottery of the period, knapped lithics and stone hand-grinders, bone awls, charred acorns and fish remains (*Pellicer, Acosta 1986.368*).

In one of the innermost and inaccessible areas of Cueva de El Toro, there are several human remains lacking any anatomical connection. These include part of the calvarium of an adult male, with part of the frontal and both parietal bones, dated to the advanced Early Neolithic (*Martín-Socas* et al. *2004; Santana* et al. *2019*). It bears a series of up to 59 cut marks on the external surface made with a sharp lithic tool and by a process of defleshing, also displaying a V-shaped mark and remains of ochre (*Guijo 2004*). This particular calvarium has been interpreted recently as a skull cup linked to ritualistic cannibalism (*Santana* et al. *2019*).

On the coast of Cádiz, at the open-air site of El Retamar, there is a double burial of a woman and a man, whose bodies were dusted with ochre (*Bueno 2002; Ramos, Lazarich 2002*). The male skull was intentionally displaced from the rest of the body, and a specimen of *Cardium edule* was located at his feet, while the mandible of the female individual was placed between the long bones of her lower extremities.

In the coastal area of central and southern Portugal, apart from Neolithic burials on some of the Mesolithic shell middens (*e.g., Bicho* et al. *2013; 2017*), burials in caves are predominant and especially abun-

dant in the Portuguese Estremadura and Alentejo-Ribatejo regions. As for evidence of rituals, the trepanation (without survival) of a skull from Casa da Moura (*Cardoso 2007.241; Carreira, Cardoso 2002*) belonging to a young adult male could be of interest (*Antunes* et al. *2009*). However, only one (carried out on an ulna) of the 12 radiocarbon dates provided for the level containing the human remains fits the advanced Early Neolithic period, in accordance with the characteristics of the pottery assemblage (*Carreira, Cardoso 2002*), while the remaining dates are more recent (*Carvalho, Cardoso 2011.396*).

In the Meseta region, individual burials in pits and isolated remains in secondary contexts are both documented. The cranium of an adult male between 20 and 30 years of age is noteworthy, with a slight depression of the nasal bone, documented at Cueva de la Vaquera in Segovia, in association with several ribs and the tooth of a sheep or goat (*Estremera, Valle 1999*). Interpreted as a relic (*Delibes* et al. *1999*), it has recently been dated to the transition between the sixth and fifth millennia cal BC (*Garrido-Pena* et al. *2012.148*).

On the Valencian coast, the predominant funerary evidence is provided by dispersed human remains, especially from caves (*Bernabeu* et al. *2001*). Of particular interest to us here is the well-known case of the ritual funerary deposition of Cova de la Sarsa. It is formed by two crania, one male and one female, the latter with trauma to the left parietal, and various post-cranial elements. They were deposited in a crevice in the cave wall, delimited by a stone structure, and located in an area difficult to access. In the same area there are cave paintings, and the human remains were accompanied by an assemblage of cardial pottery with the remains of pigment, worked bone and lithic elements, and shells (*Miguel 2008; García Borja* et al. *2011*).

At the Catalan Cova dels Lladres, a cranium and other human remains were found on the floor of the cave alongside a globular pottery container with two handles and a band of incised decoration (*Pla, Junyent 1970*). In stratigraphy, several burials are also known to be associated with two globular jars, with a high neck, lug handles and incised decoration. One of them was placed on the neck of another fragmented jar of the same type, and contained a substantial assemblage of perforated shell beads, many on *Cardium edule*, as well as numerous variscite pendants (*Ten 1980*).

The type of pottery jar, usually referred to as amphoroid or *botella* (*Llobregat 1973; Bernabeu 1989; Fábregas* et al. *2019*), was very common during the Early Neolithic, and continued in later periods. The shape, with a cylindrical neck, globular body and semi-spherical or often cone-shaped base, may reflect their use as containers for liquids or substances with a similar behaviour. This form is frequently

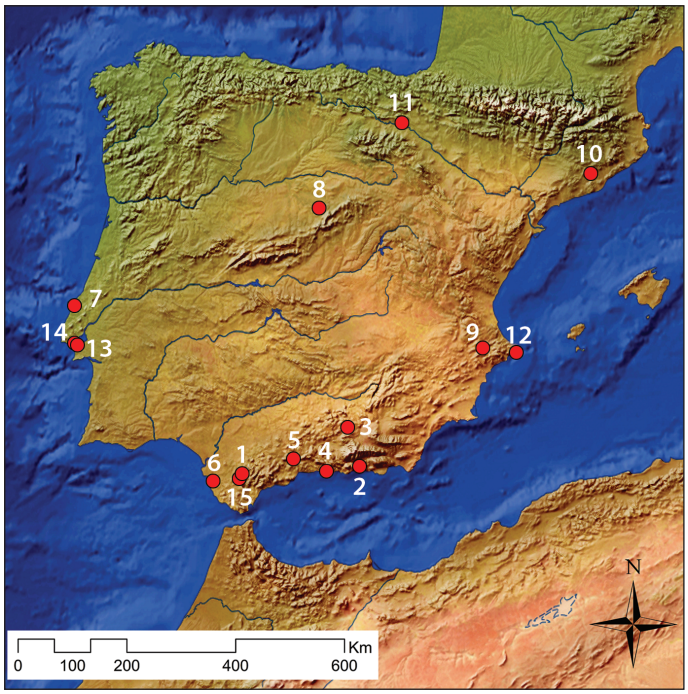


Fig. 14. Location map of the archaeological sites mentioned in the text (see Appendix 3), numbered as follows:* 1 *Cueva de la Dehesilla, Jerez de la Frontera, Cádiz (*García Rivero *et al.* 2018*);* 2 *Cueva de los Murciélagos, Albuñol, Granada (*Góngora 1868*);* 3 *Cueva de la Carihuela or Carigüela, Los Montes, Granada (*Carrión *et al.* 2019*);* 4 *Cueva de Nerja, Nerja, Málaga (*Jordá *et al.* 2003*);* 5 *Cueva del Toro, El Torcal de Antequera, Málaga (*Martín Socas *et al.* 2004*);* 6 *El Retamar, Puerto Real, Cádiz (*Ramos, Lazarich 2002*);* 7 *Casa da Moura, Óbidos, Portugal (*Cardoso *et al.* 2018a*);* 8 *Cueva de la Vaquera, Torreiglesias, Segovia (*Estremera 2003*);* 9 *Cova de la Sarsa, Bocairent, Valencia (*Asquerino 1978*);* 10 *Cova dels Lladres, Vacarisses, Barcelona (*Ten 1980*);* 11 *Los Cascajos, Navarra (*Iriarte *et al.* 2019*);* 12 *Cova de les Cendres, Moraira-Teulada, Alicante (*García-Puchol 2005; Bernabeu, Molina 2009*);* 13 *Antigos armazéns Sommer, Lisboa, Portugal (*Rebelo *et al.* 2017; Cardoso *et al.* 2018a*);* 14 *Pálacio Ludovice, Lisboa, Portugal (*Duarte *et al.* 2020*);* 15 *Cueva del Picado, Cádiz (*Mora 1970*) (Theme map: https://www.naturalearthd ata.com/).

Tab. 5. Archaeological characteristics of the Early Neolithic ritual deposits of the Iberian Peninsula. The date range given for each context corresponds to the maximum chronological rang (cal BC – 2σ) based on the available data set (Lab Codes) calibrated to two sigma according to the original publications (References).

Site	Differential treatment of skulls	Location Structures	Trauma - Marks Manipulation	Pottery jar	Grave goods Accompaniments	Cal BC – 2σ	Lab Code	References
Cueva de la Dehesilla	V (male, >45 yrs)	Innermost area, stone cover	Two incisions	V	Lithics, *Potomida littoralis*	5222–5036 [a]	CNA-4493	This paper
Cueva de la Dehesilla	V (adult)	First room	Cremation?	None	*Iberus alonensis*	–	–	*Acosta, Pellicer 1990*
Cueva de los Murciélagos	V	Deepest area	–	–	Esparto grass fibres	5210-4840 [b]	CSIC-1133	*Góngora 1868; Cacho et al. 1996; Molina et al 2012*
Cueva de la Carihuela or Carigüela	V?	–	Defleshing Cannibalism?	–	Fauna	5517-5060 [b]	Col-1566-7 1560, 1564 Pta-9163 Col-1567	*Pellicer 1964; Navarrete 1976; Arribas, Molina 1979; Botella 2000; Fernández* et al. *2007; Carrasco* et al. *2012; Molina* et al. *2012č Martín* et al. 2018
Cueva de Nerja	V (juvenile)	NM-84 Sala de la Mina	–	–	Pottery, knapped lithics, hand grinders and querns, awls, acorns and fish remains	5484-4798 [b]	OxA-26077-86	*Acosta, Pellicer 1986; Fernández* et al. *2005; Martins et al. 2015*
Cueva de El Toro	V (male, aprox. 30 yrs)	Innermost area	Defleshing 59 incisions V-shaped mark Ochre Cannibalism? Skull-cup?	None	Undecorated pottery	5040-4850 [a] 5472-4463 [b]	Beta-365288 GrN-15440 15443-4 Beta-174308 Beta-341131-2 Beta-365287-8 365290 365292-4 Beta-498412	*Guijo 2004; Martín Socas* et al. *2004; Santana* et al. *2019*
El Retamar	V (male, approx. 25 yrs)	Habitat (hearths, stone structures and shellmiddens) Open air	Ochre powder	None	Cardium edule	5497-5202 [b, c]	Beta-90122	*Ramos, Lazarich 2002; Bueno 2002; Ramos et al. 2010*
Casa da Moura	V (male)	–	Trepanation	–	–	5020-3000 [b]	TO-953, 2092-4 Wk-28004-5 28007, 28009-10 OxA-5506	*Carreira, Cardoso 2002; Cardoso 2007; Carvalho, Cardoso 2011*

Site	Differential treatment of skulls	Location Structures	Trauma - Marks Manipulation	Pottery jar	Grave goods Accompaniments	Cal BC – 2σ	Lab Code	References
Cueva de la Vaquera	V (male, approx. 25 yrs)	Habitat	Depression of the nasal bone	None	Ribs, sheep or goat tooth	6052-4695 [b]	GrN-17386 22930-3, 8241 9226, 9228	*Estremera, Valle 1999; Estremera 2003; Delibes* et al. *1999; Garrido Pena* et al. *2012*
Cova de la Sarsa	V (male and female)	Wall crack and stone wall Occulted Rock art	Female: parietal injury	–	Near complete cardial jar, pigment, bone and stone tools, shells (*Columbella*, *Cardium*)	5470-5220 [b]	OxA-V-2392-26	*Miguel Ibáñez 2008; García-Borja 2012*
Cova dels Lladres	V	Formal burial 3 globular jars	–	V	*Cardium edule*, shells, variscite	–	–	*Ten 1980*
Los Cascajos	None	Pit (Estructura 475) Cenotaph?	None	V	Necklace	5500-3750 [b]	Ua-16024-5 16203, 17793 17795, 24423-8 GrA-16204 16208-11, 16942	*García-Gazólaz, Sesma 2007; García-Gazólaz* et al. *2011; García-Martínez 2012*
Cova de les Cendres	None	Pit	None	V	–	5310-4900 [a]	Beta-75217	*Bernabeu, Molina 2009*
Antigos armazéns Sommer	None	Burial pit Open air habitat	None	V	Pottery sherds, lithics and fauna (casual?)	5200-4890 [a]	Wk-45573	*Cardoso* et al. *2018*
Pálacio Ludovice	None	Burial pit Open air habitat	–	V	Pottery sherds (undecorated, impressed, incised and boquique), lithics	–	–	*Simões* et al. *2020*
Cueva del Picado	None	Individual burial	None	V	–	–	–	*Mora 1970*

a Direct date from the archaeological materials included in this table.
b Indirect date from other materials of the broader archaeological context.
c Calibration with the Marine13 curve.

found in domestic contexts, as well as in funerary depositions. We will, therefore, only mention here some cases that, like Locus 1, illustrate the funerary and/or ritual use of this type of jar throughout the Iberian Peninsula.

The open-air settlement of Los Cascajos in Navarra had a specific area, a designated burial ground, with over thirty individual burials, and several ritual graves or pits containing material remains. Structure 475 is of special interest here, holding a complete jar, placed on top of a necklace of discoidal beads (*García-Gazólaz, Sesma 2007; García-Gazólaz* et al. *2011; Rojo* et al. *2016*). At Cova de les Cendres, on the coast of Alicante, a jar was found intact inside a pit, covered by a large flat stone (*Bernabeu* et al. *2001*). On the opposite side of the Iberian Peninsula, two such pottery containers have recently been documented in association with two separate individual burials in Lisbon. Both jars are decorated: one with *boquique* or stab-and-drag technique, at the Antigos armazéns Sommer (*Cardoso* et al. *2018b*); and the other with incisions and impressions, at Palácio Ludovice (*Simões* et al. *2020*). Returning to the south, amphoroid jars are documented at various sites vicinity of Dehesilla Cave, including an individual burial context at Cueva del Picado (*Mora 1970.283*).

This overview allows for a number of inferences to be made. A striking initial observation is that there is no identical context to the one presented here, in such a way that Locus 1 constitutes a certainly singular case. Some of the individual ritual traits are, however, common to several sites. Based on the present state of the available data, which is of course influenced by the relative qualities of the archaeological records, we may reflect on the degree of similarity or affinity between Locus 1 at Dehesilla Cave and the contexts documented at other sites.

The depositions documented at Cova de la Sarsa, Cueva de El Toro and in the old excavations at Dehesilla Cave itself are apparently among the closest to Locus 1, at least in terms of their clearly ritual nature provided by the particular use of crania (not pottery jars). At these three cave sites, skulls (some with trauma and/or markings) are located in the deepest and most inaccessible areas, as far as possible from the areas of daily activities, a pattern that may reflect ritual behaviours and beliefs shared between these populations. A similar situation is found at Cova dels Lladres, with particular regard to the finding of a human cranium in association with a decorated pottery jar.

The finds analysed from Cova de les Cendres and the open-air site of Los Cascajos are clear examples of closed and well-preserved contexts with pottery jars deposited inside pits created for this purpose within specific ritual areas. Structure 475 of Los Cascajos is located within a funerary area, yet appears to be of a different functional nature to the rest of the pits at the site. In the case of Cova de les Cendres, the deposition was made in a crevice next to the location of rock art. Pottery jars are also documented at the Antigos armazéns Sommer, Pálacio Ludovice and Cueva del Picado, although in these cases they are associated with inhumations, the most common and widespread formal treatment of Neolithic human remains.

The other sites mentioned are perhaps a little further from the ritual characteristics of the previous cases, and are more in line with the usual findings of disarticulated or isolated remains that predominate in the Neolithic record. It is worth noting, however, the case of the Sala de la Mina at Nerja, due to the peculiarity of some of the materials documented in the close proximity of the human cranium. Likewise, the double burial at El Retamar, although quite a different type of context, corroborates the well-known differential treatment, probably symbolic, given to skulls.

Discussion of the possible interpretative scenarios for the Locus 1 deposit

Cut marks on human skulls are often attributed to processes of defleshing and/or scalping, and their distribution on the cranial bones makes it possible to distinguish between these two types of intentional treatments. In the removal of soft tissues, cut marks are observed on bone surfaces at the sites of tendon and ligament insertions (*Buikstra, Ubelaker 1994*). In the removal of the scalp, the marks typically form small clusters on the frontal, parietal and occipital bones, in a kind of circle around the calvarium (*White* et al. *2012; Gresky* et al. *2017*). The incompleteness of the Locus 1 cranium does not enable a clear interpretation of the observed marks, other than their anthropogenic nature. Indeed, they indicate the use of a lithic tool for *periosteum* removal, although it is impossible to infer the precise purpose of the gestures involved.

The (negative) results of the organic residue analyses on the pottery jar are conducive to the observation that the samples do not contain absorbed fats, and that the white crust found inside the pot is not

an organic substance. Despite the frequency of this pottery form in the Neolithic record of the Iberian Peninsula, only the results of residue analysis carried out on the cardial jar from Cova Eirós in Lugo are currently known (*Fábregas* et al. *2019*). This analysis indicated that the vessel had been used in the processing of ruminant animal meat and vegetal resources. These results contrast with those obtained from the Locus 1 jar, in which the lipid concentration obtained from the analysed samples was below the minimum threshold, and evidence of alteration from heat/fire was absent. These observations may be related to the low intensity or null use of the vessel for storage, food preparation or cooking before its deposition.

Deciphering the meaning of Locus 1 is, therefore, not an easy task, considering a number of additional factors. There are not many depositions of this type dating to the Early Neolithic in the Iberian Peninsula, and this finding at Dehesilla Cave is also quite different from other known contexts. There is also a certain scarcity of studies that attempt to specifically address the interpretation of such depositions (*e.g., Jiménez-Brobeil 1990; Rubio 2001; Jiménez-Brobeil* et al. *2009*), beyond their simple description, and such studies are more common for later periods, from the Late Neolithic onwards, and are particularly concerned with megalithic activities.

However, there is a wealth of general knowledge provided by other geographic and chronological contexts, both from ethnography and archaeology, including the Central European Neolithic and the LBK culture, and especially the Pre-Pottery Neolithic B of the Near East, that provides rich and diverse data regarding the differential funerary and ritualistic treatment of human skulls. The reference to these analogies here, of course, does not imply any assumption of a relationship of ancestry nor of a historical link between these and our case study, although they may provisionally constitute a frame of reference that will serve as a guide in our interpretative exploration. Reference to the main interpretations developed in these comparative archaeological contexts may, indeed, enable us to narrow down the number of interpretative scenarios that may be aligned with the Locus 1 deposition.

The recurrence of isolated human remains, and of skulls in particular, some displaying marks from injuries, has led some authors to interpret them, both in the European framework and Near East, as war trophies or evidence of cannibalistic practices (*Villa* et al. *1986; Villa 1992; Courtim 2000; Testar 2008; Le Bras-Goude* et al. *2010; Marginedas* et al. *2020*). In the specific context of the Neolithic period in the Iberian Peninsula, anthropological studies have drawn attention for over thirty years to practices such as the defleshing of the dead and the possible existence of ritualistic cannibalism (*Botella 1973; Jiménez-Brobeil 1990; Jiménez-Brobeil* et al. *1986; 1996; 2009; Botella* et al. *2000; Santana* et al. *2019*). Moreover, possible evidence of Neolithic cannibalism has been noted at several cave sites in southern Spain, such as Tontas, Carigüela, Malalmuerzo, Mayólicas, Honda and de las Azuelas (province of Granada) and El Toro (province of Málaga) (*Botella 1973; Botella* et al. *2000; Jiménez-Brobeil* et al. *1986; Solari* et al. *2012; Santana* et al. *2019*).

However, many of these human remains, unfortunately, do not have a precise chronological identification, beyond their general Neolithic attribution, and there is very scarce evidence of this type dated securely to the Early Neolithic (*e.g., Jiménez-Brobeil 1990.125*), perhaps with the exceptions of Cueva de la Carigüela and Cueva de El Toro. An aggressive type of cannibalism has also been proposed based on evidence at Carigüela and Malalmuerzo (*Jiménez-Brobeil* et al. *2009*), due to the lack of care in the treatment of the remains and the high frequency of head injuries as an indicator of interpersonal violence. Recently this possible interpretation has also been put forward at El Toro (*Santana* et al. *2019*).

Several features of Locus 1 do not seem to fit with its interpretation as a war trophy, as we would expect this type of deposition to be socially visible to the general population, rather than being carried out in a hidden, secretive place and a remote part of a cave. It also does not align, at least in exclusive terms, with a cannibalistic interpretation, especially in its belligerent form. Indeed, for this interpretation to stand, the Early Neolithic human remains of Dehesilla Cave would need to display more common evidence of this kind (cut marks from the removal of the scalp and flesh, from percussion for the creation of calottes, *etc.*), which in fact is not present (*Robledo, Jiménez-Brobeil 1994*).

Ritualistic cannibalism of a funerary (and perhaps exceptional) nature cannot be ruled out, nor can the identification of the calvarium as a skull cup, a type of object that is quite widespread in the ethnographic and archaeological literature (*e.g., Botella* et al. *2000; Bouslestin 2012; Boulestin, Copey 2015; San-*

tana et al. *2019; Marginedas* et al. *2020*). Moreover, the association of a possible skull cup next to a pottery vessel, identified typologically as a jar or bottle, is suggestive. In any case, a scenario of ritualistic funerary cannibalism would necessarily imply other behavioural models, not necessarily alternative but at least complementary, and particular symbolic components, which appear to be present in the Locus 1 depositional context.

There are several other diverse interpretations of the symbolic dimension of the differential treatment of skulls: foundational rites (*Contenson 1992*); ritual celebrations through sacrifice and consumption (*Goring-Morris, Horwitz 2007*); expressions of social identities (individual and collective) (*Kuijt 2008; Croucher 2006*); worship of ancestors (*Kenyon 1953; Bienert 1991*) or elders (*Cauvin 2000*), if not of deities and spirits, related to wisdom, virility and fertility (*Freeman 1979*) or to supernatural powers or vital forces (*Deleonardis 2000; Verhoeven 2002; Jammo 2014*).

Emic interpretations have usually explored the basis and social or systemic (etic) consequences of ritual, in the sense of behaviours with beneficial or adaptive effects for the community, and often understood in terms of social organization, that is, hierarchy, kinship relations, cohesion and social memory (*Cauvin 2000; Verhoeven 2002; Testart 2008; Bocquentin* et al. *2016; Hacdow, Knüsel 2017*). The reasons behind past rituals are now far from our current possibilities of corroboration, since they require a certain knowledge of the structure and the cultural diversity of the population under study, which is beyond the scope of present research. Some of the theoretical behavioural models mentioned above are simply impossible to consider here, because they require a more substantial record and a more detailed knowledge than that provided by the archaeological record. Perhaps the most obvious aspect is that which envisages the expression of social identities.

In the specific case of Locus 1, the scenario of a ritual celebration may be ruled out, since there is no direct evidence of sacrifice or consumption. Interpretation as a foundational rite related to the occupation and establishment of populations at the site is also unlikely, given that the radiocarbon date from the cranium itself is notably later than the first Neolithic evidence at the cave, dated to the middle of the sixth millennium BC (*cf. García Rivero* et al. *2018a*). However, a foundational event related to the arrival of a different population after the early pioneer group(s) cannot be discarded, within the framework of complex dynamics of mobility with a degree of nomadic behaviour.

The *peri mortem* marks increase the probability that the death of the individual may have been linked directly to the timing of the ritual deposition itself, although a cranium recovered from an earlier primary burial, in line with an ancestor cult scenario, is not impossible. A heterogeneous and inclusive view of this hypothesis would, in fact, be viable, taking into account the relatively advanced age of the Locus 1 individual (>45 years) and the consideration of mature individuals as social guides or leaders. The individual whose cranium was included in the Locus 1 deposition has the highest age of the entire sample considered in this study, and it can also be noted that six of the seven sexually identified crania from the analysed sites belong to male individuals. Another interesting observation is that, among the eight or nine individuals previously documented at Dehesilla Cave, there are currently no secure formal male burials. Future research into this line of interpretation in relation to Locus 1 will require, among other things, a DNA analysis to confirm the alleged affiliation of this individual to the same population group as the other burials at the site.

The interpretative model of the cult of supernatural entities or powers, whether deities or spirits, cannot easily be corroborated. In the Iberian reference literature on the Early Neolithic period, the identification of anthropomorphic figures in a posture of prayer in both pottery decoration and rock art depictions is relatively widespread (*e.g., Hernández 2000; Escacena 2018*). If such figures are related to religious or supernatural cults, and given that they mostly share the feature of arms outstretched above the head, it is likely that the entities or powers invoked must be located in the heights, in the sky or on the tops of mountains, a belief in fact widespread in many ancient cultures of the Mediterranean. Most of the supposedly contemporaneous rock art is located in open-air panels, and thus in shelters and in the external and accessible areas (near the entrance) of caves. The magical-religious rituals known from ethnographic, archaeological and textual records usually include many meanings: propitiatory and supplicatory rites, augury or premonitory rites, prophylactic and purification rites, as well as apotropaic rites of protection and dissuasion.

The specific finding that brings us here, a pottery jar partially buried in the ground and sealed symboli-

cally and physically with a human calvarium and a large and heavy limestone block, not only occupies a hidden location in the depths of the cave, but also demonstrates, by its own structural features, a deliberate occultation. On the basis of these characteristics, and in contrast to the above, it is possible to suggest a tentative association between the deposition and the chthonic or telluric entities or forces, whether they were deities or even malign powers or spirits. It is worth recalling that the jar buried in a pit inside the cave of Cova de les Cendres was also covered by a large stone. The sealed, hidden and inviolable deposition of Locus 1 could have had a dissuasive or apotropaic character, perhaps as a container of properties, forces or spirits, although not necessarily incompatible with other functions (to predict, propitiate, purify or pray). The known cases of superstitious beliefs and religious rites of this nature, in addition to the differential use of skulls, are relatively numerous in the ethnographic record (*Yakar, Hershkovitz 1988*), but are also common in the Prehistoric European and Near Eastern archaeological records (*Bonogosfsky 2001; 2006; Borić 2003; Rubio 2004; Slon* et al. *2014; Maier 2017*), as well as in the Semitic texts (*e.g., Schmandt-Besserat 2013; Del Olmo 2015*).

Conclusions

This article has focused particularly on the comparative data for the isolated finding of human crania. Of the available sample, fortunately, many of the contexts are relatively well preserved, or sufficiently so, at least enough to corroborate the particular or differential use of these skeletal elements throughout much of the geography of the Iberian Peninsula.

The analysis of the data has enabled some recurrent patterns to be observed. Practically all of the known cases are located inside caves, most of them in relatively deep and remote chambers or crevices, and therefore display a tangible degree of differential treatment compared to the overall funerary record. There is also a bias in the demographic profile of the subjects, since most of the remains belong to adult males. Many cases show evidence of anthropogenic lesions, including incisions and cut marks, trepanation or trauma. They are usually accompanied by assemblages of materials, which include, in order of their relative frequency, shells, pottery, lithic and bone instruments or faunal remains. The known contexts probably reflect a diversity of specific activities and, therefore, of interpretive scenarios, but clearly share some behavioural traits and patterns of a ritual nature. It can therefore be put forward that these depositions probably took place within a relatively common framework of cultural behaviours and traditions of a highly symbolic nature.

The specific case of Locus 1 is singular because it provides a depositional context with an unusually good state of preservation, only paralleled at a few other Iberian sites. At least two factors contributed to this: the location in a deep and inaccessible area of the cave, without evidence of occupation and barely any sign of disturbance, and the distinctive structural characteristics of the deposition, including a heavy stone cover. It is the only discovery to date in the Iberian Peninsula of a complete pottery jar covered by a human cranium, which also makes it an extraordinary archaeological context for the Prehistory of Western Europe.

Locus 1 materializes a ritual funerary event and extends the possibilities of knowledge about the symbolic behaviour of the first Neolithic populations of the Peninsula and the Western Mediterranean. This study has allowed us to explore the theoretical interpretative models currently available for the differential treatment of human skulls in this area, and has enabled us to narrow down the range of interpretative possibilities for this particular depositional context. However, it is impossible at present to offer a single firm reconstruction, and several anthropological scenarios that could explain this finding more precisely must be left open, including ritualistic cannibalism, rites related to the elders or leaders, and/or cults to the supernatural entities or forces.

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Appendix 1

Methods of the organic residue analyses

Lipid extraction

Lipids were extracted following established protocols of one-step extraction and methylation with acidified methanol (*Craig* et al. *2013; Correa-Ascencio, Evershed 2014*). After cleaning the surface of the sherd, we took 2g of homogenised pottery powder. Prior extraction $C_{34:0}$ n-alkane was introduced as internal standard (10µl of hexantriacontane $C_{34:0}$). Methanol (4ml) was added to 1g of pottery powder and the mixture sonicated during 15 min. Sulphuric acid (H_2SO_4–800µL) was used to acidify the suspension that was then heated in glass tubes during 4 hours at 70°C. Lipids were extracted from the centrifuged pottery powder with n-hexane (3x4ml). Internal standard (10µl of hexantriacontane $C_{36:0}$) was added to all the samples to quantify the relative abundance of lipids. One sample (LD-10, 1g) was also extracted using 2:1 DCM:MeOH (3x2mL) to produce a total lipid extract (TLE) following established protocols (66). The extracts were then dried under N_2 and derivatized with N-O-bis(trimethylsilyl)trifluoroacetamide (BSTFA) heated at 70°C for 1 hour.

Analytical protocol

Gas Chromatography-Flame Ion Detector (GC-FID)

GC-FID was carried out in all samples (n=4) using an Agilent 7890S gas chromatograph (Agilent Technologies, Cheadle, Cheshire, UK). A splitless injector was used to inject the sample (1µL) at 300°C into the GC. The column used was a polymidecoated fused silica DB-1 (15m x 320µm x 0.1µm; J&W Scientific, Folsom, CA, USA). The carrier gas was helium with pressure set at 3.3 psi and with a flow rate of 2ml/min and velocity of 46.57cm/s. The temperature program

was set at 100°C for 2 minutes, raised by 20°C/min until 325°C for 3 minutes. Quantification of lipid preservation was calculated according to (Area(Sample)/Area(IS)) * (Weight(IS)/Weight (Ceramic sample)), omitting contaminant peaks such as plasticisers.

Gas Chromatography-Mass Spectrometry (GC-MS)

GC-MS analysis was undertaken on 4 acidified lipid extracts to identify the main molecular components. An Agilent 7890A series chromatograph was used, attached to an Agilent 5975 Inert XL mass detector (Agilent technologies, Cheadle, Cheshire, UK). A splitless injector was used to keep the sample at 300°C (1μL). Helium was used as carrier gas with a constant flow of 3mL/min. The ionisation energy of the MS was 70eV and spectra were obtained by scanning between 3 and 44. A DB-23 (50%-Cyanopropyl)-methylpolysiloxane column (60m 0.250mm 0.25mm; J & Scientific, Folsom, CA, USA) was used. The temperature was set at 50°C for 2 minutes, then raised by 10°C/min until it reached 100°C, then raised by 4°C/min to 140°C, then by 0.5°C/min to 160°C, then by 20°C/min to 250°C where it was maintained for 10 minutes. Peak integration and quantification was carried out using ChemStation Rev. B.04.02 SP1. Automated integration was selected over manual integration to avoid inconsistencies. The analytical protocol was oriented to the identification of main molecular components (saturated and unsaturated fatty acids, branched fatty acids, dicarboxylic fatty acids, alkanes and isoprenoid fatty acids, u-(o-alkylphenyl) alkanoic and phytanic acids).

High Temperature Gas Chromatography-Mass Spectrometry (HTGC-MS)

HTGC-MS was performed on the TLE extracts (n=1) using a 7890A Series chromatograph attached to a 5975C Inert XL mass-selective detector with a quadrupole mass analyser (Agilent Technologies, Cheadle, UK). The carrier gas was helium, and the inlet/column head-pressure was constant. The GC column was inserted directly into the ion source of the mass spectrometer. The ionisation energy of the mass spectrometer was 70eV and spectra were obtained by scanning between *m/z* 50 and 1000. General screening of the TLE was performed using a DB-5 MS (5%-phenyl)-methylpolysiloxane column (30m x 0.250mm x 0.25μm; J&W Scientific, Folsom, CA, USA). The temperature for this column was set at 50°C for 2 minutes, then raised by 10°C/min to 325°C, where it was held for 15 minutes. A second analysis was performed with a HT-DB1 100% Dimethylpolysiloxane (15m x 0.320mm x 0.1μm) (J&W Scientific, Folsom, CA, USA) column. The injector was maintained at 350°C. The temperature of the oven was set at 50°C for 2 minutes, and then raised by 10°C/min to 350°C, where it was held for 15 minutes.

Gas Chromatography-Combustion Isotope Ratio Mass Spectrometry (GC-C-IRMS)

GC-C-IRMS analysis was undertaken on 1 sample because it was the only extract which preserved the enough amount of $C_{16:0}$ and $C_{18:0}$ to be analysed. Stable carbon isotope values of methyl palmitate ($C_{16:0}$) and methyl stearate ($C_{18:0}$), derived from precursor fatty acids were measured by GC-C-IRMS, following existing procedure (*Craig* et al. *2012*). An Isoprime 100 (Isoprime, Cheadle, UK) linked to a Hewlett Packard 7890B series GC (Agilent Technologies, Santa Clara, CA, USA) with an Isoprime GC5 interface (Isoprime Cheadle, UK) was used for the analysis. One μL of each sample was injected into DB-5MS ultra-inert fused-silica column. The temperature was set at 50°C for 0.5 minutes, then raised by 10°C/min to 300°C where it was held for 10 minutes. The carrier gas used was ultra-high purity grade helium with a flow rate of 3mL/min. The gas flow eluting from the column was split into two streams. One was directed into an Agilent 5975C inert mass spectrometer detector (MSD), for the sake of sample identification and quantification, while the other was directed through the GC5 furnace tube (CuO) kept at 850°C to oxidise all the carbon species to CO_2. A clear resolution and baseline separation of the analysed peaks were achieved. Eluted products were ionized in the mass spectrometer by electron impact and ion intensities of m/z 44, 45 and 46 were recorded for automatic computing of the $^{13}C/^{12}C$ ratio of each peak in the extracts. Data analysis was carried out with IonVantage and IonOS softwares (Isoprime, Cheadle, UK) and was based on comparisons with standard reference gas (CO_2) of known isotopic composition that was repeatedly measured. The results of the analysis were expressed in per mill (‰) relative to an international standard, VPDB. The accuracy and precision of the instrument was determined on n-alkanoic acid ester standards of known isotopic composition (Indiana standard F8-3). The mean ±S.D. values of these were 29.82 ± 0.16‰ and 23.28 ± 0.19‰ for the methyl ester of $C_{16:0}$ (reported mean value *vs.* VPDB −29.90 ± 0.03‰) and $C_{18:0}$ (reported mean value *vs.* VPDB −23.24 ± 0.01‰) respectively. Each sample was measured in replicate (mean of S.D. 0.11‰ for $C_{16:0}$ and 0.10‰ for $C_{18:0}$). Values were also corrected subsequent to analysis to account for the methylation of the carboxyl group that occurs during acid extraction. Corrections were based on comparisons with a standard mixture of $C_{16:0}$ and $C_{18:0}$ fatty acids of known isotopic composition processed in each batch under identical conditions. To compare the isotopic values of the main fatty acids (palmitic and stearic), data obtained on ruminant, and non-ruminant adipose fat, dairy and marine derived fatty acids resources throughout Europe have been compiled (Appendix 2).

Appendix 2

Data obtained on ruminant and non-ruminant adipose fat, dairy and marine derived fatty acids throughout Europe

Resource	Values (‰)		
	$\delta^{13}C_{16:0}$	$\delta^{13}C_{18:0}$	$\Delta^{13}C(C_{18:0}–C_{16:0})$
Porcine adipose fats			
Mean	–25.2	–24.4	0.8
Standard deviation	0.8	0.9	0.6
N	66	66	66
Ruminant adipose fats			
Mean	–29.1	–30.7	–1.6
Standard deviation	1.3	1.9	1.0
N	32	32	66
Ruminant dairy fats			
Mean	–28.7	–33.6	–4.8
Standard deviation	1.7	2.4	1.4
N	36	36	66
Marine oils			
Mean	–22.8	–22.3	0.5
Standard deviation	2.6	2.6	1.2
N	100	100	66

Summary of $\delta^{13}C$ values of $C_{16:0}$ and $C_{18:0}$ n-alkanoic acids obtained from modern European reference fats and oils (ruminant, non-ruminant, dairy and marine) (*Craig *et al.* 2013; Cramp *et al.* 2014; Dudd 1999; Spangenberg *et al.* 2006; Bell *et al.* 2007; Spiteri 2012; Recio *et al.* 2013*).

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Appendix 3

Geographic coordinates for the archaeological sites mentioned in the text

No.	Site	X	Y	Latitude	Longitude	UTM Zone
1	Cueva de la Dehesilla	264554.81	4061867.432	36°40'21.7862" N	5°38'4.2919" W	30
2	Cueva de los Murciélagos	483892.52	4075115.45	36°49'16.1954" N	3°10'50.165" W	30
3	Cueva de la Carigüela	461989.158	4144825.745	37°26'56" N	3°25'47" W	30
4	Cueva de Nerja	424695.324	4069025.891	36°45'48.271" N	3°50'37.3128" W	30
5	Cueva del Toro	363234.189	4091203.509	36°57'23" N	4°32'10" W	30
6	El Retamar	753619.904	4046164.546	36°31'35" N	6°9'59" W	29
7	Casa da Moura	478091.82	4353132.739	39°19'36" N	9°15'15" W	29
8	Cueva de la Vaquera	411222.3	4549088	41°5'15" N	4°3'25" W	30
9	Cova de la Sarsa	712672.739	4292999.192	38°45'34"N	0°33'09"W	30
10	Cova dels Lladres	409242.963	4603718.884	41°34'45.4" N	1°54'40.8" E	31
11	Los Cascajos	564468.418	4709469.643	42°32'03" N	2°12'54" W	30
12	Cova de les Cendres	252261.347	4285836.315	38°41'09" N	0°09'07" E	31
13	Antigos armazéns Sommer	488672.516	4284614.07	38°42'34" N	9°07'49" W	29
14	Pálacio Ludovice	487465.719	4285139.897	38°42'51" N	9°08'39" W	29
15	Cueva del Picado	262198.62	4054892.33	36°36'33.5715" N	5°39'31.3417" W	30

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Insights into the funerary practices in the dolmen of Cabecinha (Figueira da Foz, Portugal)

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ABSTRACT – *The dolmen of Cabecinha in the region of* Figueira da Foz *(Coimbra, Portugal) was excavated at the end of the 19th century by António dos Santos Rocha. This tomb belongs to a Megalithic necropolis of* c. *21 dolmens in Western-Central Portugal and was explored and published between 1880 and 1909. The aim of this contribution is to present the human bone collection of the* Megalitho da Cabecinha*, cross-referencing this data with the original available documentation from the excavation and the chronology obtained from direct radiocarbon dating of a human bone fragment. This approach is adopted to get insights into the funerary practices, and the biological and pathological profiles of the individuals deposited in the dolmen. The most relevant information obtained pertains to the mortuary behaviour, where a unique funerary practice for this Megalithic necropolis was identified. In each corner of the irregular polygonal chamber, an adult individual was deposited in crouching or squatting position in sandy sediment and surrounded by small flat limestone slabs. All but one individual was associated with votive items.*

KEY WORDS – *Megalithic tombs; burial practices; human bones; dolmen; Chalcolithic; central-west of Portugal*

Vpogled v pogrebne prakse v dólmenu Cabecinha (regija Figueira da Foz, Portugalska)

IZVLEČEK – *Raziskovalec António dos Santos Rocha je konec 19. stoletja izkopal dólmen Cabecinha na območju Figueira da Foz (Coimbra, Portugalska). Grobnica sodi v okvir megalitske nekropole, ki vključuje ok. 21 dólmenov v zahodno osrednjem delu Portugalske in je bila raziskana ter objavljena med leti 1880 in 1909. V članku predstavljamo zbir človeških kosti iz najdišča Megalitho da Cabecinha, primerjamo podatke z originalno dokumentacijo o izkopavanjih in kronologijo, ki smo jo vzpostavili z neposrednim radiokarbonskim datiranjem odlomka človeške kosti. S tem pristopom smo želeli pridobiti vpogled v pogrebne običaje ter v biološke in patološke profile posameznikov, ki so bili pokopani v dólmen. Najpomembnejše informacije, ki smo jih pridobili, se nanašajo na pogrebne prakse, saj smo prepoznali edinstven običaj, vezan na to megalitsko nekropolo. V vsakem kotu te nepravilne poligonalne komore je bil položen en odrasel posameznik v čepečem položaju, in sicer v peščen sediment in obkrožen z majhnimi ploščatimi apnenčastimi ploščami. Vsi razen enega posameznika so imeli ob sebi votivne predmete.*

KLJUČNE BESEDE – *megalitske grobnice; pogrebni običaji; človeške kosti; dólmen; halkolitik; osrednji del zahodne Portugalske*

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Introduction

In the last decade, research in Portugal has demonstrated that funerary practices from the Middle Neolithic to the Late Neolithic/Chalcolithic were less homogeneous than previously thought. This diversity is visible in terms of funerary practices and structures (*Boaventura* et al. *2014; Silva 2003a; 2002; 2012; Silva* et al. *2017; 2019; Valera* et al. *2014*), with the regions of Estremadura and Alentejo the best documented. Mortuary activities have been described for Megalithic tombs (*Boaventura* et al. *2013; Evangelista 2019; Silva 2020*), pit graves (*Silva 2002; 2012*), natural (*Carvalho* et al. *2012*) and artificial caves (hypogea) (*Silva 1993; 1996; 2019; Silva, Ferreira 2007*), and more recently, for ditched enclosures (*Valera* et al. *2014*) throughout that period. These tombs are frequently characterized by collective or multiple burials, with individual ones occurring less commonly. Primary and/or secondary unburnt and burnt depositions are also documented (*Bettencourt* et al. *2020; Silva 2003a; Silva* et al. *2015; 2017; 2020; Valera* et al. *2014*).

Between the end of the 19th and beginning of the 20th centuries a set of 21 megalithic tombs were excavated by the archaeologist António dos Santos Rocha, in the region of Figueira da Foz (Coimbra, Portugal; Fig. 1). The majority of these tombs, located in the central-west region of Portugal, were disturbed prior to their archaeological excavation. The interventions were published in four volumes of *Antiguidades Prehistoricas do Concelho da Figueira* (*Santos Rocha 1888; 1895; 1897; 1900*), republished in 1949 (*Santos Rocha 1949*) and by Luiz W. Carrisso and António dos Santos Rocha (*1909*). A number of these tombs revealed human bones, including the Megalitho da Cabecinha[1] (Alhadas, Figueira da Foz), representing a unique opportunity to get information about the funerary behaviour and biological and paleopathological profile of the individuals deposited in these dolmens. These human bone assemblages, nowadays curated at the Museu Municipal Santos Rocha (MMSR) were forgotten and never exhaustively studied. Additionally, and as usually happens to many old museum collections, part of the material was lost due to, among other reasons, reorganization, movements, and the lending of samples (*Silva, Ferreira 2016–2017*).

In recent years, research on the collection from this necropolis started to be conducted, including work on anthropological and archaeological findings. Among the former are the study of a possible trepanation in an adult male skull recovered from the Megalitho da Capella (*Silva 2003b*), and the analysis of the human bone assemblages from Megalitho do Facho (*Silva 2020*) and from Megalitho do Cabeço dos Moinhos (*Bettencourt* et al. *2020*).

The aim of this contribution is to provide a complete anthropological analysis of the human remains of the Megalitho da Cabecinha currently curated in the Municipal Museum of Santos Rocha (MMSR), cross-referencing this data with the original available documentation of the excavation, and the chronology obtained from direct radiocarbon dates of the human bones. This approach intends to obtain insights into the burial practices, biological profiles, and health status of the individuals who lived at the end

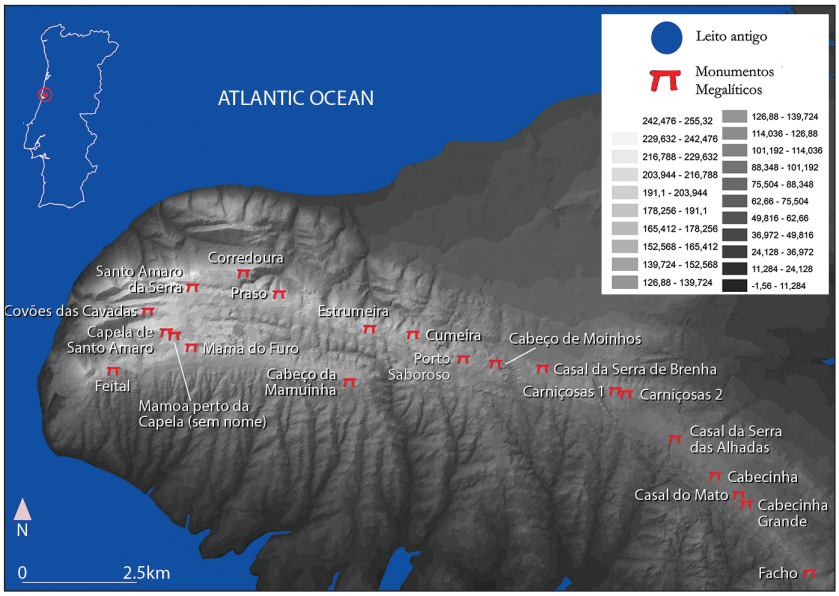


Fig. 1. Megalithic necropolis in the region of Figueira da Foz (Portugal) excavated by António dos Santos Rocha between the end of the 19th and beginning of the 20th centuries. Megalitho da Cabecinha is indicated by a red circle (adapted by Carlos Baptista – MMSR).

1 The original designation of Santos Rocha, Megalitho, is used. However, Megalitho, dolmen and the Portuguese expression 'Anta' all represent tombs without major architectural differences.

of the Neolithic and the beginning of the Chalcolithic periods in the central-west region of today's Portugal. As these populations are poorly known, the study will contribute substantial new information for this period.

The documentary sources of Megalitho da Cabecinha

The dolmen is composed of a chamber and a gallery oriented E-W. The gallery, formed by six orthostats (Fig. 2), presented a well-adapted door, with the entrance on the eastern side. The major axis is 3.5m long, 1.85m of the gallery (including the door) and 1.65m of the chamber. The gallery is 0.64m wide, and the chamber width varies between 1.75m and 2m – both measured at the level of the floor. The gallery was found intact with preserved coverage of small horizontal slabs. The larger roof slabs were made of sandstone and the small ones of limestone (Tab. 1). The door was made of two small slabs, placed against the end of the supports and held by two stones stuck in the ground as a buttress. Outside, a large accumulation of small stones surrounds the whole monument. The majority of the roof slabs of the chamber were missing, and one of the orthostats to the west was taken by the landowner to make millstones. This perturbation affected the chamber only superficially, except where the slabs were ripped out. Here the perturbation reached the base of the tomb, including the mortuary deposit lo-

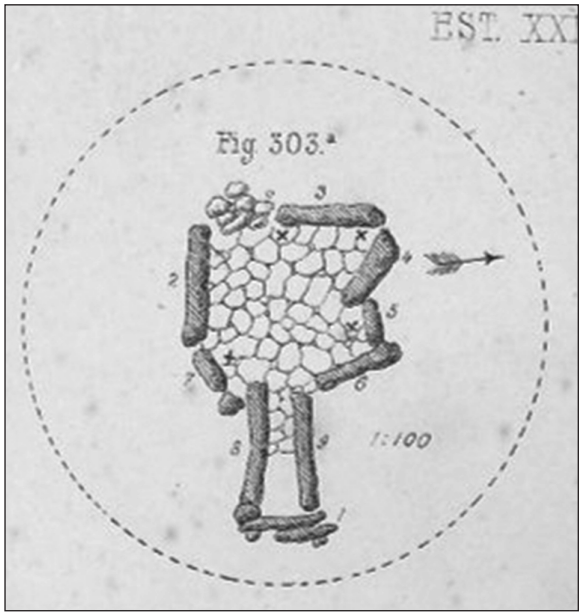


Fig. 2. Santos Rocha's drawing of the dolmen – Megalitho da Cabecinha (adapted from* Santos Rocha 1900.Fig. 303*). An X indicates where human bones were recovered.

cated between the angle of the missing orthostat and orthostat 3. The interstices of the supports were sealed with small stones. The floor of the chamber and part of the gallery were made of small and thin limestone slabs, laid over a layer of sand (*Santos Rocha 1900.196*).

All the contents of the chamber were mixed at the bottom of the monument due to old disturbances. At 0.4m, the superficial layers started to display signs of fire up to 0.65m deep, as evidenced by the presence of ashes, charcoal mixed with splinters of quartz and quartzite, small fragments of sandstone, and other materials. At that level (0.65m), signs of fire disappear, but the content continues to display signs of intense mixing.

The upper layer of the chamber was composed of reddish clayey soil, like the one in the tumulus. At around 0.5 to 0.7m, in the areas marked (with crosses) in the plan of the monument, evidence of four fire loci was found (Fig. 2). Each included ashes and charcoal, not exceeding 0.5m in diameter, with clods of undercooked clays, all strongly stuck in sandy soil. This level displays a thickness between 0.1 to 0.25m. Outside these areas, rubble in clayed soil continued to appear until the floor. The signs of fire then disappear completely around 0.15 to 0.25m beneath this, with only some splinters of quartz and flints being recovered. Below this level, the soil changes to limestone and groups of human bones started to appear. The burials were clustered next to the orthostats, crushed by the rubble, jammed over the pavement slabs, and very poorly preserved. These were surrounded by small flat stones of white limestone, except on the side of the supports. Santos Rocha (*1900.197–198*) made it very clear that no human bone displayed any signs of fire, and that such signs disappear entirely between 0.15 to 0.25m above the level of bones.

Santos Rocha (*1900.198*) provides a description of the burials of this tomb. The intact bones of the disturbed burial in the western part of the chamber (due to the ripping out of one orthostat) include long bones, vertebrae, ribs, some hand and foot bones, and several stone instruments (including an arrowhead, two blades, a hammerstone and a lithic nucleus).

In the corner formed by orthostats 3 and 4, several bones that probably belong to an adult skeleton were recovered. The femurs and tibias are stretched along orthostat 4, with tibias under the femurs. The

N	Side	Nature of the slab	Height	Length	Width
6	N	Sandstone	0.75	0.68	0.28
5	N	Sandstone	0.8	0.57	0.16
4	N	Sandstone	1.3	1	0.25
3	W	Sandstone	1.16	0.8	0.2
2	S	Sandstone	1.2	1.1	0.3
7	S	Sandstone	1.35	0.45	0.27
1	Door	2 slabs			Between 0.05 and 0.08

Note: All measurements, in meters, were taken from the level of the natural soil; *N* North; *W* West; *S* South (adapted of *Santos Rocha 1900.196–197*).

Tab. 1. Summary of the data of the orthostats of the Megalitho do Cabecinha (according to* Santos Rocha 1900. 196–198*).

cranium was deposited in the corner, and next to it were arms and trunk bones (all poorly preserved). Santos Rocha considered that the body was placed squatted in the corner with the face turned to the centre of the chamber (*Santos Rocha 1900.198*).

Another skeleton was found next to orthostat 5. The best preserved bones were femurs and tibias. Field observations allowed Santos Rocha to conclude that the skeleton was leaning against the support, facing the middle of the chamber. A small black pot was found on the left side of this skeleton between the body and the nearest orthostat. The soil inside the pot was the same as that covering the bones, and it contained a small, apparently human bone. Post-depositional perturbations of the tomb were most likely responsible for the introduction of this bone into the pot. Some artefacts were also recovered from this deposit, including a stone axe, some retouched blades and one arrowhead (*Santos Rocha 1900. 198*).

Another group of human bones, that according to Santos Rocha (*1900.199*) were "*completely decayed*" (translation by the author), were excavated among orthostats 2, 7 and 8, closer to the gallery. They apparently belonged to the same skeleton and were associated with prestige artefacts. Two notable pieces, one flint bade and a flint dagger blade, were recovered in a kind of niche "*next to the remaining bones*". However, Santos Rocha is not clear with regard to the location of this niche.

According to Santos Rocha (*1900.203–204*), the human bones were so poorly preserved that only a muddy block containing part of a crushed cranium, some teeth, fragments of femurs and tibias were taken to be curated in the MMSR. Among them, two fragments of femurs have a well develop *pilastrum* and a fragment of tibia, marked platycnemia. It seems that this set of bones belong to the same skeleton, although it is not possible to associate it with one of the burials described above.

Fragments of two small black pots (including the one next to the skeleton placed against orthostat 5) and a considerable number of artefacts were recovered from this dolmen (*Santos Rocha 1900.199–203*). Nowadays, the majority of these are on display in the permanent exposition of the MMSR, and include one flint blade, one flint dagger blade, 15 flint arrowheads, one polished stone axe-head, one flint and hyaline quartz nuclei and eleven flint blades. Some drawings were originally published by Santos Rocha (*1900*), but the complete set can be found in the work by the Leisner couple, in their compilation of Megalithic graves of the Iberian Peninsula (*Leisner 1965.126–128, Tabs. 90–91*). At present, this set of artefacts are currently being studied by collaborators of the MMSR.

This monument was dismounted and restored, with the help of Francisco Ferreira Loureiro, responsible for the drawings and plans of the tomb, in an exhibition space designed specifically for its display in one of the buildings belonging to the city hall of Figueira da Foz, where the local museum was created in 1899 (*Santos Rocha 1900.197*). Strictly, the available documents only attest to its presence in the gardens of city hall until the year of 1897. So, unfortunately, the whereabouts of its parts are now unknown [2].

Material and methods

All bone fragments currently curated at MMSR were dry-brushed with small brushes, labelled and marked. This process was followed by an inventory of the materials using an MS Excel sheet. An attempt was made to refit broken fragments of individual bones. The minimum number of individuals (MNI) was estimated according to Ana Maria Silva (*1993*, adapted from *Herrmann* et al. *1990*). Age at death of adult individuals was confirmed by the degree of completion of epiphyseal unions (*Ferembach* et al. *1980*). Identification of the sex of the adult remains was attempted using morphological traits following Denise

2 Personal communication of Ana Margarida Ferreira, Director of MMSR.

Ferembach's *et al.* (*1980*) recommendations. Nonmetric dental traits were scored following the ASU-DAS protocol (*Scott, Irish 2017; Turner* et al. *1991*), and the mandibular molar pit-tubercle (MMPT) according to Luís Miguel Marado and Ana Maria Silva (*2016*). Postcranial discrete traits were recorded following Shelley Rae Saunders (*1978*) and Michael Finnegan (*1978*) approaches. Dental wear was scored according to Bennett Holly Smith (*1984*) as adapted by Silva (*1996*). The osteological remains were macroscopically examined for evidence of pathologies, lesions and stress indicators.

Results

The collection curated at the MMSR includes one tooth and 31 bone fragments. Among the latter, six are small fragments with signs of exposure to fire, showing a black colour. Due to poor preservation we cannot rule out the possibility that these charred fragments are non-human faunal remains. Moreover, according to the notes by Santos Rocha, no signs of fire were observed in the recovered human bones. As such, these are probably fragments from the upper levels which percolated into the tomb and not related to the burial context, and thus not considered in the following anthropological analysis.

One small long bone fragment (Cabecinha 201) confirmed the Chalcolithic chronology of these human remains, placing them in the first half of the 3rd millennium BCE (Tab. 2).

The bones are very fragmented and mostly reduced to small pieces (Fig. 3). At present, the collections include cranial (n=7) and long bones fragments (n=18) and one tooth. Among the long bones, humerus, femurs and tibias were identified.

The bone fragments exhibit several changes related to various taphonomic agents, such as the presence of roots marks, small black spots and reddish spots on the only tooth recovered (Fig. 4). While the black spots can be attributed to the presence of manganese in the soil, the red spots are compatible with the use of pigment. Santos Rocha (*1900.203*) mentions the recovery of a piece of iron oxide from the site, that if sprayed produced a very intense red paint.

The preserved bone remains correspond to a minimum number of three adults based on the femoral fragments. No anatomical bone section was available for a more specific age at death or sex estimation. However, taking into account the femur sample, two individuals were clearly more robust than the third. The results of the nonmetric dental analysis can be seen in Table 3. Only the femur sample allows the scoring of postcranial nonmetric traits. In two femurs hypotrocanteric fossa were observed (2/3), and one of those also displays a third trochanter (1/3). The most gracile femur presented both traits.

The only preserved tooth is a lower left first molar, which displays dental wear of grade 5 (medium/high), without cariogenic lesions or deposits of calculus (Fig. 4). No pathological lesions were observed in the preserved bone fragments.

Discussion

Over the last few decades, a renewed interest in the study of skeletal remains of Prehistoric burials has emerged when their informative potential was recognized (*Evangelista 2019; Fernández-Crespo 2015; Silva 2002; 2017; 2020; Silva, Ferreira 2016–2017*). Thus, the comprehensive analysis of these assemblages from the Iberian Peninsula in the last two decades has revealed valuable details with regard to burial practices (*Boaventura* et al. *2014; Carvalho* et al. *2012; Evangelista 2019; Fernández-Crespo 2015; Silva* et al. *2015; 2017*), demographic profile (*Cunha* et al. *2015; Fernández-Crespo 2015; Fernández-Crespo, De-la-Rúa 2015; Silva, Ferreira 2007*), population affinities (*Irish* et al. *2017; Martiniano* et al. *2017; Olalde* et al. *2018; 2019; Szecsenyi-Nagy* et al. *2017*), mobility (*Carvalho* et al. *2016; Waterman* et al. *2014; Valera* et al. *2020*), diet and daily behaviours (*Bonilla* et al. *2019; Carvalho* et al. *2019; Cubas* et al. *2020; Fontanals-Coll* et al. *2016; González-Rabanal* et al. *2020; Guiry* et al. *2016; Silva* et al. *2012; Waterman* et al. *2016*), and the types of diseases and injuries these prehistoric individuals underwent (*Silva 2003b; 2011; 2017; Silva, Ferreira 2008a; 2008b; Silva, Marques 2011; Silva, Wasterlain 2010; Tomé* et al. *2017*), as well as their medical skills (*Silva 2003b; Silva* et al. *2017*), information that could not have been obtained otherwise.

Reference	Conventional	cal BC	cal BP	Isotopes (C/N = 3.2)
Beta 557667	4160±30 BP	2821–2632 cal BC (76.2%) 2880–2831 cal BC (19.2%)	4770–4581 cal BP (76.2%) 4829–4780 cal BP (19.2%)	$\delta^{13}C = -19.8$ $\delta^{15}N = 9.5$

Tab. 2. Results of radiocarbon dating of a fragment of the diaphysis of a human long bone from Megalitho da Cabecinha.

Unfortunately, the human bones recovered from this dolmen are scarce and there is no information as to which burial (or burials) they belonged to. However, careful reading of Santos Rocha's work allows us to recognize unique data on the funerary practices carried out in this dolmen, which differ from those documented in the other dolmens of this necropolis. The analysis of the human bone sample from Cabecinha confirms that all the bones belonged to adult individuals, at least three, an estimation close to the existing excavation notes that described four. However, the skeleton found next to orthostats 2/7/8 was, according to Santos Rocha (*1900.199*) field notes, completely decayed, so probably no bone fragments were recovered, and thus nowadays this individual is not represented in the assemblage curated in the MMSR.



Fig. 3. Set of bone fragments preserved from Megalitho da Cabecinha, illustrating the substantial fragmentation and poor preservation of the assemblage.

There is no evidence supporting more detailed age at death estimates other than marked tooth wear in the only preserved tooth, suggesting that it probably belong to a mature adulthood, based on the life stage model approach proposed by Mirjana Roksandić and Stephanie D. Armstrong (*2011*).

Although according to Santos Rocha the chamber of this monument was almost intact at its discovery, the bones within it were poorly preserved, and adhered to the stone slabs of the floor. However, data on the deposition of the cadavers and their funerary package could be obtained. The careful reading of Santos Rocha's field notes reveal some funerary peculiarities of this tomb. One individual was deposited in each corner of its irregular polygonal chamber, adding to a total of four inhumations. All individuals seemed to be adult ones. They were placed in

Traits	Observation/Grade
Number of Cusps	5
Groove pattern	Y
Presence of C6	N
Presence of C7	N
Deflecting wrinkle	NO
Protostylid	N
Mandibular molar pit-tubercle	N

Tab. 3. Non-metric dental traits observed in the only preserved tooth from Megalitho do Cabecinha, a lower first left molar. Legend: NO not observable; N not present.

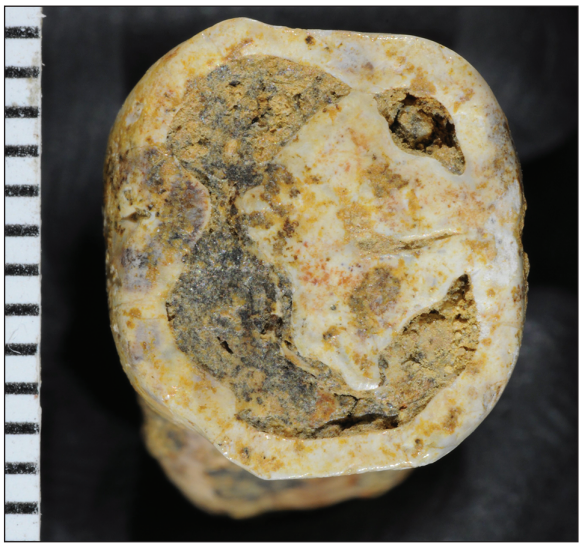


Fig. 4. Lower left first molar from Megalitho da Cabecinha exhibiting tenuous reddish spots on its occlusal surface.

a crouching or squatting position on the stony floor against the orthostats. The bodies were buried in sandy sediment and surrounded by small flat limestone slabs. These were probably used to support the burials as well as to separate them. The individuals placed against orthostats 3–4 and 5 were facing the centre of the chamber (no information is available for the remaining burials). Varied funerary packages were found next to the skeletons. All but one individual, the one next to orthostats 3–4 (*Santos Rocha 1900.256*), were associated with votive items, as described in the previous section. According to him, the most impressive funerary package was recovered with the individual buried next to orthostats 2, 7 and 8. It included a bifacial flint blade and a bifacial flint blade for a knife, which are now part of the permanent exhibition at MMSR (see footnote 2). There is no spatial information on the ob-

jects other than the fact that they come from the chamber, except for a few pieces such as the two flint blades and the pot mentioned above.

Although data is scarce, it does support the inference that there was some kind of selection of individuals who were buried in this tomb. The low number of burials (three according to the preserved human bone samples, and four, according to field notes of Santos Rocha), is also noteworthy, as well as the fact that at least three of them were associated with varied and abundant funerary packages, besides the set of funerary items recovered from the tomb that were not found linked with a specific burial. The archaeological assemblages are currently under study, but preliminary data suggests there is a large number of artefacts compared to the number of individuals buried in the tomb.

Human bones from nine of the 21 tombs in this necropolis are nowadays curated in the MMSR. Besides Cabecinha, AMS radiocarbon dates (Tab. 4) and anthropological data are also available for Facho and Cabeço dos Moinhos and will be here used for comparative purposes.

The analysis of the findings from these three dolmens suggests different burial practices. Facho and Cabeço dos Moinhos include unburnt and burnt samples, although the later produced older AMS radiocarbon dates (see Tab. 4). These two collections share a similar age profile as they include remains of both adult and non-adult individuals (Tab. 5). Cabecinha's sample on the other hand is made up of only unburnt bones of adult individuals. This tomb has the lowest number of individuals and also the smallest chamber. AMS radiocarbon dating confirmed that all human remains in these collections are dated from the first half of the 3rd millennium BCE, corresponding to the Chalcolithic period, with the exception of the unburnt sample of Cabeço dos Moinhos, which revealed a Neolithic chronology (5500–2900 BP).

Some major differences in the architecture (Fig. 5) and grave goods are noted. Cabeço dos Moinhos is, according to Santos Rocha (*1895.93*), the biggest and richest monument of this necropolis with orthostats of different lithological types. Facho and Cabecinha are smaller tombs with polygonal chambers, and short galleries. The former includes limestone and sandstone orthostats, the latter only sandstone ones. Therefore, besides the diversity in burial practices, architectural differences are also noted. Concerning the grave goods, differences are apparent in Santos Rocha's descriptions, and a detailed study of all these collections curated in the MMSR is underway. The assemblage of Cabecinha also stands out in the presence of field notes describing the deposition of the bodies, since the burial level of the chamber was found almost intact: they were placed in a crouching or squatting position on the stony floor against the orthostats, buried in sandy sediment and surrounded by small flat limestone slabs. For two of them, it was possible to confirm that they were facing the centre of the chamber (individuals placed against orthostats 3–4 and 5). The assemblage of graves goods was also different between the burials: no votive items were found next to the burial of ortosthats 3–4, and different votive packages were found for the remaining three. The richness of the burial next to ortosthats 2/7/8 stands out when compared to the others (*Santos Rocha 1900.198–199*).

Dolmen	Reference	Bone sample	Conventional
Cabecinha	Beta 557667	Long bone diaphysis	4160±30 BP
Facho	Beta 542625	Rib fragment (unburnt)	4180±30 BP
(*Silva 2020*)	Beta 549966	Cranial fragment (burnt)	4170±30 BP
Cabeço dos Moinhos	Beta 383084	Bone (unburnt)	4960±30 BP
(*Bettencourt* et al. *2020*)	Beta 383085	(burnt)	4360±30 BP

Tab. 4. Results of available radiocarbon dating from dolmens from the Megalithic necropolis of the regions of Figueira da Foz.

Sample	Adults	Non-adults	Total	Area chamber
Cabecinha	3 or 4*	0	3 or 4*	±3m²
Facho	7 (63.6%)	4 (36.4%)	11	±4.5m²
Cabeço dos Moinhos** (unburnt)	8 (80%)	2 (20%)	10	±10.5m²

Tab. 5. Proportion of adults versus non-adults in the considered samples. Legend: * laboratory analysis now suggests NMI of three individuals, but field data suggests four adults (see text); ** the burnt samples are presently being re-analysed for a separate estimation of NMI.

Among the biological profiles of the individuals from Cabecinha, the presence of hypotrochanteric fossa, a skeletal variant, is a common trait in all of them (Tab. 6). This depressed area at the back of the femur seems to be a varied manifestation of the attachment area of *gluteus maximus*, a muscle responsible for the movement of the hip and thigh. According to several authors, the development of this fossa may be related to increased develop-

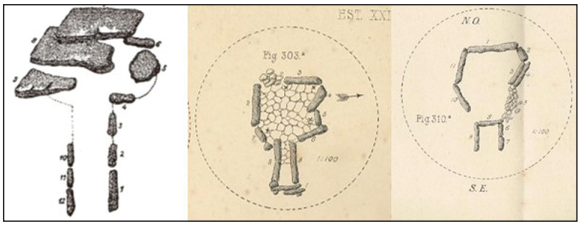


Fig. 5. Original drawings by Santos Rocha of the Megalitho da Cabecinha, Megalitho do Facho and Megalitho do Cabeço dos Moinhos.

Sample	Septal Aperture	Hypotrochanteric fossa	Third trochanter
Cabecinha	–	2/3	1/3
Facho	1/1	2/3	–
Cabeço dos Moinhos	–	3/4	1/4

Tab. 6. Morphological non-metric traits observed in the samples discussed in the present study.

ment of this muscle to reduce the mechanical stress on the femoral diaphysis (*Marioti, Belcastro 2011*). This suggests a mobile lifestyle for these individuals in an irregular mountain region, such as the Serra da Boa Viagem.

The scattered nature of the human remains from Cabecinha hindered the observation of pathological changes in the bones, and thus obtaining insights on the general health status and living conditions of these individuals was not possible. This data would have been relevant not only in trying to understand why they were selected to be buried in this tomb, but also in order to compare them with data obtained from the individuals buried in Facho and Cabeço dos Moinhos. The paleopathological analyses of these last two assemblages revealed signs of infections, trauma, articular and non-articular degenerative disease and physiological stress indicators. The presence of largely remodelled and non-active lesions suggests that these individuals were resilient and survived various health problems (*Silva 2020*).

Final remarks

The major contribution of the present work is in the domain of funerary practices, by integrating the data from the documentary sources with the findings of the bioarchaeological analysis, and the chronology obtained from direct radiocarbon dating of a human bone sample. The carefully analysis of all the sources, documents and human bone assemblages made it possible to identify a unique funerary behaviour in one dolmen of this necropolis, where apparently only three adult individuals (four according to field notes) were deposited, accompanied by a significant set of artefacts. The femur sample suggests that two individuals were clearly more robust than the third one.

It has to be highlighted that the three dolmens of this Megalithic necropolis, where the human bones were studied using modern osteological methods (Cabecinha, Facho and Cabeço dos Moinhos), reveal different burial practices, confirming the growing heterogeneity of funerary practices of the human communities of the Late Neolithic and Chalcolithic period of today's Portugal. The study of the remaining human bone collections of this Megalithic necropolis is now underway, and the results will allow us to obtain valuable data about the human populations that lived in Prehistoric times in the more central-west region of the Iberian Peninsula.

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Dating the ladies: spatio-temporal development of the Early Bronze Age cemetery at Nižná Myšľa (Slovakia)

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ABSTRACT – *The cemetery in Nižná Myšľa is one of the most important funerary sites in Early Bronze Age Central Europe. Many years of excavations led to the discovery of nearly 800 graves associated with the Otomani-Füzesabony culture. The presented paper is an attempt to reconstruct the spatial development of the cemetery, based on statistical analyses of grave goods and using the latest findings concerning the absolute chronology of selected categories of finds. A significant role in the analyses was played by female burials, in which numerous objects were discovered, which were evidence of the relatively high status of women in the local community. This provided the authors with a basis for discussion with regard to the dominant male-oriented narratives concerning the communities of fortified settlements.*

KEY WORDS – *Otomani-Füzesabony; Early Bronze Age; correspondence analysis; chronology; female status*

Datiranje žensk: prostorsko-časovni razvoj starejšega bronastodobnega grobišča Nižná Myšľa na Slovaškem

IZVLEČEK – *Grobišče Nižná Myšľa je eno od najpomembnejših pogrebnih prostorov iz časa starejše bronaste dobe v Srednji Evropi. Večletna izkopavanja so odkrila ok. 800 grobov, ki so vezani na kulturo Otomani-Füzesabony. V našem prispevku skušamo rekonstruirati prostorski razvoj grobišča, in sicer s pomočjo statistične analize grobnih pridatkov in z uporabo najnovejših ugotovitev, ki so vezane na absolutno kronologijo izbranih kategorij najdb. Pomembno vlogo pri analizi imajo ženski grobovi, v katerih so bili odkriti številni pridatki, kar kaže na višji družbeni status žensk v lokalni skupnosti. To predstavlja avtorjem tudi osnovo za razpravo o prevladujočih zgodbah, ki so osredotočene na moške, v povezavi s skupnostmi, ki so živele v utrjenih naselbinah.*

KLJUČNE BESEDE – *Otomani-Füzesabony; starejša bronasta doba; korespondenčna analiza; kronologija; status žensk*

Introduction – the Early Bronze Age site at Nižná Myšľa

The Nižná Myšľa (hereinafter NM) site, located in the Košice Basin, is one of the best archaeologically recognized elements of the Otomani-Füzesabony (hereinafter OF) culture settlement network in Slovakia (*Fischl, Olexa 2020*) and more broadly – in the vast area where the mentioned phenomenon developed (Fig. 1) (*Fischl, Kienlin 2020*).

Archaeological research on the NM site began in the late 1970s and is still carried out today by a team

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led by Ladislav Olexa (*Olexa 2003.10–12; Olexa, Nováček 2015.9–12*). As a result of several decades of research, the complex structure of the site was identified, consisting of two separate fortified settlements, different in terms of chronology, with a cemetery associated with the older one (*Olexa 2003; Olexa, Nováček 2013; 2015; 2017*). Both settlements were surrounded by extensive and massive fortifications in the form of walls and ditches (*Jaeger 2016.113–114*). The excavations of their interiors provided numerous remains of huts (mainly in the form of partially preserved compacted loess floors and hearths) and pits with various functions. The main difference between the two settlements was the size and space they occupied. The fortifications of the older settlement covered an area of approx. 50x60m. The younger settlement covered a much larger area of approx. 7ha (*Gašaj 2002.27*). Its fortifications also had larger dimensions and a more complex structure. They covered not only the layers and remnants of the buildings of the older settlement, but also the area of the cemetery associated with it, which is the subject of the current analysis (*Gašaj 2002.33; Olexa, Nováček 2015.8*). The burial place related to the younger settlement has not been discovered so far.

Chronology and space of the cemetery – the current state of knowledge

Over a long period of research, a total of 792 graves (including cenotaphs) have been discovered in the cemetery (Fig. 2) (*Olexa, Nováček 2013; 2015; 2017*). Most of the burials were preserved well enough to determine the age and sex of the deceased (*Nováček 2017.24*). Grave goods and the forms of burials were thoroughly analysed by Tomáš Nováček as part of his PhD thesis (*Nováček 2017*). On the basis of typochronology and the few available radiocarbon dates, the development of the cemetery was divided into three horizons correlated with the local chronological system based on the classical scheme by Paul Reinecke (*1924*): (i) the pre-classical horizon (BA2); (ii) the older classical horizon (BA2/BA3); and (iii) the younger classical horizon (BA3).

No archaeological sources related to the earliest Koštany-Otomani stage of OF development in Slovakia have been observed in the cemetery. Its decline, on the other hand, precedes the youngest stage of OF development in the BB1 period, when a second fortified settlement was established, covering the area of an older settlement and a cemetery (*Nováček 2017.16–19*).

The typochronological order of the sources from the cemetery (*O.c.*) was to be generally reflected in its specific spatial arrangement. The oldest burials (BA2) were grouped in the western part of the area, in the central one artefacts from the 'transition period' (BA2/BA3) were found, while in the eastern part the burials with the typologically youngest finds (BA3) were located.

Generally, it can be said that the burials were arranged regularly, in linear patterns along the W-E axis. The linear plan of the cemetery also shows that individual burials located closer to each other form separate groups in several cases. The lack of a significant number of graves with a similar relative chronology remaining in a stratigraphic superposition (only two cases; *O.c.35*) allows us to assume that they were originally marked on the surface. Their locations were respected while preparing a new burial place.

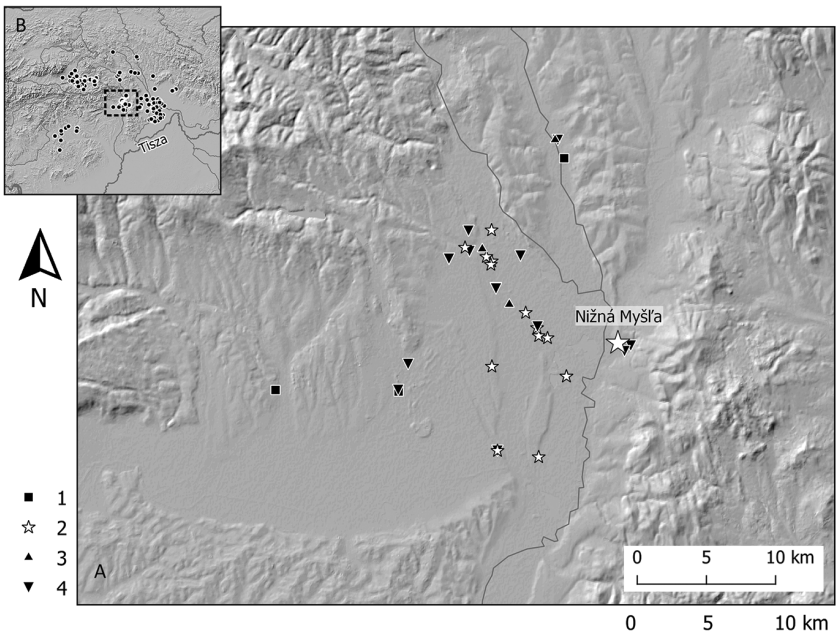


Fig. 1. Distribution of Otomani-Füzesabony culture sites in the area of the Košice Basin (A): 1 stray finds; 2 cemeteries; 3 hilltop or fortified settlements; 4 open settlements. General distribution of Otomani-Füzesabony culture sites in the territory of present-day Slovakia (B).

The chronology and space of the cemetery in the light of statistical analysis

The small number of radiocarbon dates available, in the context of the very large number of burials discovered at the site, hinders the spatial and chronological debate. However, in order to achieve this goal, it was decided to apply a set of statistical methods combined with the current state of knowledge about the absolute chronology of particular finds registered on the NM cemetery.

On the one hand, the aim of the analysis was to verify and possibly clarify the chronological scheme presented by Nováček (*2017*)[1], and on the other, to try to recreate the history of the cemetery's development in terms of absolute chronology.

Methods and selection of sources

The choice of grave goods is not accidental, but related to the existence of cultural and social rules in a given place and time. In light of the huge amount of data from the cemetery in NM, it was decided to use multidimensional statistics. One of the methods used to reduce and classify data is Correspondence Analysis (hereinafter CA). The advantage of CA over other statistical analysis is not only the search for correlations between data offered by it, but also the presentation of the actual structure within them, regardless of the degree of its irregularity (*Jensen, Høilund-Nielsen 1997.3–7*). CA has found wide application in archaeology, including detailed studies of burials (*O.c.39*).

In order to determine the degree of dependence between individual NM burials, the finds constituting grave goods were subjected to statistical analysis. To avoid the 'garbage in/garbage out' effect, it was decided to reduce the variables to those with a relatively high frequency of occurrence (more than 10 cases). In this way, it was possible to detect significant trends in the analysed correlation. In addition, data regarding grave goods were supplemented with information about the sex and age of the deceased. These are important anthropological categories, practically without exception culturally valued in prehistory (*Müller 2005*) and as such they may constitute factors significantly influencing the shape of the relationship of attributes within the set. The results of the CA helped to establish the chronological and spatial sequence in the process of shaping the NM cemetery (Fig. 3). Due to the size of the cemetery and its complexity, it was decided to perform a two-stage analysis.

The results of the analysis – chronology

At the first stage, all graves were taken into account and analysed on the basis of selected variables characterizing separate statistical trends (Fig. 3.a). The obtained results clearly show two concentrations of points. This division largely coincides with the relative chronology of individual graves in the cemetery. Burials interpreted as older and related to the A2 period appear on the left side of the chart, while graves generally dated to the A3 period on its right side. The boundary between both sets can be taken as the area running through the centre of the graph (on the Y axis, approximately between the values –0.75 and 0). The graph shows a clearly greater correlation of points and attributes associated with the A3 phase. This may suggest a greater unification of the burial rite and a certain standard existing in the funeral inventory at that time. The correlation of the variables is also more concentrated, which strengthens the above-mentioned interpretation. On the basis of the obtained results, it is possible to indicate the elements of grave inventories which are dominant in the various stages of the

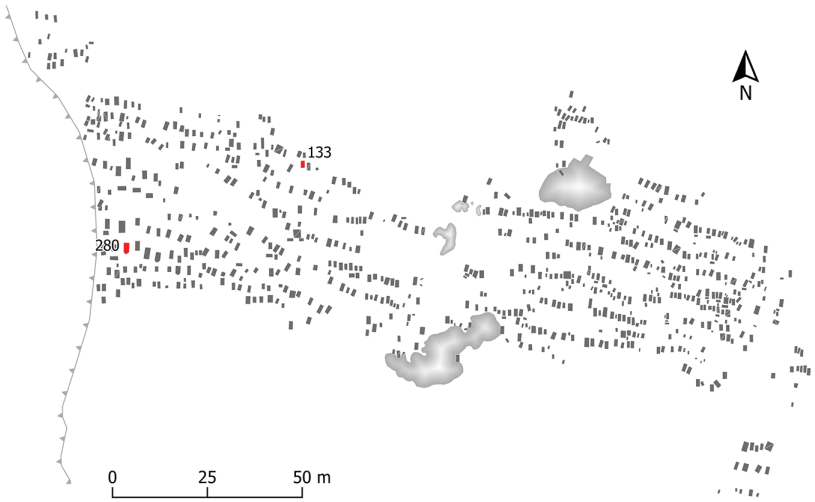


Fig. 2. Nižná Myšľa. General plan of the cemetery. Metallurgists' graves marked in red.

1 In this text, the terminology taken from the cited study is used with regard to ceramic forms.

existence of the cemetery. For the A2 period, this would be the set consisted of: boar tusk pendants, arrowhead(s), bone awl, bone needle, Rollenkopf pin type II, shell, obsidian, DC jug, and PB cup. The bronze earring and the HA pot were of marginal importance. However, for the A3 period, a characteristic set consisted of: needle-like pins, Rollenkopf type II pins, Kugelkopf and Hülsenkopf type pins, amber, faience and more ceramic forms, *i.e.* DA and DB jugs, PB cup, HB pot, MB2 bowl and settlement vessel. Bronze awls and daggers were of less importance (from a statistical point of view), although their presence should be noted.

There is a tendency with regard to the sex and age of the deceased. Namely, men are located in the centre of the chart, which proves the equivalent occurrence of male deceased in both (A2 and A3) periods of the cemetery's existence. On the other hand, women are more correlated with the younger period (A3). At this stage of the analysis, the relationship between the sex of the deceased and their age was also documented. The following relationships are visible: male -> *adultus*, female -> *infans*, and *iuvenis*. These results prompted the authors to make the analysis more detailed, and thus in the next stage separate calculations were made for both sexes of the deceased (Fig. 3.b-c).

As a result of separate CA analysis of the male and female burials, the chronological division visible in the previous analysis was maintained. In the case of CA of male burials, a smaller correlation of individual attributes is noticeable, mainly in the A3 period, which may indicate greater diversity (greater freedom) in the selection of grave goods or a different level of complication of the rules of the burial rite. For the A2 period, a set of grave goods typical for a male burial (boar tusk/boar tusk ornaments, arrowhead(s), PB cup, shell, bronze earring, Rollenkopf pin type I, awl and bone needle) on the one hand clearly refers to the figure of 'man-hunter', on the other hand, to some extent, it corresponds to female burials, which would indicate a certain stage of unification of the grave goods in regard to both sexes (see below). In the A3 period, ceramic forms appear in a larger number than previously (DA and DB jugs, MA and MB2 bowls, PA cup, HB pot). On the other hand, the CA results for female burials indicate a much lower degree of inertia of the attributes taken into account in the analysis, which suggests a strict set of grave goods for particular chronological periods. In the BA2 period, the dominant grave inventory (bone awl and bone needle, shell, Rollenkopf pin type I, PB cup, DC jug) can be partially perceived as related to economic activities within the household (bone awl and bone needle), moreover, a modest representation of ornaments is noticeable. However, in the A3 period, there is a clear change in this respect. There are numerous items made of less accessible non-local raw materials and of foreign stylistic (amber, faience, Rollenkopf type II, Kugelkopf, Hülsenkopf and needle-like pins) and new ceramic forms (PA cup, DA and DB jugs). The above results show that the rules of burial rite vary over time and, for some time, depend on the sex of the buried individual (Fig. 4).

In order to detail the chronology of the cemetery in NM, it was decided to use information from studies on selected categories of finds carried out for other areas of Central Europe (*Stockhammer* et al. *2015; Erneé 2015; 2020; Brunner* et al. *2020; Massy, Stockhammer 2020*). A detailed analysis of the grave goods from NM burials (*Nováček 2017.40–115*), supported by the results of statistical analysis, made it possible to distinguish chronologically most 'sensitive' finds from the available set. They were mainly ornaments, *i.e.* boar tusk pendants and different types of bronze pins. A total of 277 pieces of bronze pins were identified in NM burials (*Nováček 2017. 81–82*). Four types were the most numerous: Rollenkopf, needle-like, Hülsenkopf and Kugelkopf pins. The rest of the finds are mostly fragmentary preserved pins that cannot be identified typologically. Pins are the most numerous group of non-ceramic items among NM grave goods (*Nováček 2017.81*). The vast majority of them were placed in female burials of all age categories identified at the site.

As mentioned in the introduction, the NM site has a very complex structure and history of development, within which there were two settlements and probably also two cemeteries. The younger settlement did not respect the funeral space created by the community previously inhabiting the selected area, as evidenced by a large number (201 cases) of graves disturbed while digging pits of various functions (*Nováček 2017.36*). Unfortunately, there is a small amount of radiocarbon dates that would allow us to reconstruct the settlement's development and burial rites' changes at the site. All radiocarbon datings from the settled area are associated with a later stage of the younger settlement's existence (*Jaeger 2016.130–131; Nováček 2017.18–20*). For the cemetery, we have only two radiocarbon datings, coming from the metallurgists' graves (Fig. 2) (*Olexa 1987; Jaeger, Olexa 2014*) and locating them in the

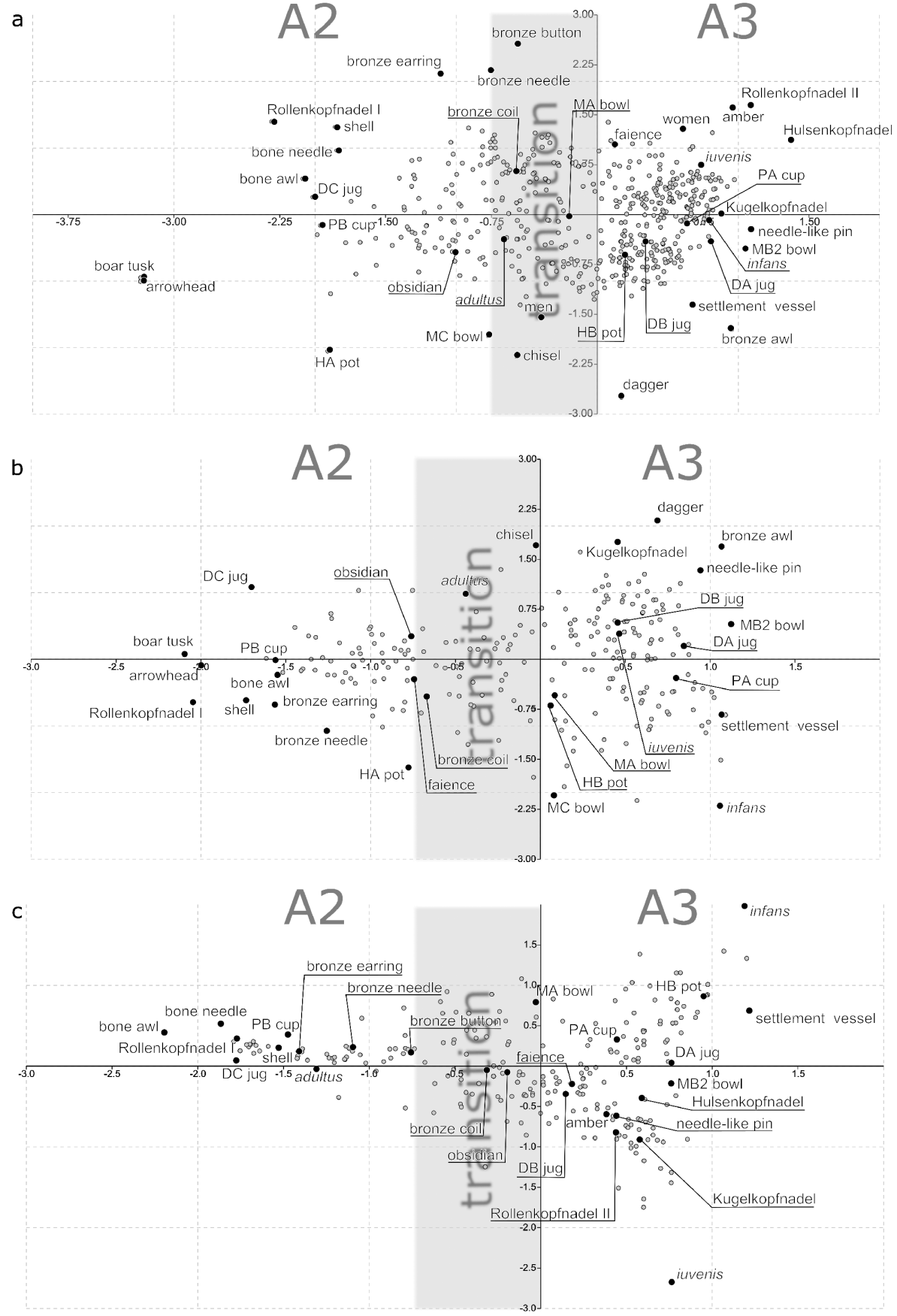


Fig. 3. Nižná Myšľa. Results of correspondence analysis of grave goods for:* a *all graves;* b *male graves;* c *female graves (shown on the 1st and the 2nd eigenvectors).

older stage of the funeral space existence. However, the age of these graves is important due to the particular items that make up their grave goods. Among them the most significant are casting moulds. In grave no. 280, a casting mould for a pin with a spherical head (Kugelkopf type) was discovered, a ready-made example of such a pin (unornamented), and ornaments made of boar tusks. These items have relatively many radiocarbon-based analogies that indicate their location more precisely on the time scale. The discovery of the casting mould can be treated in this context as a chronological reference point (*terminus post quem*) in the discussion concerning the age of burials equipped with Kugelkopf pins in the NM cemetery. In the case of grave no. 133, the discovered casting mould was used to produce simple forms of Rollenkopf pins. Two types of Rollenkopf pins are known from NM burials and they have a different chronological position. The first type had a rolled tip (type I) and the second one had a tip which was first flattened and afterwards rolled (type II).

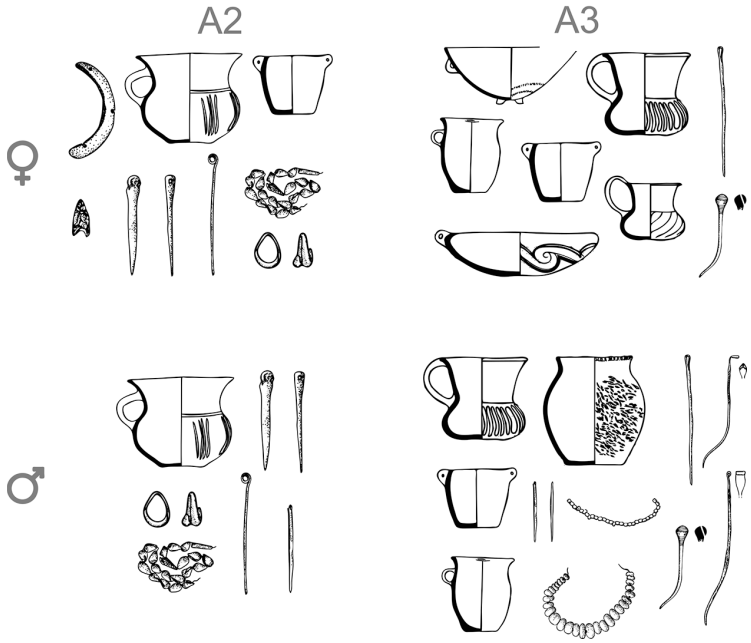


Fig. 4. Idealized grave goods sets for male and female burials in periods A2 and A3.

The analysis of available radiocarbon dates related to specific pins also present in NM burials allows for a new look at the spatial development of the cemetery. In the light of the available dating for the boar tusk ornaments, bone needles, and following pin types, the correctness of the general development trend of space along the W-E axis, determined with the use of typochronological data, can be indicated (Fig. 5). In the western part of the site, there are mostly female burials equipped with simple Rollenkopf pins type I. They are typologically the oldest forms, which in statistical analysis correspond to the oldest male burials, characterized by the presence of obsidian arrowheads, bone needles and ornaments made of boar tusks (Fig. 5.a-b). Available radiocarbon dates coming from other regions of Central Europe dating Rollenkopf pins type I, ornaments made of boar tusks, and bone needles, allow this stage of creating a funeral space in NM to be located around 2000–1900 cal BC (*Stockhammer* et al. *2015; Lorenz 2013*). In the centre of the cemetery, the basic forms of pins deposited in graves were Rollenkopf pins type II and large needle-like pins (Fig. 5.c-d). The first of these are the above mentioned younger variant of the Rollenkopf pin. In turn, pins in the form of a large, sometimes decorated, needle are an eminently local form. They are probably ornaments that had their prototypes in tools – bone needles, found in numerous burials in the oldest part of the cemetery[2]. Their aesthetic function is evidenced, on the one hand, by their delicate and non-functional structure, sometimes with decorations in the form of grooves placed under the loop, and their deposition in graves near the head or chest of the deceased. The bone needles (as well as awls, chisels and other tools) were located in NM practically without any exception near the feet of the deceased (*Nováček 2017.83*). The remaining pins known from NM are the Kugelkopf and Hülsenkopf pin types and are concentrated in the eastern part of the cemetery (Fig. 5.e-f).

Based on the available radiocarbon dated examples of those pins in other regions of Central Europe, it can be assumed that the central area of the cemetery was used in a relatively short period of around 1900–1850 cal BC. These dates indicate the older section of the eastern (younger) part of the area which was finally covered by the cemetery in NM. As mentioned above, the pins of the Kugelkopf type were known and locally produced in the period of

2 A similar change of the raw material from bone to bronze was observed in the case of awls. These tools were made of bone in the early stage of the cemetery's existence. With time, however, these forms were replaced by examples made of bronze.

the functioning of the oldest stage of the cemetery (see the mould and the pin from grave no. 280). However, there are very few finds of this pin type in the western part of the cemetery (only three burials). Their greatest number and concentration are observed in the most eastern, *i.e.* much younger, part of the cemetery (Fig. 5.e). In this context, grave no. 280 should be treated as a remnant of the initial stage of production of a new type of ornaments, which became popular at a later period. Hülsenkopf pins have a similar location within the cemetery (Fig. 5.f). Burials equipped with pins of both types constitute the group of the youngest objects in the cemetery. Based on the available radiocarbon dated examples from outside NM, the period of occurrence of these types of pins should be assumed to be around 1850–1650 cal BC (*Brunner* et al. *2020; Stockhammer* et al. *2015*).

To sum up, on the basis of the current knowledge about the absolute chronology of the occurrence of certain types of pins and boar tusk pendants in female graves (Fig. 6), the stages of the development of the funeral space in NM can be determined within the following general framework:

- stage I: BA2 – 2000–1900 cal BC (A1);

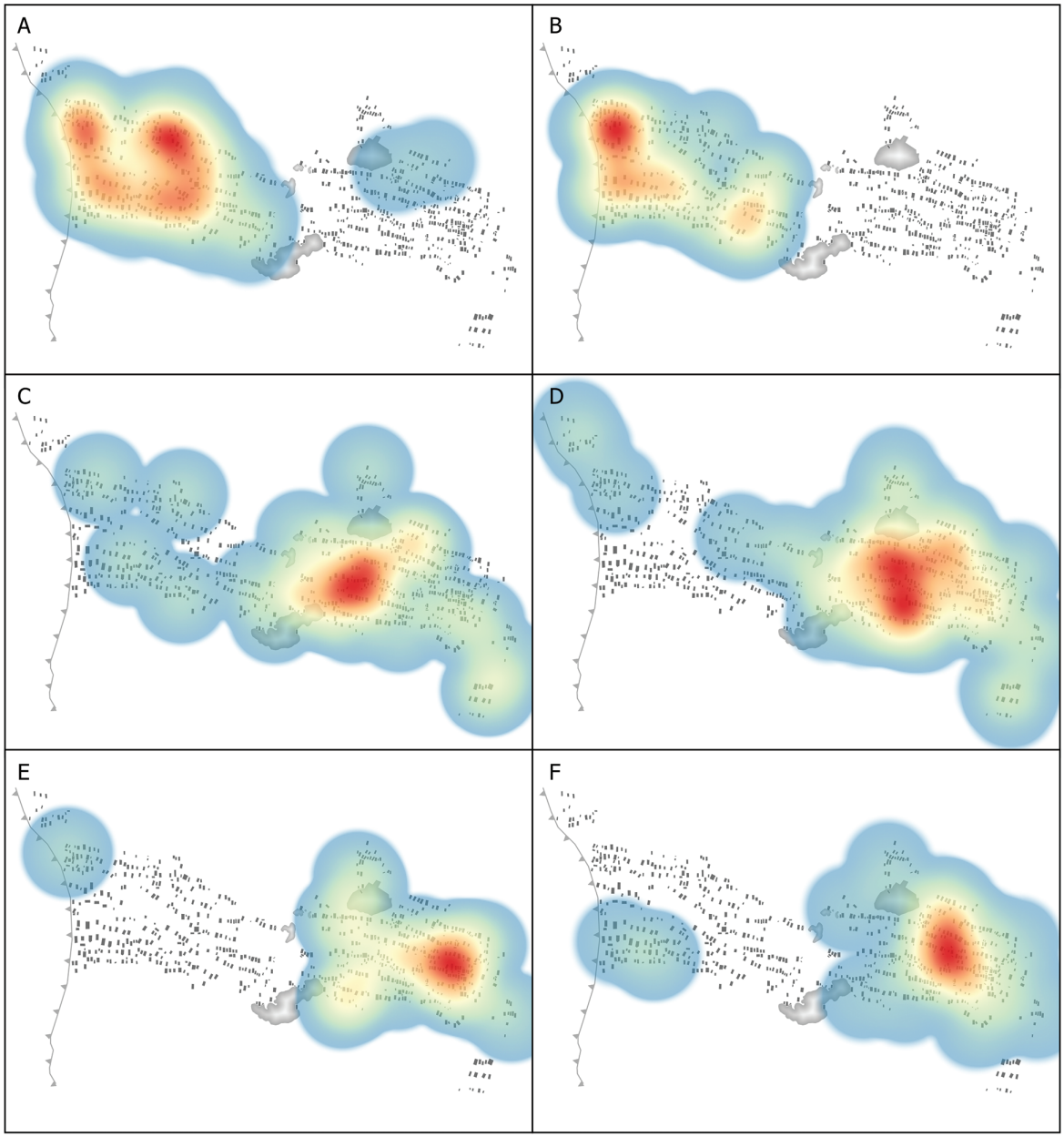


Fig. 5. Nižná Myšľa. Distribution and Kernel Density Estimation results of:* A *boar tusks ornaments and bone pins;* B *Rollenkopf pins type I;* C *Rollenkopf pins type II;* D *needle-like pins;* E *Kugelkopf pins;* F *Hülsenkopf pins.

- stage II: BA3/older – 1900–1850 cal BC (A1/A2);
- stage III: BA3/younger – 1850–1650 cal BC (A2).

The results of the analysis – space

As mentioned above, the general layout of the cemetery indicates a relatively high regularity and linearity in the location of burials along the W-E axis. The documented linear burial arrangements are not, however, the result of constructing a funeral space starting from an undefined single point as the first and oldest grave. In the light of the convergent radiocarbon dating of metallurgists' burials, which were located in separate groups, at a large distance from each other, within the western part of the cemetery (Fig. 2), it can be assumed that the observed arrangement of the cemetery space is instead the result of creating it simultaneously in several places. In other words, the arrangement of individual groups of burials probably reflects the ties between the deceased in life, although the chronological dimension of this practice can also be grasped to some extent. Assuming the hypothesis that the burial places of families appeared as spatially separate groups of graves, the methodology used in spatial statistics

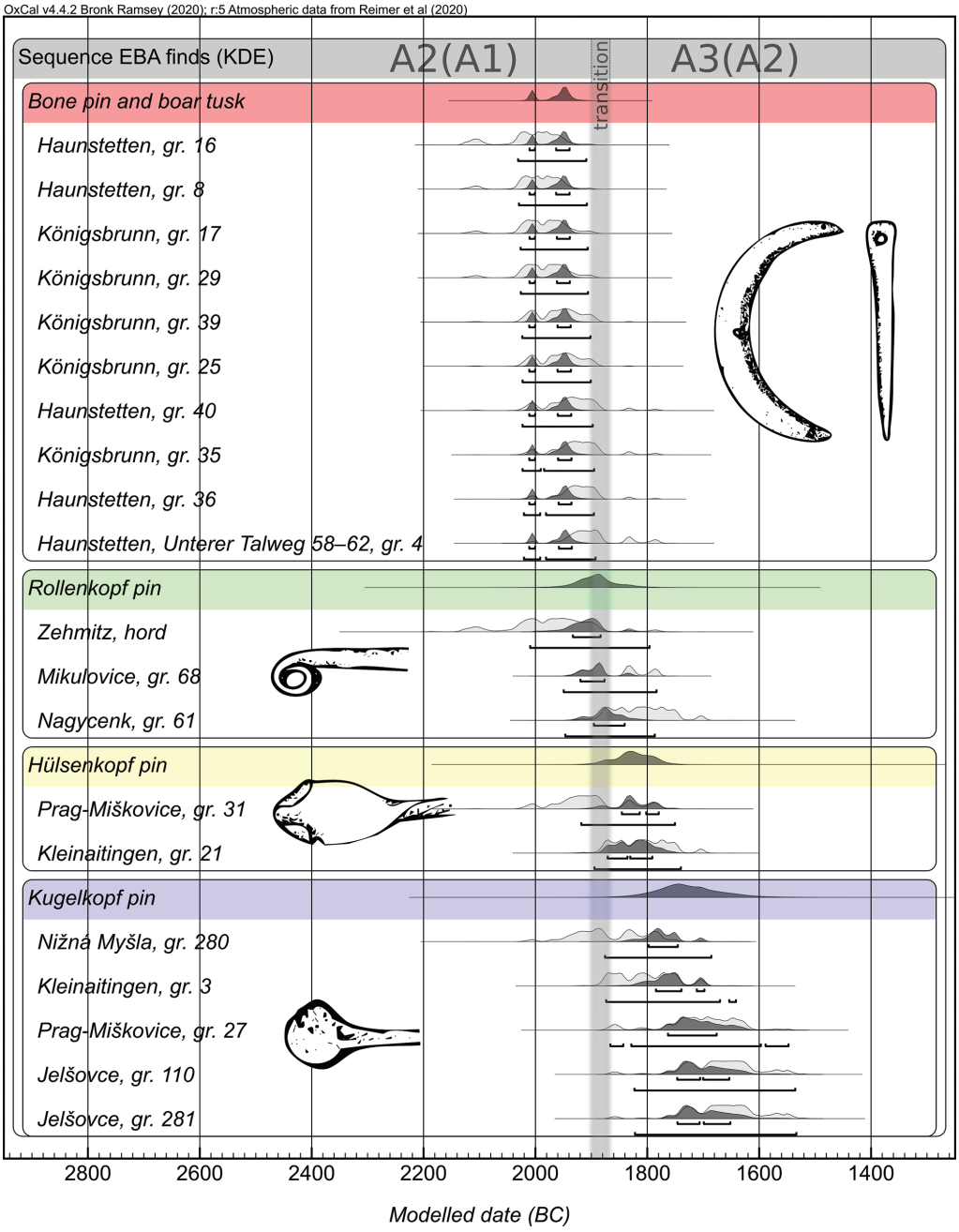


Fig. 6. Plot of dates from Central European sites with pin and bone finds analogous to those from Nižná Myšľa cemetery.

was applied (*Krištuf, Švejcar 2015*). Kernel Density Estimation (hereinafter KDE) and Nearest Neighbour Distance (hereinafter NND) analysis were used to identify these burial groups. In the case of KDE, the radius of analysis was arbitrarily assumed to be 5m (Fig. 7).

The KDE results revealed that the eastern part of the cemetery showed a much greater dispersion of the graves. Only one concentration of graves, located in the north-west of the area, was recorded there. However, in the eastern zone there are five concentrations, sometimes with a linear course, the largest of which is located near the eastern edge. The distances between the centres of all locations were then calculated based on the centroid of each burial. In the case of the NM cemetery, the average closest distance was approximately 2.9m. All points were then connected at a distance of 3m (Fig. 8). It is assumed that families in the Neolithic and Bronze Age were rather small, consisting of four to six members (*Neustupný 1983*). Taking the above into account, the described systems indicate potential family lineages. Smaller clusters of two or three graves could reflect a different kind of family lineage. Groups of seven or more burials should be interpreted as reflecting other categories of social relationships and ties. In the further analysis, the obtained results were correlated with information on the sex and age of the buried people.

The aforementioned typological findings by Nováček assume full reflection of the three horizons of relative chronology in the space of the cemetery. Statistical analysis of all grave goods and a separate analysis of female burials furnished with pins made it possible to propose a more complex process of the formation of the funeral space in NM. First of all, it is necessary to point to another specificity of the staged history of the place where the deceased are buried. The area documented as a result of archaeological research did not immediately function as a funeral space. First it covered the westernmost part of the area. Burials were located there in a relatively short period of about 100 years (2000–1900 cal BC). In this part of the cemetery, relatives (two or three individuals – 26 groupings) and family lineages (four to six individuals – 18 groupings) clearly dominated. Groupings of more than seven individuals per series occurred only in seven cases (Fig. 8). The results of the NND also indicate that in the linear systems representing four to six graves only 6% had individuals of one sex, with 20% having two to three individuals. However, with regard to the division into older individuals (*adultus/maturus*) and younger (*infans/iuvenis*), burials from one age category account for only about 20% of the total.

In the light of statistical analysis, the central part of the cemetery is not characterized by the presence of burials with a significantly different set of grave goods (characterized as 'transition period' A1/A2). The grave goods placed in these burials are instead related to the next, younger stage of burying the deceased at the site, covering the period around 1900–1650 cal BC. During this period, the creation of a new spatial arrangement of the younger part of the cemetery begins. The graves are again located in linear systems. The individual groups of burials in lines, however, remained in general spatial agreement with the older arrangements, probably marked on the surface.

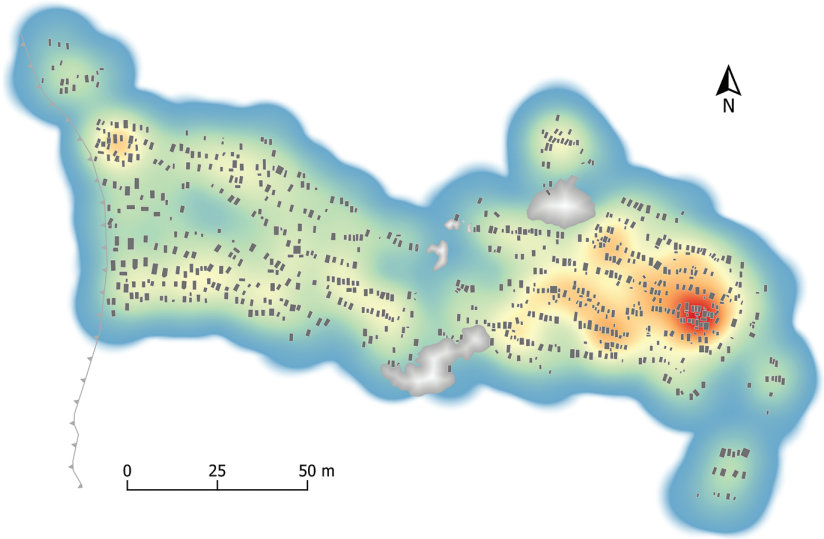


Fig. 7. Nižná Myšľa. Kernel Density Estimation results of grave locations within the cemetery.

In the eastern, younger part of the site the ratio of the different types of lineages become more equal. Small systems of two to three graves predominate, with a total of 17. The number of family lineages is significantly reduced and amounts to 11, while there are nearly half as many more long groupings, often including much more than seven individuals in a sequence (12 groupings) (Fig. 8). Regarding sex, in groupings of

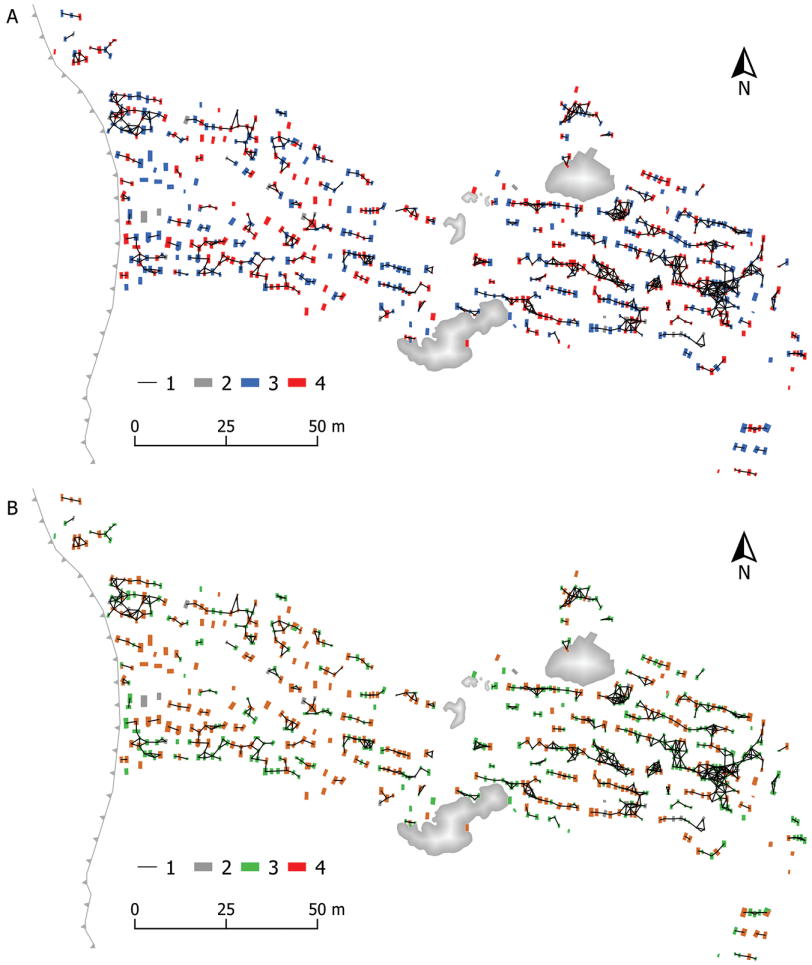


***Fig. 8. Nižná Myšľa. Nearest Neighbour Analysis results of grave locations with regard to (A) sex and (B) age of deceased:* A *links up to 3m distance;* 2 *empty graves;* 3 *male burials;* 4 *female burials.* B *links up to 3m distance;* 2 *empty graves;* 3 infans/juvenis*;* 4 adultus/maturus.**

two or three individuals 35% of them were same-sex. In family lineages, groupings with one sex accounted for 18% of the total.

Status of female burials

The issue of the Bronze Age fortified settlements' societies has been presented for many decades in a very specific way. It is discussed primarily in the context of hypothetical long-distance relations between Central Europe and the Aegean zone (*Vladár 1973; Kristiansen, Larsson 2005; Przybyła 2016; cf. Jaeger 2014; 2017; Kienlin 2015*), or as evidence of the intensification of warfare. In both cases, the key role is assigned to the figure of a male warrior. With regard to Central Europe, the idealized image of a Bronze Age warrior was developed largely as a parallel of figures known from sources related primarily to the Early Mycenaean culture. This mechanism is well presented by the concept of warriors on the move (*Kristiansen 2004; Kristiansen, Larsson 2005; 2007*). As reconstructed by Kristian Kristiansen, the dense network of exchange and trade that surrounded Bronze Age Europe (and existed even beyond the borders of the continent) was to lead to the creation of a specific model of societies in which a belligerent aristocracy played a leading role (*Kristiansen 1999*).

In Kristiansen's view, its representatives were the organizers and beneficiaries of long-distance contacts, in fact being their fullest 'product'. Warriorhood understood and described not only as a phenomenon of a military nature, but above all as a social phenomenon (*Kristiansen 1999.181*), was to appear in a fairly short time as an element common to the Mycenaean culture, the Carpathian Basin and the Nordic zone societies (*Kristiansen, Larsson 2007; Vandkilde 2014*). The starting point for the phenomenon of the elite aristocratic warrior was to be "*(...) empires and palace cultures of the Near East and the Eastern Mediterranean (...)*" (*Kristiansen 1999.177*). In the thus outlined history of the development of the Bronze Age societies, little space was left for consideration of the status and role of women in the promotion and development of specific cultural patterns and behaviours. The case studies presented in recent years (*Stockhammer* et al. *2015; Massy* et al. *2020*) show that in addition to the rarely questioned model of the spread of innovation by mobile male warriors, scenarios in which women played the main role should also be considered. The above-described appearance of a new type of personal ornaments – a pin of the Kugelkopf and Hülsenkopf types – in female burials of the younger phase of the NM cemetery, is in our opinion likely evidence of exogamy. Taking into account the presence of prestigious and non-local raw materials, such as gold, faience and amber, as well as a larger amount of bronze (or copper and tin), it is possible to point to a potentially multidirectional exchange of ideas, goods and people. As a result, innovations (*e.g.*, new elements of

clothes and new ornaments) appeared in NM not only thanks to *warriors on the move*, but also through women. In this context, we treat women not as an object of exchange, but as an equal subject (next to men) of particular activities, endowed with agency. This is evidenced by the imperceptible difference in the richness of the burials of both sexes and large number of female burials equipped with unique items and those made of gold, amber and faience.

In the NM cemetery, female graves constitute 49% (387) of all burials for which the sex of the deceased was determined (*Nováček 2017.24*). However, not all age categories were present in this collection. The burials of children (*infans I* and *infans II*, 129 burials) as well as adult women (*adultus*, 134 burials) and adolescents (*juvenis*, 87 burials) predominated. Absolute exceptions are graves in which mature people were buried (*maturus*, 5 burials). Moreover, there is a complete lack of burials of elderly people (*senilis*). The age structure of women buried in the NM cemetery does not differ significantly from that of men. In the case of the latter, attention is drawn to the dominance of adult burials (*adultus*, 150 burials), the almost complete lack of burials of mature people (two burials) and again the absence of the deceased in old age. At the same time, it should be noted that there are no statistically significant differences in the quality of equipment between representatives of specific age groups of the deceased of both sexes. In the light of this information, it seems reasonable to conclude that both women and men had the right to the same burial rites. These rights were obtained at birth, but probably lost in adulthood[3]. The statistical analysis revealed the existence of certain permanent patterns of equipping the deceased, both in the older and younger section of the cemetery. Within these sets there were mainly the following types of ceramic vessels:

- women BA2 (A1): PB cup, DC jug;
- men BA2 (A1): PB cup;
- women BA3 (A2): PA cup, DA and DB jugs;
- men BA3 (A2): DA and DB jugs, MA and MB2 bowls, PA cup, HB pot.

It is worth noting that the burials equipped with weapons (daggers) were not accompanied by other items that could emphasize the special status of men. The vast majority of items made of non-local or rare raw materials, such as amber and gold, were put together as equipment for female burials.

Discussion

Due to the scale of research and the number of discovered burials, the NM cemetery undoubtedly offers unique analytical possibilities in the framework of Early Bronze Age studies in Central Europe. The combination of statistical methods and contextual data on the absolute chronology of selected finds made it possible to create a spatial-temporal model of the formation and development of the cemetery in question. Its area is divided into two parts which, in the light of the results of the analysis of grave goods, reflect the chronological sequence. Radiocarbon dating of particular finds of selected types of bronze pins and ornaments made of boar tusks from Central Europe allow us to define the stages of the cemetery's functioning as: older (A1), lasting approx. 2100/2000–1900 cal BC, and younger (A2), lasting approx. 1900–1650/1550 cal BC (*Brunner* et al. *2020*). The chronological sequence is reflected in the structure of the separate phases of the cemetery.

The analytical procedures applied resulted in a number of significant conclusions regarding the spatial and temporal development of the cemetery:

- Differences were identified in the arrangement of the funeral space and the choice of the location of graves in individual parts of the cemetery; in the older, western part (A1) of the cemetery, small linear layouts of graves dominate, interpreted as relatives or family lineages. On the other hand, in the eastern part, the younger one (A2), there is a notable predominance of long linear layouts, often exceeding seven burials. The graves in the western part are more scattered, in the eastern part they are more aggregated; this fact can be interpreted as an increase in the number of burials (and thus population growth) within a relatively small available space.

- A clear quantitative and qualitative differentiation of grave goods was observed in both chronological periods. During the A1 period, there was a limited set of objects. In turn, the A2 period was characterized by a more extensive range of objects constituting the burial items. In the A1 period, some of the grave goods suggest a connection with strictly de-

3 We treat a small number of burials of mature women and men (*maturus*) as those which, from the point of view of the existing ritual rules, were related to a group of adults (*adultus*). The age limit separating both categories is conventional and is the assumption of modern science. As a consequence, we accept the thesis according to which people in mature and old age (*maturus* and *senilis*) were not buried in the form documented in the cemetery.

fined economic activities and crafts – different in the case of the female burials (awls and needles = weaving, leather/fur processing) and men (arrowheads, ornaments made of boar tusks = hunting); this observation does not apply to burials from the younger part of the cemetery (A2).

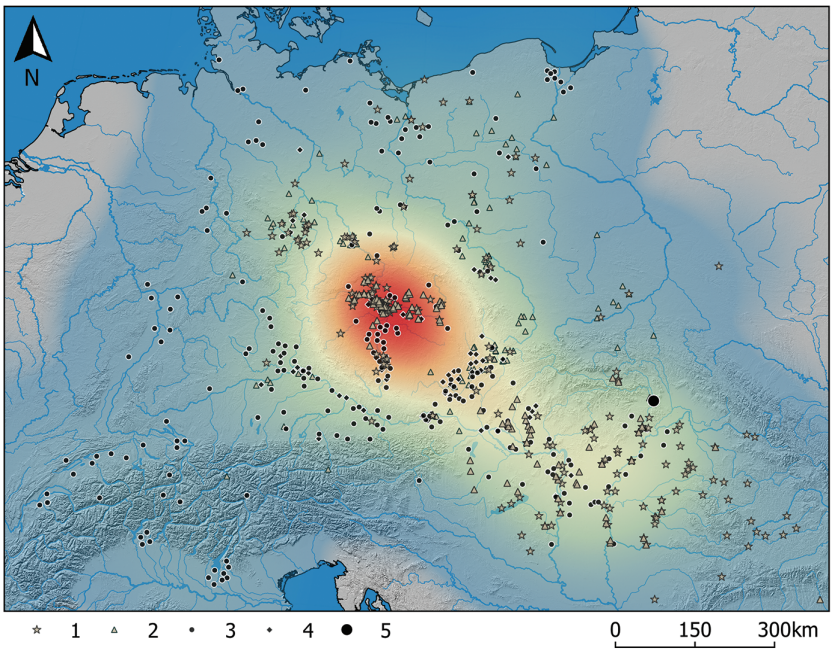


Fig. 9. Distribution and Kernel Density Estimation results of selected artefacts in Central Europe:* 1 *gold finds;* 2 *amber finds;* 3 *Kugelkopf pins;* 4 *Hülsenkopf pins;* 5 *location of Nižná Myšľa cemetery.

● In the light of the above observations, it can be concluded that the analysed collection of sources reflects a number of changes that the local community underwent in a period lasting about three centuries. These changes, visible in the ways of creating a funeral space, suggest transformations of existing social institutions. It seems that family/kinship ties were initially the basic and at the same time the main factor creating the relations. Gradually, more complex structures emerged, probably related to the satisfaction of new common needs, of an undefined nature (religious, social or political). While we consider the importance of family/kinship ties to be a local tradition, we perceive the complication of community structure (reflected in a new, more extensive, linear burial system) as a likely result of an influx of a new population group. Their material contribution is probably the more present amber ornaments and the new, non-local types of bronze pins of the Hülsenkopf and Kugelkopf types, predominant in female burials. These are the forms that dominate in the analysed period of the Early Bronze Age in the area of today's southern Germany, Czechia, Moravia and Austria, *i.e.* in the region constituting the core of the settlement of the Únětice culture (Fig. 9) (*Bartelheim 1998; David-Elbiali 2000; Krenn-Leeb 2011*). The probable appearance of new population groups ('*Fremdefrauen?*', *Jockenhövel 1991*) can be associated with an increase in the population size, reflected in the proportion of the number of burials to the duration of the funeral space: A1 – 490 graves over a period of around 200 years, A2 – 302 graves over a period of around 100 years (*Novaček 2017.23*).

The results presented above should be treated as an attempt to recreate the changes taking place in a specific local community of the Early Bronze Age, based solely on the sources from the cemetery. The potential of these sources, even taking into account their large number, cannot be fully used at present. As the authors, we are aware that some of the presented hypotheses can be verified and completed only with the use of long series of ^{14}C dating and with the use of new methods, with DNA and isotope analyses at the forefront.

ACKNOWLEDGEMENTS

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Appetite for destruction: current interpretations of accidental or deliberate destructions in Bronze Age Cyprus

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ABSTRACT – *Destruction processes are considered 'time capsules of material culture' (*Driessen 2013*) as they freeze a site at one moment of its history providing key evidence for interpreting the archaeological record and reconstructing social, political, cultural and ideological circumstances. By focusing on selected case-studies, this paper aims at briefly discussing existing evidence of destruction events in Bronze Age contexts in Cyprus, and at a preliminary presentation of new research data resulting from ongoing interdisciplinary analyses at Middle Bronze Age Erimi.*

KEY WORDS – *destruction events; abandonment practices; Bronze Age Cyprus*

Želja po uničenju: sodobne interpretacije naključnih in namernih uničenj v bronasti dobi na Cipru

IZVLEČEK – *Procese uničenja razumemo kot 'časovne kapsule materialne kulture' (*Driessen 2013*), saj prostor zamrznejo v nekem trenutku njegovega obstoja, s čimer zagotavljajo ključne dokaze pri razlagi arheološkega zapisa in nudijo rekonstrukcijo družbenih, političnih, kulturnih in ideoloških okoliščin. S tem prispevkom nudimo kratko razpravo o obstoječih dokazih in o dogodkih uničenja v kontekstu bronaste dobe na Cipru, in sicer na podlagi izbranih študijskih primerov, hkrati pa predstavljamo nove raziskovalne podatke, ki izhajajo iz interdisciplinarnih analiz, ki so v teku na ciprskem srednje bronastodobnem najdišču Erimi.*

KLJUČNE BESEDE – *dogodki uničenja; prakse opuščanja; bronasta doba; Ciper*

Introduction

All archaeological contexts are destruction contexts. Human actors, natural disasters, and post-depositional processes, all represent transformative forces that contribute to changing the original occupation setting. The primary importance of abandonment and destruction sequences in the analysis of built environments has long been recognized in the study of formation processes of archaeological deposits (*Schiffer 1987; La Motta, Schiffer 1999*). As a matter of fact, the concept of destruction embodies a social and cultural dimension. As much as construction and maintenance activities, destruction practices form part of the settlement life cycle, and as such they represent a social phenomenon involving a community (*Cameron 1991; 2003; Driessen 2013; Stevanovic 2002; Tringham 2013; Twiss* et al. *2008*).

Destruction events represent the culmination of social, cultural, political, and ideological circumstances; therefore, cases of destruction should be analysed by taking into account their preceding phases in order to provide a better understanding of the causes that led to the final destruction and to identify its agents (*Zuckerman 2007; Torrence, Grattan 2002*). It is fundamental to consider the multiple aspects of destruction processes when we approach the analysis of an archaeological context. Destruction is multiscalar: it can affect a single structure or an entire set-

DOI: 10.4312/dp.48.1

tlement. Destruction has a multi-temporal dimension: it can be temporary, then followed by reparation and renovation, or definitive with no chance of second reconstruction. Destruction can be random and sudden, when triggered by external and uncontrolled factors, such as natural disasters, or it can be an anticipated consequence of deliberate actions carried out by individuals or communities who destroy to express identities, beliefs and ideas (*Tringham 2005; Stevanovic 1997; Cameron, Tomka 1993*). Each of these aspects impacts on the archaeological record by producing distinct evidence.

Detecting disasters like earthquakes may be extremely challenging in the archaeological record, especially when degradable building materials are used in the construction practice. Recent studies have applied an integrated approach for identifying ancient earthquakes, combining macroscopic indicators and supporting evidence from microscopic geoarchaeological techniques, such as micromorphology (*Schachner* et al. *2019; Lazar* et al. *2020*). Recurrent patterns of macroscopic markers have been detected as expected effects of earthquakes observable on the stratigraphic deposits and included in the so-called 'Potential Earthquake Archaeological Effects' (PEAEs) (*Jusseret* et al. *2013*). PEAE markers include effects expressed in architectural elements (*e.g.*, tilted walls, displaced walls) and in the characterization of the archaeological deposit (*e.g.*, oriented fallen objects, localized fire damage, compact layers of rubble burying valuables suggesting sudden collapse) (*Lazar* et al. *2020.Tab. 1*).

In this paper we examine the act of building destruction as a complex social phenomenon, and in doing so we focus on a set of Bronze Age contexts in Cyprus. The aim is to present a brief review of studies concerning abandonment dynamics and destruction processes in Cyprus by discussing evidence from Early-Middle Bronze Age sites, and by briefly presenting new research results on destruction sequences at Middle Bronze Age Erimi.

Between the event and the practice: interpreting destructions in Bronze Age Cyprus

The multi-scalar and multi-temporal dimension of destructions is rarely observed in the interpretation of prehistoric contexts. However, these two dimensions are key to understanding the nature of a specific destruction and identifying it as either an uncontrolled event or as a deliberate practice. The first can be caused by natural catastrophes or human agency, and its consequences for the community are rather unpredictable. Conversely, the second type of destruction has controlled effects and may also serve a 'regenerative' social function. In both scenarios, destruction marks a crucial turning point in site history, but they greatly differ from each other insofar as they embody different perceptions that the community has of its own history.

Thanks to the increasing number of projects that are sensitive to depositional, destructive and abandonment processes, which are based on fresh analysis of old excavated contexts like that of the Sanctuary of the Horned God at Enkomi (*Papasavvas 2014*) and on new excavations, especially at Early and Middle Bronze Age sites (*e.g., Frankel, Webb 1996; 2006; 2012; Swiny* et al. *2003; Bombardieri 2017; Sneddon 2019*), Cypriote Prehistory offer good case-studies to discuss abandonment destruction practices (Fig. 1, Tab. 1).

At Early Bronze Age Marki *Alonia*, the inter-related analyses of architectural units, features and finds have made it possible to broadly analyse depositional contexts and exclude the occurrence of localized catastrophic events or sudden site-wide abandonment (*Frankel, Webb 2012*). In the settlement structures there is a continual process of change as individual rooms or areas were renovated, reorganized, rebuilt, demolished or left as standing ruins (*Frankel, Webb 1996; 2006*). Marki *Alonia* represents a straightforward case where the absence of indicators for destruction by natural disaster or deliberate anthropic actions indicates



Fig. 1. Map of Cyprus showing the Bronze Age sites mentioned in the text.

that the settlement was gradually abandoned and the structures were subjected to slow deterioration by post-depositional processes, and possibly to episodic post-abandonment re-use.

In other contexts, however, abandonment sequences indicate the occurrence of rapid destruction events, as the cases of Sotira *Kaminoudhia* and Alambra. Evidence of destruction retrieved from these sites has been interpreted as indicating destruction by natural circumstances: an earthquake for some of the collapsed structures at Sotira, and an accidental fire at Alambra.

Evidence of coursed tumbles retaining the spatial arrangement of the building blocks, coherent with a PEAE marker, has been documented in the destruction sequences of many structures at Early Bronze Age Sotira *Kaminoudhia* and interpreted as the consequence of a seismic event that specifically affected houses in Areas A and B (*Herscher, Swiny 2003.505*). In support of the seismic event interpretation, Stuart Swiny indicates a series of evidence including the complete abandonment of the settlement and the absence of traces of reconstruction post-destruction; the occurrence of collapsed roofing materials completely sealing the houses' inventory; the presence of human skeletal remains in three rooms (units 6, 16 and 22) without any clear mortuary treatment (*Herscher, Swiny 2003; Swiny 2008*) as evidence of accidental death in catastrophic circumstances; the recurrence of burnt deposits covering the floors of many structures as result of conflagration associated with an earthquake event (*Swiny* et al. *2003.53–54*).

In validating the assumption of a seismic event at Sotira, George Rapp (*2003.465–466*) asserts that mudbrick and undressed stone construction used in building technique in the settlement are poorly resistant to seismic damage. However, it is important to stress that foundations cut into the solid bedrock – as in many buildings at Sotira (*Swiny* et al. *2003.56*) – are much more stable to seismic waves than unconsolidated soil materials (*Grant* et al. *1974*), and that one-storey structures generally have a better static performance during strong earthquakes due to their inferior load (*Kallika 2017*). Even in the circumstance of intense earthquakes with the consequent collapse of the mudbrick superstructure, only moderate damage to the stone structure is produced (*Rapp 1986.368*), thus permitting fast rebuilding and restoration of the structures to habitable condition.

Chronological phases	Approximate dates Cal BC
Philia Early Cypriot	2400/2350–2250
Early Cypriot I	2250–2150
Early Cypriot II	
Early Cypriot III	2150–1950
Middle Cypriot I	1950–1850
Middle Cypriot II	1850–1750/1700
Middle Cypriot III	1750/1700–1680/1650

Tab. 1. Chronological schema for Early and Middle Bronze Age Cyprus (after* Manning 2013*).

In this regard, the idea of human burial as possible victims of a catastrophic earthquake at Sotira should be also reconsidered. In the examination of destruction sequences in archaeological contexts it is common to attribute the occurrence of skeletons buried under rubble to a sudden death caused by the collapse of building in an earthquake (*Bombardieri in press*). Skeletons of people killed and buried under the debris of fallen dwellings imply that the collapse came suddenly, without warning, and caught them while sleeping or lying down. However, ethnographic analyses conducted in a large set of traditional villages in the Near East destroyed by earthquakes in the 1960s and 1970s indicate that in general younger people, who attempted to escape outdoors, are those that suffered more causalities from being injured by collapsed structures falling around. In contrast the elderly, who stayed indoors, were much safer (*Ambraseys 2006.1011*). We must also consider that bodies of people killed outdoors or indoors are almost always recovered by the survivors and given proper burials, as also recorded in ethnographic cases (*Ambraseys 2006*) and as expected for early societies with standardized funerary rituals and mortuary treatment traditions, like those of Bronze Age Cyprus (*Bombardieri in press; Baxevani 1997; Keswani 2012; Knapp 2013.311–321*).

In advancing these criticisms, we do not exclude the idea proposed by Swiny of a seismic event at Sotira; however, we question the assumption of an earthquake as a principal triggering factor for the definitive destruction and abandonment of many structures at the settlement.

Taking into consideration the possibility of a fire event as a consequence of the earthquake, it is unlikely that an accidental fire could have been responsible for an extended burnt horizon as that documented in all three areas of the settlement (*Swiny* et al. *2003.53–54*). In fact, structures in mudbrick and stone are very difficult to ignite without additio-

nal accelerants (*Dennis 2008.177; Harrison 2008; Amadio, Bombardieri 2019.6–7*). Therefore, even in the case of an uncontrolled blaze, fire could not have spread from one building to the other, and from one area of the settlement to the other.

A similar conclusion can be drawn for the destruction context at Early-Middle Bronze Age Alambra, which represents a further interesting case-study to analyse destruction processes in prehistoric Cypriot contexts. No evidence of wall collapse by seismic event has been recorded at the site; however, Andrew Sneddon (*2019*) reports the occurrence of extended traces of burnt and ashy materials in the abandonment sequences of unit 1 and in other structures of the ancient settlement – including clusters of buildings in Areas A and C (*Georgiou 2008; Sneddon 2015*) – which he considers clear indicators of destruction by fire.

By focusing on the analysis of unit 1, Sneddon (*2019*) interprets the absence of objects in the structure as a deliberate act of clearing as part of a planned and gradual abandonment; yet his reconstruction of the fire event appears less defined. Considering that the fire was not restricted to unit 1, but also involved other areas of the settlement, Sneddon sustains the hypothesis of a large conflagration, possibly due to a forest fire, which swept across part of Alambra soon after the settlement was abandoned.

Likewise, units 22 and 44 at Sotira, unit 1 at Alambra presents a case of a human internment covered by a layer of ashy debris. According to Sneddon's (*2019*) interpretation, this intramural burial is unlikely to be the victim of a catastrophic fire, due to the fact that mudbrick buildings with stone footing – like those of prehistoric Bronze age villages – do not explode into flames (*Swiny 2008.51*), and a person inside would have had the time to escape outdoors to abandon the building before the roof collapsed (*Bombardieri in press*). In the analysis of the context, Sneddon rejects the idea of a possible act of violence or conflict because of the evidence of a set of copper ingots deliberately placed on the deceased's chest (*Sneddon 2019.10*). He further discards the hypothesis of the burial as part of an act of 'domicide' – the act of deliberate destruction to mark the end of the house's occupation upon the death of the head of the household (*Tringham 2005; 2013*). However, one may also hypothesize that unit 1 was destroyed by fire because of the burial itself, as argued for Prehistoric Levant (*e.g., Verhoeven 2000; Akkermans 2008; Akkermans* et al. *2012*) and potentially attested by ethnographic parallels (*e.g., Porteous, Smith 2001*).

The assumption that the conflagration of unit 1 might have been part of the symbolic destruction of specific residential clusters at Alambra is difficult to validate due to the lack of univocal evidence in the analysis of the destruction context. Additionally, the identified macroscopic PEAE markers (*e.g.*, localized fire damage, broken *in situ* vessels) (*Lazar* et al. *2020.Tab 1*) can either be interpreted as the effects of a controlled destruction or the consequences of natural catastrophic events, including earthquakes.

Nonetheless, even if the practice of deliberate house/settlement destruction, as a preliminary step toward the settlement's final abandonment, has never been identified in prehistoric Bronze Age contexts in Cyprus (*Sneddon 2019.10*), the repeated occurrence of burnt structures in the contexts presented above certainly deserve further consideration, especially on the basis of the new evidence and the application of a new multi-scalar methodology at Middle Bronze Age Erimi.

A case for destruction at Middle Bronze Age Erimi: ongoing analyses and interpretations

Erimi *Laonin tou Porakou* is a Middle Bronze age site in the south region of Cyprus, on the river Kouris valley area (Limassol district). Extensive excavations since 2009 have exposed a substantial part of the prehistoric settlement, which was built on a limestone hill and organized in three main areas: the productive area, with a workshop complex on the top (Area A); the residential area on the degrading terraces (Areas B, B2; T2, T3); and the funerary clusters on the slopes surrounding the settlement (Area E and *Vounaros*) (Fig. 2). The research programme conducted at Erimi has provided a wealth of new data on Middle Bronze Age society in Cyprus, from settlement life-history to material culture, technologies and subsistence practices (*Bombardieri 2017; Webb, Knapp 2021*).

Excavations in the workshop complex revealed the occurrence of wholly burned building-units, full of ashes and other incinerated materials (Fig. 3). Since the destruction sequences in these structures are characterized by a totally different depositional history from those of naturally degraded buildings of the workshop complex and of the residential areas (*Amadio, Bombardieri 2019; Amadio* et al. *in press*),

interdisciplinary scientific analyses have been applied to the examination of these contexts in order to provide multi-scalar and networked data to analyse and reconstruct the destruction dynamics.

Stratigraphic analysis has been integrated with micromorphology to conduct high resolution characterization of depositional sequences and examination of the pre-depositional environment, depositional and post depositional processes that impacted on the deposits and materials in order to identify natural and/or anthropic processes that contributed to the formation of destruction sequences. FTIR analyses have been applied to a wide range of materials, including intact and degraded mudbricks, burnt deposits, floors, objects and natural sediments to distinguish between carbonates of different origins and ascertain the heating temperatures of clay minerals in order to examine the impact of fire on surfaces and deposits. Phytolith analysis was further applied as an important proxy to analyse the occurrence of plant materials in destruction deposits and occupation sequences in order to acquire information about possible organic substances that contributed to the conflagration. The analyses conducted on burnt structures at Erimi in the workshop complex are summarized in Table 2, with specific reference to unit SA V.

According to the integrated analyses on macro and micro evidence (*Amadio* et al. *in press*) the destruction by fire at Erimi was most probably deliberate, as demonstrated by the fact that burnt structures are not adjacent to each other, as we would expect in

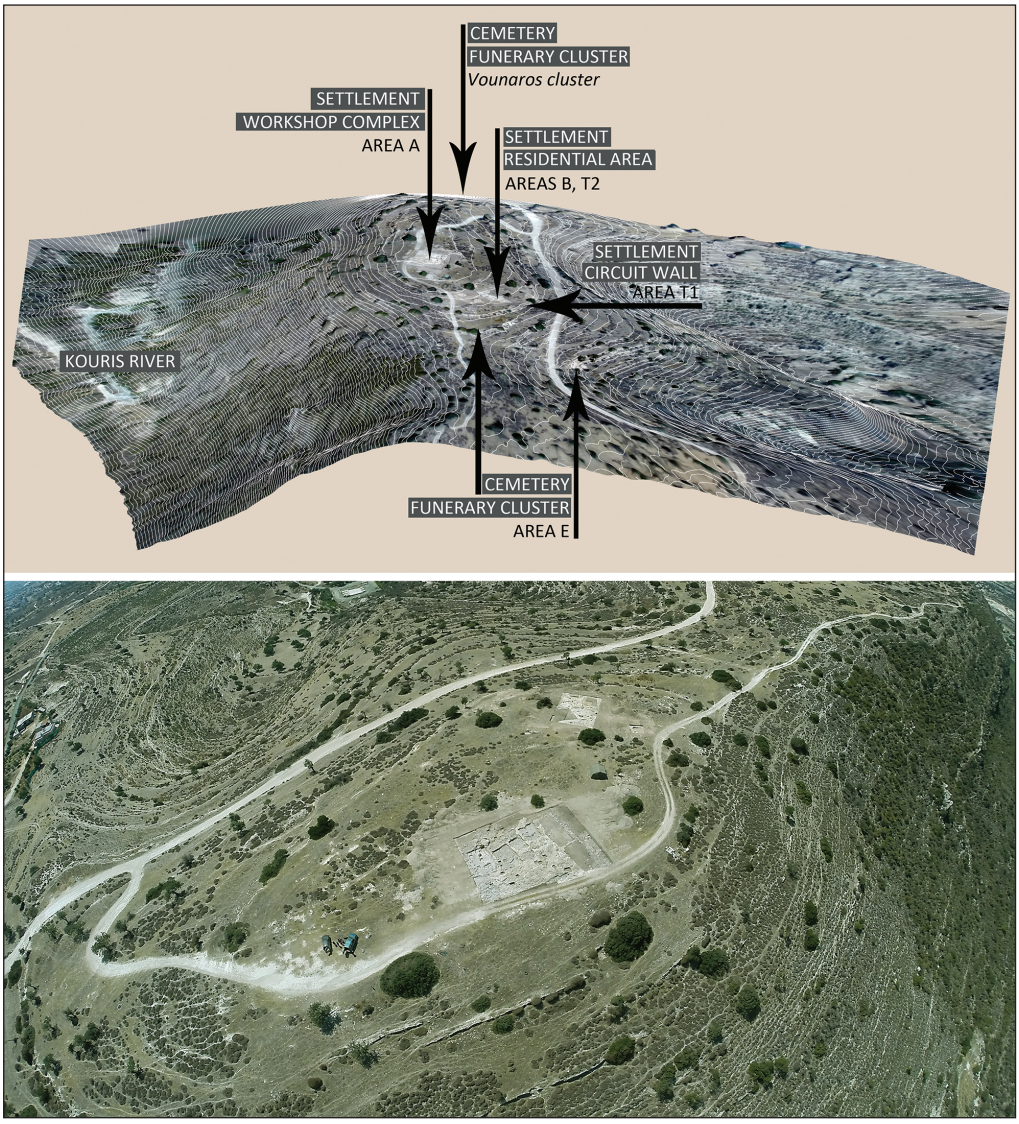


Fig. 2. Erimi. The terraced configuration of the Middle Bronze Age settlement and cemetery site, on the east bank of the Kouris river valley (Limassol, Cyprus) (Archive Erimi Archaeological Project/Italian archaeological mission in Erimi, Cyprus).

	in situ EVIDENCE	*INTERPRETATIONS*
MACRO	Burnt building-units are not contiguous.	Structures were burnt intentionally.
	No evidence of re-construction and re-use after the destruction event.	Structures were not re-occupied but were definitively abandoned.
	No evidence of fire outside the building's perimeter.	The fire was controlled.
	Occurrence of rich floor assemblages in a good state of preservation (most of the medium-small size vessels are intact).	Possibly deliberate deposited objects.
	Intact mudbricks showing T of 450–500° C.	The fire was intense enough to bake part of the mud-brick wall structure.
	Burnt deposits mostly composed of pyrogenic calcite.	Formation of ash due to slow burning fire.
	Floor not altered by fire (no ignition points).	The fire did not start from the floor.
	Object are coated by a crust of pyrogenic calcite.	Ash produced during combustion of roofing structures deposited on the vessels.
	Unfired loom weights on the floor show no signs of fire alteration.	Ash produced during combustion of roofing structures insulated the objects.
MICRO	Occurrence of high percentage of dendritic phytholiths on the floor.	Possible addition of flammable material (?).

Tab. 2. Summarized data from integrated analyses conducted on burnt buildings at Erimi (*Amadio *et al.* 2021*).

case of uncontrolled fire spreading all over a settlement area, and as indicated by the limited occurrence of burnt and ashy residues outside the external perimeter of the building, which suggests that precautions were taken to contain and control the fire. Micro data further indicate that temperatures were prolonged enough to bake and sinter part of the mudbrick wall structure. In fact, accidental fires of modest intensity and short duration result in no or very little sintering of the mud wall (*Akkermans* et al. *2012.311; Shaffer 1993*). Data also show that the fire was ignited starting from the roof, as the floor of the building-unit SA V shows no sign of alteration by fire. This constitutes further evidence in favour of an intentional conflagration rather than an accidental burning. As demonstrated by experimental analysis, a house with mudbrick and stone walls and a flat roof made of wood and clay – as at Erimi – must be prepared for burning or it will not burn at all (*Gordon 1953.149; Dennis 2008*).



Fig. 3. Erimi. Burnt structures in the workshop complex – Area A:* a *unit SA I;* b *unit SA V;* c *unit SA IV, the picture shows the black deposit covered by a layer of degraded mudbricks (the pale orange layer) and some intact mudbricks (the white rectangular features);* d *E-W section of unit SA I;* e *E-W section of unit SA V;* f *E-W section in unit SA IV; all the three sections shows a similar sequence formed by a layer of degraded and intact mudbrick materials covering the black ashy deposits; this destruction sequence covers the plaster floor, which – in most of the cases – is not preserved intact due to the collapse of the upper-standing structures during the conflagration (Archive Erimi Archaeological Project/Italian archaeological mission in Erimi, Cyprus).

While the data that was collected made it possible to attempt a valid reconstruction of the destruction event at Erimi, which presumably consisted of a first phase of a slow burning fire and a second phase of a well-vented fire, more uncertain is the interpretation of the causes that triggered the presumed deliberate destruction. The analysis of residues and assemblages on the floors of burnt buildings, which indicates the occurrence of many intact non-functional vessels with possible ritual use, such as a zoomorphic *askos* (Fig. 4), along with prestige and imported objects bearing a symbolic value and homogeneous tool sets (Fig. 5), may suggest that these materials were deliberately deposited within the buildings and that the abandonment was possibly organized in advance.



Fig. 4. Erimi. Unit SA III. A goat-shaped askos found on the floor of the building-unit (Archive Erimi Archaeological Project/Italian archaeological mission in Erimi, Cyprus).

This assumption may be further supported by the absence of victims inside of the workshop complex. The idea of an intentional conflagration of selected building-units of the workshop complex as part of abandonment rituals is also conceivable. The lack of evidence for reconstruction and re-occupation of the building-units after the conflagration, the fact that the structures destroyed by fire are those with a richer floor assemblage (maybe a deliberate deposition?), and that all the burnt structures are those of the communal and most representative area of the settlement, might endorse this interpretation. However, caution is needed before arriving at a more certain conclusion about motivations on the basis of the presumed deliberate destruction and final abandonment at Middle Bronze Age Erimi.



Fig. 5. Erimi. Unit SA XII. A set of textile tools and large ceramic containers on the floor of the building-unit (Archive Erimi Archaeological Project/Italian archaeological mission in Erimi, Cyprus).

Conclusions

The cases presented in this short review provide new insights into the examination of destruction processes and practices in Early and Middle Bronze Age communities in Cyprus. The paper underlined the primary importance of destruction events in the examination of long-term socio-cultural processes and in the reconstruction of settlement life-histories. Throughout the case-studies presented we illustrated the complexity of analysis focused on destruction sequences because destruction events are always multifaceted and involve many distinct aspects, which all contribute to the formation of multiform *in situ* evidence and consequent ambiguous interpretation.

The case of Sotira well exemplifies the difficulty of finding a univocal reconstruction for the destruction

and final abandonment of the settlement. In this regard a consideration should be made. Many structures at Sotira were built with a foundation cut into the bedrock floor, possibly to enable better static performance of the buildings (*Wright 1992.399–405*). Considering that the cutting of the calcareous bedrock is a task that required communal effort and a large investment of labour, why was the decision made to not reconstruct the collapsed parts of the buildings and instead to definitively abandon the structures? By advancing this consideration, we want to stress that even admitting the occurrence of a natural catastrophic event at Sotira, as well as at Alambra and Erimi, the choice of destruction and abandonment was possibly based on socio-cultural factors and motivations.

In examining the processes and causes of deliberate destruction, analyses conducted at Alambra and the new research initiatives and results at Erimi have disclosed interesting directions to examine the meaning of intentional conflagrations for Middle Bronze Age communities in Cyprus. In future analyses, the examination of the social, political, cultural and ideological implications behind the practice of deliberate destruction might offer an excellent point of entry into the social configuration of Cypriot society at the end of Middle Bronze Age Cyprus, which represents a significant turning point from a household-based society into a transformed socio-cultural system typical of Late Bronze Age urban centres.

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Enclosures of death in the Early Iron Age: the necropolis of Esfola (Beja, Portugal)

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ABSTRACT – *This article focuses on the study of the Early Iron Age necropolis of Esfola, taking into account the burial rituals of the site (the architecture, the funerary objects and the human skeletal analyses are dealt with in the context of 'burial ritual' studies). This research will contribute to the body of knowledge on Early Iron Age necropolises with enclosures, typical of the Beja and Ourique regions in southern Portugal,* i.e. *Vinha das Caliças 4, Monte do Bolor 1–2, Cinco Réis 8, Carlota and Palhais. All these sites identified in the southern Iberian Peninsula allow us to characterize the funerary rituals practised in this region during the Early Iron Age.*

KEY WORDS – *southern Iberian Peninsula; funerary rituals; bioanthropology; grave goods; prestige items*

Ograde smrti v starejši železni dobi: nekropola Esfola (Beja, Portugalska)

IZVLEČEK – *V članku se osredotočamo na študijo nekropole Esfola iz časa starejše železne dobe, pri tem razpravljamo o pogrebnih obredih na najdišču (kot so arhitektura, grobni pridatki in analize človeških kosti, ki so obravnavani v kontekstu študij 'pogrebnih obredov'). Raziskava bo prispevala k poznavanju starejših železnodobnih nekropol z ogradami, ki so značilne za regiji Beja in Ourique na jugu Portugalske, kot so Vinha das Caliças 4, Monte do Bolor 1–2, Cinco Réis 8, Carlota in Palhais. Vsa omenjena najdišča iz območja južnega Iberskega polotoka nam omogočajo prepoznati pogrebne obrede, ki so se izvajali v tej regiji v času starejše železne dobe.*

KLJUČNE BESEDE – *južni Iberski polotok; pogrebni obredi; bioantropologija; grobni pridatki; prestižni predmeti*

Introduction

The archaeological site of Esfola (ESFO'15) was excavated in 2015, encompassing archaeological works to minimize impacts on cultural heritage during the implementation of the São Matias Hydraulic Circuit connected with the Cegonha Reservoir. The field work covered a total area of 351.02m^2 and took place under the supervision of the archaeologists Gina Dias, Ricardo Santos and Linda Melo. A long diachrony was identified from the Early Iron Age (7th and 6th centuries BC) to the Modern Period (*Melo* et al. *in press*). This work will focus on the funerary rituals (architecture, body position, orientation and grave goods) biological profile, paleodemography and paleopathological conditions. Anthropolo-

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gical studies of Portuguese necropolises of the Early Iron Age are scarce. One of the few exceptions is the one of Vinha das Caliças 4 (*Pelicano 2016*), which allowed some comparisons to be made.



Fig. 1. Necropolises of Early Iron Age in Beja region:* 1 *Palhais 1;* 2 *Fareleira 2;* 3 *Fareleira 3;* 4 *Poço da Gontinha 1;* 5 *Poço Novo 1;* 6 *Vinha das Caliças 4;* 7 *Carlota;* 8 *Pisões;* 9 *Monte do Bolor 1–2;* 10 *Cinco Reis 8;* 11 *Quinta do Estácio 6;* 12 *Montinhos 6;* 13 *Monte da Lage;* 14 *Esfola.

Background of EIA necropolises

The known of funerary world of the Early Iron Age (EIA) in the Beja region started in the 1940s with the necropolis of Quintos (Herdade das Carretas), near the town of Beja (Abel Viana, 1945). During the 1970s and 1980s, Caetano de Mello Beirão and his team worked in Ourique region on several EIA necropolises; for instance, A-do-Mealha-Nova and Herdade do Pego (*Dias* et al. *1970*), Chada and Fonte Santa (*Beirão 1986*), and Favela Nova (*Dias, Coelho 1983*). In the 1990s, José Morais Arnaud (*1993*) worked on the necropolis of Nora Velha 2. Rui M. Soares and Artur Martins (*2013*) recently published some new data on burial practices there. Manuel and Maria Maia (*1996*) carried out several archaeological works at the site of Neves Corvo, near the city of Castro Verde. It is also important to include the necropolis of Corte Margarida, excavated by Artur Martins (*1999*) and studied a few years later by Manuela de Deus and José Correia (*2005*). However, most of the discoveries have been made in the last 15 years, due to a large number of archaeological excavations related to the construction and implementation of the Alqueva Irrigation Network. These allowed for a veritable 'revolution' in the existing knowledge of the prehistory of the region (*Mataloto, Boaventura 2009*). The fieldwork uncovered several EIA necropolises and highlighted the great heterogeneity in burial rituals, which contrasted with the previously understood reality of cremation necropolises in the Ourique region.

These newly recorded and excavated necropolises in the region around Beja form the so-called 'Núcleo de Beja', which also chronologically coincides with the 'Núcleo de Ourique', and are very important because of the similarities with Esfola. Among the known funerary sites on the right bank of the Guadiana River (Fig. 1) are Palhais, Beringel (*Santos* et al. *2010; 2017; Valério* et al. *2013*); Fareleira 2 and 3, and Poço da Gontinha 1 (Peroguarda, Ferreira do Alentejo), and Poço Novo 1, Pedrogão (*Figueiredo, Mataloto 2009*); Vinha das Caliças 4, Trigaches, São Brissos (*Arruda* et al. *2017*); Carlota, São Brissos (*Salvador Mateos, Pereira 2017; 2010*); Pisões, Beja (*Bargão, Fernandes 2017*); Monte do Bolor 1–2, Trigaches, São Brissos (*Soares* et al. *2017; Valério* et al. *2017*); Cinco Réis 8, Santiago Maior (*Salvador Mateos, Pereira 2017*); Quinta do Estácio 6, Nossa Senhora das Neves (*Pereiro* et al. *2017*). Along the left bank of the Guadiana, a grave at Montinhos 6 and another at Monte da Lage, both near the town of Serpa, are known (*Soares* et al. *2017*).

The Necropolis of Esfola: enclosures and graves

Since only a small part of this necropolis was excavated (351.02m²), it is not possible to quantify what was unearthed. Nevertheless, two enclosures with an orthogonal plan were identified and fully excavated. A third was identified but not fully excavated. A fourth was also identified, but unfortunately not excavated, as it was located outside the construction limits (*Melo* et al. *in press*). Enclosure 1 (UE 1164) that was identified in survey 11, formed by four

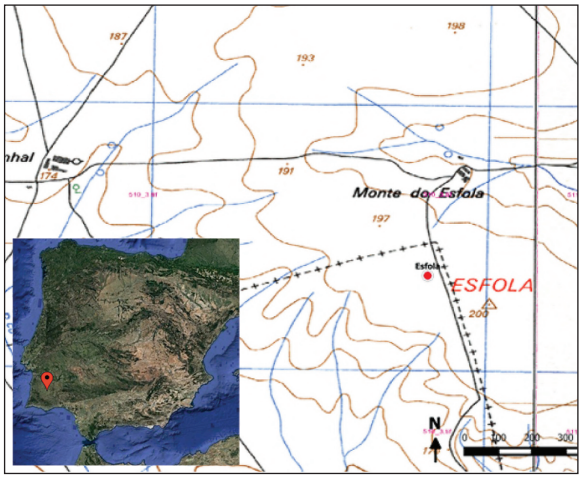


Fig. 2. Location of Beja and the archaeological site in the military letter 511-1/25 000.

straight ditches, has a sub-quadrangular plan with a central grave (grave 9). It is a pit with a rectangular plan, where an individual was buried (skeleton 9 – SU I09). In the peripheral area of the enclosure 1, other graves were recorded: grave 8, located in a ditch, while graves 10, 11, 12, 13, and 14 were located outside of, but associated with the enclosure (Fig. 3).

Enclosure 2 (UE 732), identified in survey 7, has a sub-rectangular plan, also with a central pit grave (grave 4, skeleton 4, SU I04;). In one of the ditches another grave (grave 7) was also recorded (Fig. 3).

All enclosures and graves were opened in the geologic substrate. Most grave pits, characterized by their rectangular plan, are narrow and shallow. Four graves, 7, 8, 11, and 14 reveal a stone 'cuirass' that would have probably served as a cover. Grave 4, in addition to the cover, also has a 'bed' and a side wall made of large stones. This grave appears to be an exception, since no other grave in this necropolis has evidence of these characteristics. Grave 10 had the same type of large stone elements, but only on the grave walls. Each grave represented a single primary burial; however, signs of perturbations were noted in the form of upturned stone blocks, as well as some bones.

Material and methods

In addition to the data that were registered during field work, all human remains were analysed in the laboratory. The human remains were poorly preserved, and comprised nine skeletons: two non-adults and seven adults. The latter include four males, two females and three skeletons of unknown sex (Tab. 1). The age at death of non-adults was obtained through the dental development and eruption patterns using the methodology of Shatha J. AlQahtani *et al.* (*2010*). For the adults, the external end of the clavicle was used to assess age at death based on the method introduced by Sue M. MacLaughlin (*1990*). Sex determination was based on pelvic morphology (*Bruzek* et al. *2005*), and diameter of the femur head, according to the Wasterlain's (*2000*) methodology and by the dimensions of calcaneus and talus, using Silva's (*1995*) approach.

Morphological dental traits were scored following the ASUDAS protocol (*Scott, Irish 2017; Turner* et al. *1991*), including an examination of the hypotrophic root of upper central incisors (*Cunha* et al. *2015*) and the mandibular molar pit tubercle (MMPT; *Marado, Silva 2016*). Cranial traits such as metopic suture or foramina parietal were scored according to Hauser's and De Stefano's (*1989*) method. Postcranial traits, such as septal aperture and third trochan-

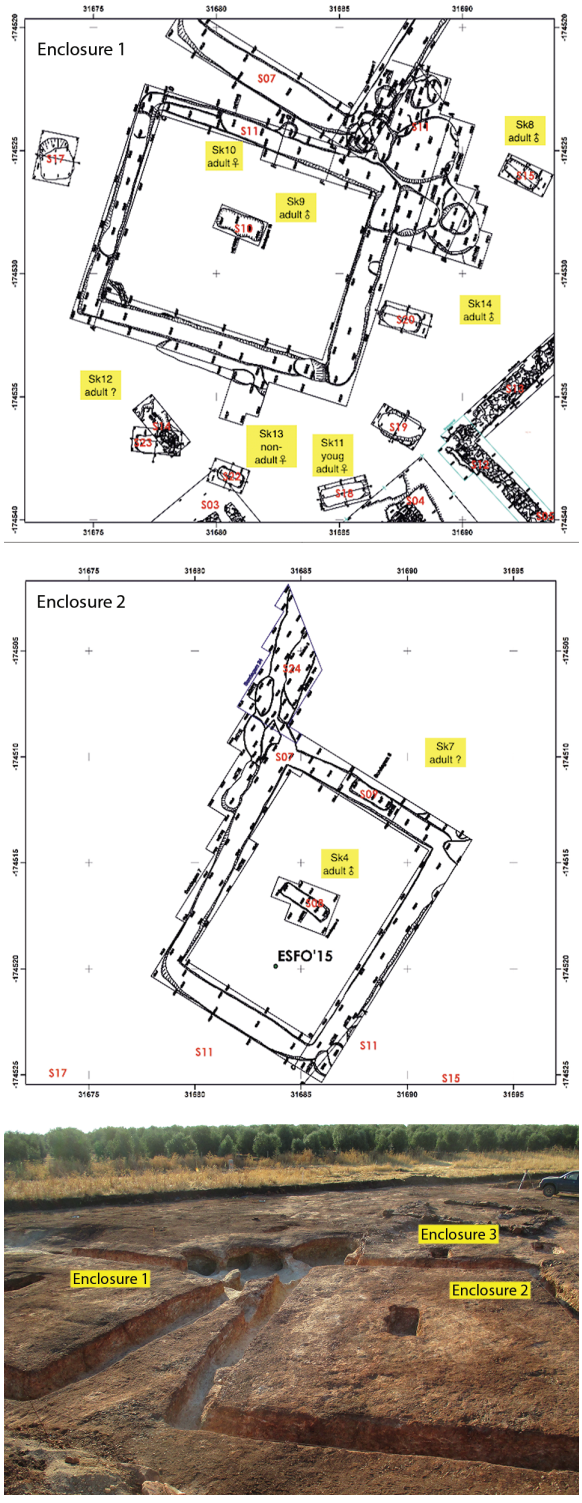


Fig. 3.* A, B *archaeological drawing of Enclosures 1 and 2 with the central and peripherical grave;* C *picture of the Enclosures 1, 2 and 3 with central graves from necropolis of Esfola adapted from Melo* et al. *(*in press*).

ter, among others, were scored following the methods outlined by Michael Finnegan (*1978*) and Shelley R. Saunders (*1977*).

Tooth wear was recorded according to Holly B. Smith (*1984;* adapted from *Silva 1996*), unusual wear according to Petra Molnar (*1972*), chipping and notching according to Benedetta Bonfiglioli *et al.* (*2004*), and grooving and slanting according to Dave Grant (*2010*).

Enclosure	Skeleton	Orientation	Deposition	Age at death	Sex	Method
2	4	NO-SE	LLD	Adult	M	*Bruzek 2002; Murail 2005; MacLaughlin 1990*
2	7	NO-SE	LLD	Adult	I	–
1	8	NO-SE	RLD	Adult	M	*Silva 1995*
1	9	NO-SE	RLD	Adult	M	–
1	10	NO-SE	RLD	Adult	F	*Bruzek 2002; Murail 2005*
1	11	NO-SE	LLD	±16 years	F	*Alqahtani* et al. *2010*
1	12	NO-SE	RLD	Adult	I	–
1	13	NO-SE	RLD	±8 years	I	*Alqahtani* et al. *2010*
1	14	NO-SE	LLD	Adult	M	*Bruzek 2002; Murail 2005;*

Tab. 1. Summary of the data obtained from the skeletons of Esfola necropolis. Left lateral decubitus (LLD); Rigth lateral decubitus (RLD).

All human remains were carefully examined for pathological lesions. Cariogenic and calculus lesions were the most common, and they were recorded according to Lukacs' (*1989*), and Martin's and Saller's (*1956*) methodologies. The same was done with bones, where the most common pathologies were degenerative diseases. For articular diseases such as arthrosis (*Assis 2007*), and for non-articular changes in enthesis Henderson's *et al.* (*2013*) methodology was used.

Results

As for the spatial disposition of the Esfola necropolis, the central burials in both excavated areas were adult males. In the ditched area, the burials were adult males, adult and young females, and non-adults. All bodies were deposited directly on the floor of the grave above the geological substrate. The bodies lay in a similar position, lateral decubitus (right – 5 skeletons; left – 4 skeletons), with the upper and lower limbs half flexed and aligned Northwest-Southeast (Tab. 1). It should be emphasized that all skeletons had archaeological grave goods, except skeleton 13 (non-adult). The data obtained for dental morphological features and non-metric features of the skeleton are presented in Tables 2 and 3.

With regard to the oral pathological lesions, 3.9% (n=6/153) of teeth, belonging to four individuals, displayed cariogenic lesions. All these cariogenic lesions, mostly small and medium sized, were located at the interproximal level of the posterior teeth. The mean dental wear was 1.8% (n=153). Dental calculus was noted in 18.3% of the teeth (n=28/153), in small or medium deposits. The linear enamel hypoplasia (LEH) were identified in 9.1% (n=14/153) of teeth, including upper and lower canines. Finally, 3.2% of teeth (n=5/153) were lost *antemortem*, all belonging to the anterior teeth of skeleton 8 (adult male). This individual also displayed hypercementosis in teeth 17 and 27, corresponding to 1.3% (n= 2/153) of the sample.

Dental traits	FDI	Frequency %
Shoveling	11;21	83% (5/6)
(+=ASU 3-6)	12;22	75% (6/8)
Labial convexity	11;21	60% (3/5)
(+=ASU 2-4)	41;31	0% (0/2)
Hypotrophic roots (-)	11;21	50% (2/4)
(*Cunha* et al. *2015*)	21;22	0% (0/6)
Interruption grooves (-)	11;21	0% (0/6)
	12;22	71% (5/7)
Tuberculum dentale	11;21	50% (3/6)
(+=ASU 2-6)	12;22	37% (3/8)
	13;23	30%(3/10)
Metacone/ C_3	16;26	100% (5/5)
(+=ASU 3-5)	17;27	100% (8/8)
	18;28	90% (9/10)
Hypocone/ C_4	16;26	100% (5/5)
(+= ASU 3-5)	17;27	87% (7/8)
Metaconule/ C_5	16;26	0%(0/4)
(+=ASU 1-5)	17;27	0%(0/6)
	18;28	40%(4/10)
Enamel extensions (-)	16;26	0% (0/5)
	17;27	14% (1/7)
	18;28	0% (0/8)
	46;36	0% (0/7)
	47;37	0% (0/8)
	48;38	0% (0/2)
Lower Premolar Cusp	44;34	100% (8/8)
Number (+=ASU 3-5)	45;35	100%(7/7)
Protostylid	46;36	40% (2/5)
(+=ASU 1-6)	47;37	0% (0/8)
	48;38	0%(0/4)
Mandibular molar pit	46;36	40% (2/5)
tubercle (*Marado, Silva 2016*)	47;37	0% (0/8)
	48;38	0%(0/4)
Lower Molar Groove	46;36	100% (5/5)
Pattern (+=ASU Y)	47;37	100% (7/8)
	48;38	25% (1/4)

Tab. 2. Dental traits from the skeletons of Esfola necropolis.

Other dental alterations were observed (Tab. 3 – Supplementary material) including chipping, slanting, and notching. Chipping was identified in 11.5% (n=3/26) of upper teeth, all belonging to skeleton 14 (Fig. 4.A). Slanting was noted in 17.6% (n=3/17) of upper anterior teeth and in 10% (n=1/10) of lower anterior teeth, all belonging to skeleton 10. Notching was only observed in tooth 31 (1/10) of skeleton 10 (Fig. 4.B), and grooving was not observed. The oral observations of these individuals are summarized in Table 4.

Pathological lesions were noted which corresponded to infections, degenerative (articular and non-articular), neoplastic, and unknown etiologies in five adult skeletons from this necropolis. These pathological lesions are summarized in Table 5.

Concerning the pathological lesions were only observed exostoses in two skeletons. Skeleton 10: in the proximal region of the right tibia, with 15mm x 8.5mm (Fig. 5.A) and in the acromial end of the right clavicle measuring 3mm x 1.5mm (Fig. 5.B). Skeleton 11, scored around the external *auditory meatus* in both temporal bones with similar dimensions (3.9mm x 2.5mm) (Fig. 6).

In the left acetabulum of male skeleton 14, a small perforation (around 8mm in diameter) was observed (Fig. 7). The edges of this hole show signs of remodelling. Signs of remodelled infections were also scored for the right foot bones of this skeleton.

Grave goods

Only one handmade carinated vessel was found, with skeleton 10, and it was completed but quite fragmented. With skeletons 4 (Enclosure 2), 8, 9, and 14 (Enclosure 1) a total of six iron spears were identified. In addition, an iron dagger was recovered with skeleton 4. From graves 7 and 12, two Tartessian belt-buckles of type 4A (*Cerdeño 1981*) were identified with the active and passive parts.

The only specimen of fibula recovered in the graves of the Esfola was a fibula of Ponte 8a (fibula of Alcores type) (*Ponte 2006*). The second is a complete bronze fibula of the Ponte 9 type (Acebuchal fibula), subtype Ponte 9/a1 (*Ponte 2006*). It has a simple, full-back, semi-circular section laminar profile. The foot is long, with a caudal appendix with a button. The shape is triangular and the spring is bilateral, symmetrical, with an inner rope to the arch that consists of 18 turns. The axis is independent and has the following dimensions: 60mm x 15mm. A fragmented fibula was recovered in survey 11 [1100] of Enclosure 1, but unfortunately out of its original context.

A remarkable set of ornaments was recovered with skeleton 11. A pair of complete bracelets with two ovoid finishes and a depression in the centre giving them a heart shape (bracelets *acorazonados*). Two rounded and simple metal bracelets, one bronze al-

Cranial traits	**Frequency %**
Hauser and De Stefano (*1989*)	
Foramina parietal (skull)	25% (1/4)
Metopic suture (skull)	25% (1/4)
Post-cranial traits	
Finnegan and Saunders (*1978*)	**Frequency %**
Septal *aperture (humerus)*	20% (1/5)
3rd Trochanter (femur)	0% 0/5)
Patella emarginata	0% 0/5)
Morphology of the subtalar facets (*astragalus*)	Divided - 0% (0/6)
Absence of anterior facet of *calcaneus*	0% (0/6)

Tab. 3. Cranial and post-cranial non metric traits from the skeletons exhumed from Esfola Necropolis.

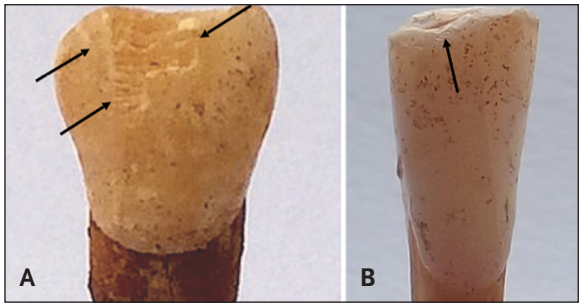


Fig. 4.* A *labial view of tooth 23 with chipping-grade 3 (Sk.14, adult male);* B *labial view of tooth 31 with notching-grade 1 (Sk.10, adult female).

Enclosure	Skeleton	Caries	Calculus	AM	LEH	Chipping	Slanting	Notching	Grooving
2	4	no	no	no	X	no	no	no	no
	7	no	no	no	no	no	no	no	no
1	8	X	X	X	X	no	no	no	no
	9	X	No	no	no	no	no	no	no
	10	no	X	no	X	no	X	X	no
	11	X	no	no	X	no	no	no	no
	12	no	no	no	no	no	no	no	no
	13	no	no	no	no	no	no	no	no
	14	X	X	no	X	X	no	no	no

Tab. 4. Summary of oral conditions of individuals from Esfola.



Fig.5.* A *anterior and posterior views of the proximal part of the right tibia showing a bone exostosis;* B *anterior view of acromial end of the right clavicle both from skeleton 10 (adult female) from Esfola.

loy ring and one metal alloy ring. Several beads (150) were also present near the neck, some were monochromatic (with black and transparent tones) and decorated with buds for 'eyes', and others were polychromatic (presented black and white tones) with a zigzag/serpentiform decoration. This type of polychromatic bead was also recovered with skeleton 12. Some recovered beads were made from glassy paste (in white, black and transparent glass) with segments with stratified eyes. A few of the beads found were made of seashells (6) and animal teeth (2). It is quite interesting that the items found in Esfola clearly attest to the Mediterranean influence on the community that used the necropolis (*Valério* et al. *in press*).



Fig.6. Exostoses observed around the left external* auditory meatus *of skeleton 11 (young adult female) from Esfola. This lesion displays bilateral expression.

Discussion

In recent years, due to the construction and implementation of the Alqueva Irrigation System, a large number of funerary necropolises have been discovered. The so-called 'Núcleo de Beja' shows some uniformity in burial practices and rituals, but in comparison with the 'nucleus of Ourique' there are some differences due to the presence of ritual cremation cysts.

The human remains exhumed at Esfola are very fragmented and poorly preserved. A total of nine skeletons were identified from both sites: four male, two female, and three of unknown sex. All but two individuals, an eight-year-old and an adolescent of about 16 years, were adults. The sample of the necropolis of Vinha das Caliças 4 is larger. It has a total of 53 skeletons: 15 adult females, 13 adult males, 18 adults of undetermined sex, and seven non-adults (*Pelicano 2016*). However, both necropolises were not fully excavated, and thus a more comprehensive understanding of these archaeological sites is not possible.

Concerning atypical dental wear patterns, the majority of alterations observed in the upper and lower anterior teeth of these individuals were chipping and slanting (*Molnar* et al. *2011*). The patterns of chipping in anterior teeth could be suggestive of the use of teeth in daily activities, such as weaving, while in the posterior teeth chipping could be explained by the ingestion of hard or not well-cooked food (*Bonfiglioli* et al. *2004*). In the individuals recovered from this necropolis, chipping was located on the upper anterior dentition of skeleton 14 (an adult male). A similar pattern was observed but in a different period, in the Bronze Age in individuals from the ne-



Fig.7. Small perforation observed in the left acetabulum of skeleton 14 (adult male) from Esfola.

Skeleton	Pathologies
Ind. 4 ♂	Signs of remodeled infection in the lower limb bones (particularly tibiae).
Ind. 8 ♂	Low grade articular lesion in the articulation of the right shoulder/elbow, left knee and left tarsal bones. Circular osteoma ('button' osteoma) with 7mm diameter in the occipital bone.
Ind. 10 ♀	Low articular lesion in the temporomandibular point, entheseal change of grade 1 in the solear pit of the right tibia. Exostoses in proximal region of the diaphysis of the right tibia (15mm x 5mm). Exostoses in the acromial end of the right clavicle (3mm x 1.5mm).
Ind. 11 ♀	Exostoses in the external auditory meatus in both temporal bones with similar dimensions (3.9mm x 2.5mm).
Ind. 14 ♂	Entheseal change of pectoralis major and supracondilar crest of the right humerus, tibial tuberosity and distal part of the left tibia. Hole with 8mm diameter in the left acetabulum displaying remodeled edges. Signs of remodeled infection in the bones of the right foot.

Tab. 5. Identified pathologies in the skeletons unearthed of Esfola necropolis.

cropolis of Casas Velhas in Melides (Portugal). Here chipping was recorded in five anterior and two posterior teeth, corresponding to three individuals (two males and one of unknown sex) according to Ana M. Silva *et al.* (*2016*). Chipping was also found in the Middle Bronze Age hypogea of the archaeological site of Torre Velha 3, but only on the anterior teeth of two female adult individuals (*Fidalgo* et al. *2020*). It is possible that the atypical wear in both Esfola and Casas Velhas is due to abrasive food ingestion and the use of teeth in daily activities, while at Torre Velha 3 it could just be due to the use of teeth in daily activities. However, more study is needed, especially on the EIA necropolises, to better understand these parameters.

Among the observed pathological lesions, the bone exostoses observed in the lateral part of the right tibia of skeleton 10 could represent a case of *Myositis ossificans*. This alteration may occur in response to calcification of a hematoma caused by a trauma (*Campillo 1993*). In skeletons exhumed from Portuguese EIA necropolises no similar cases have been reported, probably because there are only few publications for EIA. However, a case was identified in the necropolis of Angorilla (Spain), in the right humerus of a young adult male (skeleton 553; *López Flores 2014*).

In skeleton 11 it is possible to observe an exostosis in the external *auditory meatus* in both temporal bones. Clinical investigations call it 'surfer's ear', which is an inflammation caused by the frequent contact with water, especially cold water, in the auditory canal (*Lorentz 2020*). Several Iron Age activities could result in these alterations, such as swimming, fishing, or exploring water recourses (*Villote* et al. *2014*).

With regard to the spatial disposition of Esfola, some authors propose that the distribution of the graves could possibly represent familial relationships based on the exploration of territory (*Figueiredo, Mataloto 2017*) or between the individual burials in the same enclosure (*Aubet* et al. *1996*). Forthcoming DNA studies may help to test this theory. Some bone samples from Esfola were submitted to Harvard University to be analysed by David Reich and his team, and the same has been done in the necropolis of Vinha das Caliças by Breslin (PhD thesis in preparation).

In Esfola, as in Vinha das Caliças 4, the importance of the symbolic and decorative objects such as chain beads, rings and bracelets offered by the living to the dead is striking. The effects of looting are visible in the majority of the tombs, especially in the thoracic region of the skeletons, where the most valuable objects were located. Some authors call this 'surgical looting' (*Figueiredo, Mataloto 2017*).

Some grave goods appeared to be distributed based on the sex of the individual, with men being associated with weapons and females with adornment and pottery.

The grave goods recovered from skeleton 11 (Enclosure 1), are particularly rich and diverse (see Table 1); including two bracelets, *acorazonados*, also identified in the necropolises of Vinha das Caliças 4 (*Arruda* et al. *2017*) and Monte do Bolor 1–2 (*Soares* et al. *2017*). Other recovered grave goods include two rounded and simple metal bracelets, one bronze ring, and a necklace with more than 150 glass beads (polychromatic beads in black and white tones, black glass bead with cross sections and two animal teeth and six cowrie shells). Bracelets are well documented in Portuguese territory, and specifically in the region of Beja (*Mataloto 2015*), as is witnessed in Vinha das Caliças 4 (*Arruda* et al. *2017*), Monte do Bolor 1–2 (*Soares* et al. *2017*), Quinta do Estácio 6 (*Pereiro* et al. *2017*), and in Monument VI of Monte-do-

Mealha Nova in Ourique (*Dias* et al. *1970*). These bracelets are also associated with female individuals in Angorrilha, Sevilla (*Ferrer Albeda, Bandera Romero 2014*).

Fibula appeared in the graves of male skeletons 4 (Enclosure 2) and 14 (Enclosure 1). The first corresponds to a complete fibula of the Ponte 8a type – fibula of the Alcores type (*Ponte 2006*). The second is a complete bronze fibula of the Ponte 9 type – acebuchal fibula, subtype Ponte 9/a1 (*Ponte 2006*). This type of fibula parallels in the necropolis of Olival do Senhor dos Mártires in Alcácer do Sal (*Ponte 1985*). In other necropolises of Beja, fibulae seem to be more associated with male burials (*Figueiredo, Mataloto 2017*), as in Vinha das Caliças 4 (*Arruda* et al. *2017*). However, they also appear to be associated with females, as the fragment recovered in the grave of skeleton 10 of Esfola necropolis suggests. It was not possible to identify any relationship between belt-buckles and sex at Esfola because they were recovered from male, female, and unknown sex graves. Despite this, some scholars have pointed out that the pieces of 'Tartesic type' are closely related to female skeletons (*Almagro-Gorbea* et al. *2008*), and this was also observed in similar necropolises of the Beja region (*Figueiredo, Mataloto 2017*), such as Vinha das Caliças 4 (*Arruda* et al. *2017*).

A very fragmented iron knife was identified next to skeleton 4 (Enclosure 2), buried in the left lateral decubitus and facing this skeleton. This is a common object and also has parallels in the aforementioned necropolises of Vinha das Caliças 4 (*Arruda* et al. *2017*) and Monte do Bolor 1–2 (*Soares* et al. *2017*) in the region of Beja.

With skeleton 4 (Enclosure 2) and skeletons 8, 9, and 14 (Enclosure 1), a total of four iron spears were identified, including in dorsal or ventral positions in burials, as in other necropolises in the region of Beja. However, with skeleton 14 two spears appeared positioned differently, crossed over the lower limbs.

Final remarks

The Beja region was part of the so-called orientalization process in the 7th and 6th centuries BC. This region has provided deep archaeological insights in the last 15 years, and today it is possible to understand a little more about the great diversity of funerary gestures during this period, contrary to what was previously thought. Indeed, not only is the existence of necropolises of cremation known, but also of inhumation, and sometimes both in the same necropolis.

Skeletons	Grave goods
4	1 spear, 1 knife, 1 *fibulae*
7	1 belt-buckle
8	1 spear
9	2 spears
10	1 vessel, 1 ring, 1 *fibulae*
11	2 bracelets '*acorazonados*', 2 metal bracelets, 1 bronze ring, necklace-beads (>150, 2 animal teeth, 6 cowrie shells)
12	1 belt-buckle
13	–
14	1 bronze *fibulae,* 2 spears

Tab. 6. Skeletons and grave goods of Esfola Necropolis.

The necropolis of Esfola, similar to the others identified in the 'Núcleo de Beja', shows great investment of the living in relation to the dead. This is evidenced by the monumental features of the necropolises, the dimensions of the enclosures, and also the large number and quality of the funerary objects. Similarities in the orientation of the skeletons, the position of the upper and lower limbs and the grave goods can also be observed (Tab. 6).

Although Esfola has not yet been fully excavated, the current discoveries fall within the scope of funerary anthropology and paleobiological research in the region. Only nine individuals were exhumed in this necropolis, with more males than females. Some social distinctions based on sex may be present, as the men had weapons and the women had grave goods of jewellery and pottery. In addition, it is also possible to deduce something about the life of these communities in terms of health status and pathological diseases associated with possible activities of these Early Iron Age individuals who died in the region of Beja.

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Dealing with the outside: social power and legitimation in the South-East Iberian Peninsula during the Iron Age (6th–1st centuries BC)

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ABSTRACT – *The aim of this paper is to analyse some strategies of power, social control and legitimation during the Iberian Iron Age (6th–1st centuries BC). It addresses how the Iberian elites exploited the domain of the 'outside' to legitimize and retain their status. A diachronic approach is presented seeking to analyse the role of the outside realm throughout all the examined period and the variety of its expressions within the Iberian societies. In particular, the paper focuses on the south-east of Spain, an area with a rich archaeological record which, however, has never been examined from this approach.*

KEY WORDS – *Iron Age; Iberian Peninsula; legitimation; elite; society*

Spoprijemanje z zunanjim: družbena moč in legitimacija na jugovzhodnem Iberskem polotoku v železni dobi (6.–1. stoletje pr. n. št.)

IZVLEČEK – *V članku analiziramo strategije moči, družbenega nadzora in legitimacije v iberski železni dobi (6.–1. stoletje pr. n. št.). Raziskujemo, kako so iberske elite izkoriščale domeno 'zunanjega', da bi legitimirale in ohranile svoj status. Predstavljamo diahron pristop pri analizi vloge zunanjega sveta skozi celotno preučevano obdobje in pri preučevanju raznolikosti teh izrazov v iberskih družbah. V članku se bolj podrobno osredotočamo na jugovzhodno Španijo, območje z bogatimi arheološkimi zapisi, ki pa do sedaj še niso bili raziskani s takšnim pristopom.*

KLJUČNE BESEDE – *železna doba; Iberski polotok; legitimacija; elite; družba*

Introduction

From the end of the 6th century BC to the beginning of Roman influence in the 2nd to 1st centuries BC, the Mediterranean territories of the Iberian Peninsula were marked by significant changes at various levels, which also found expression in the landscape. These are particularly remarkable in the 5th and 4th centuries BC, when a hierarchical landscape was defined through the consolidation of a number of fortified sites (*oppida*). They were located in strategic positions along the main regional valleys, controlling the territory and other secondary rural settlements around them. These changes were one of the diverse expressions of a wider process of transformations which led to an increasing social complexity defined by the territorial consolidation of the socio-political elites and the development of a new social framework based on client networks (*Ruiz, Molinos 2007.188–190*).

Within this changing framework, the analysis of the strategies of power and legitimation used by the local elites emerges as a key issue in order to understand this process from a comprehensive perspective. In particular, this paper focuses on the south-

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east of Spain (Fig. 1) and the current region of Murcia, an area which provides a rich and wide material record and where some of the most remarkable peninsular sites of this period are located. Regarding the analysed record, it is important to outline that most of the data have been provided by necropolises and sanctuaries linked to the main fortified settlements, while little is known about domestic contexts, where very little fieldwork has been carried out. In any case, funerary areas and cult places provided us with remarkable examples to illustrate our analysis and explore this issue which, however, has been never approached in the area from this perspective. In fact, the few studies addressing these territories have hardly ever dealt with socio-political issues, paying attention to the archaeological study of main sites and necropolises (amongst others, *Gallardo* et al. *2017; Lillo Carpio 1981; Page 1998; Page, García 1993*) or, more recently, focusing on individual sites (*González* et al. *2014; López-Mondéjar 2016*). Fortunately, some works have examined these aspects in the nearby regions (*Grau 2014; Ruiz, Molinos 2013*), providing an interesting framework to examine for the first time the territories in question from a global and integrative perspective. Since our current knowledge about every regional site is very different and not all of them have been object of systematic archaeological fieldwork, any comparative analysis is clearly difficult. It is for this reason that our final objective here is not to present a distinction between *oppida*, but to provide a global picture of the study area and a first insight into the legitimation strategies of the south-east Iberian communities.

A review of the rich archaeological record provided by funerary areas and cult places associated to the *oppida* of the study area from 6th to 1st centuries BC suggests that space and distance were not neutral concepts for these societies. On the one hand, there is evidence of the existence of a dual conception of the world by the analysed societies, and not only was this not strange to the ancient Mediterranean world in which they were inserted, but it also appears to be clearly reflected through both their material record and their organization of the landscape (*Grau 2010.108; Ruiz, Rueda 2009.71*). From this perspective, space should be understood as an active element, embedded and implicated in social action (*Tilley 1994.10–11*). As a result, and as indicated by Durkheim, dimensions such as geographical space and distance should be understood as categories that were replete with symbolic meanings (*Durkheim 1915.11; Helms 1988.8*). On the other hand, by examining the materials we assume the significance of the external realm for these communities, whose images and symbols reveal its socio-political use by the ruling groups throughout the Iron Age, constituting a powerful strategy of social control and legitimation in the hands of the Iberian elites. Of course, we are aware of the fact that internal and external factors played a significant role in the socio-political processes of this period (*Ruiz, Molinos 2007; Padilla, Arboledas, López 2019.372; Sanmartí 2008.279*) and that diverse strategies of legitimation were used by local elites. Any different approach would mean a simplified view of a much more complex process. Keeping this in mind, this work aims to address the role played by the external realm as one of those strategies, a key aspect which has not been previously examined by the regional research and which, however, is essential if we are to obtain a complete picture of these communities during the centuries in question.

While not beyond criticism, Helms' studies provide us with a first and interesting anthropological approach to this issue. They offer a number of ideas

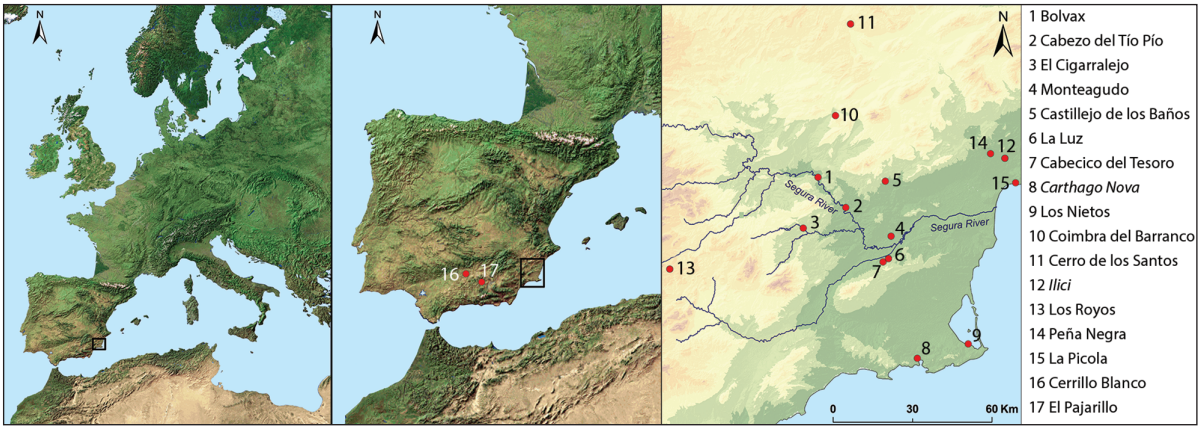


Fig. 1. Location of the study area and main sites cited in the text.

and perspectives through which to address the processes of social and political legitimation during the Iberian Iron Age. In examining traditional societies, Helms highlights the importance of the external realm as a key element for legitimating ideologies (*Helms 1992.157–158; 1993.160–169*). Through her analysis of different chiefdoms, tribes and states, she argues the existence of two realms within which human activity is developed. On the one hand, the 'inside', the ordered world of any society and culture, and on the other, the 'outside', the external world, ruled by cosmological and natural forces. According to Helms, the individuals, objects and activities which link both realms, and especially those that come from 'outside' have a special significance. In particular, she highlights the symbolic meaning of foreign goods and crafts which become crucial elements for individuals seeking socio-political power (*Helms 1993*). In addition, Helms' ideas also express the significance of both space and distance. On the one hand, space has a well-defined extension and an ideological significance in traditional societies and is full of power (*Helms 1988.4; 1992*). According to this idea, the symbolism and connotation of certain places also gives a precise meaning to the actions, peoples, and objects linked to them (*Helms 1992. 158*). Distance becomes another essential characteristic of the outside realm. As noted by Helms, in traditional societies both people and objects associated with distant places acquire an aura of prestige. This is the case with socio-political and ideological leaders, and certain 'liminal' specialists such as religious practitioners, hunters and warriors (*Helms 1993*).

To return to my main theme, and considering the concepts of space and distance, in the case of the Iberian communities the outside realm appears expressed through two different but complementary levels, clearly reflected in the archaeological record. The first one would be linked to the concept of space and identified with the undomesticated and wild territories located beyond the *oppidum*, the community, and its farmlands. The second level is related to the concept of distance, implying a wider framework and going beyond those territories around the *oppidum* to include, in the case of the area being analysed, other Iberian and Mediterranean regions. This second level of analysis will be especially interesting at the end of the examined period, with the integration of the Iberian communities in the Roman sphere of influence.

Bearing these two levels of analysis in mind, we have organized this paper as follows. Firstly, we approach the first level, addressing the images and symbols associated with it. Secondly, we focus on the second level, examining the connections with the Mediterranean and Roman world, and their significance in the processes of social legitimation. Finally, we propose a diachronic view of the subject, by exploring how the relationship with the 'outside' was shaped, and how the elites used it as one of their legitimating tools throughout the period in question.

The territory beyond the *oppidum*: symbols and images of the 'outside'

In the case of the first level of the 'outside', an overview of the archaeological record of the territories in question reveals its importance in the ideology of these communities. As indicated for European societies (*Wells 2008.14–15, 25*), an increasing number of images appeared in the south-east of Iberia during the Iron Age. A review of this rich iconography, documented through different supports such as sculpture or pottery, provides us with good examples to approach and to illustrate our ideas. In addition, studies dealing with these images and iconography in other Iberian territories constitute examples to address their meaning and symbolism in the study area (*Grau and Olmos 2005; Olmos 2003a; 2003b; Sala 2007; Santos 2003; Tortosa 1996; 2006; Uroz 2013*).

Although we only have fragmented data, some examples offer interesting information, such as the sculptures found in Monteagudo (Murcia), close to the Segura Valley. Here, amongst others, fragments of a gryphon, a lion and a warrior have been documented (Fig. 2.a). In a similar vein, one sculpture found at El Cigarralejo (Mula, Murcia) has been also interpreted as part of an individual taking part in a heroic combat (*Sala 2007.70–71*), where an aristocrat defeats these exotic animals and mythological creatures, showing his control over the undomesticated world, and becoming protector and guardian of the community. In both cases, the images have been related to funerary areas, and consequently linked to the local elites whose tombs usually include these types of funerary monuments in the south-east Iberian Peninsula (*Castelo 1995*) (Fig. 2.b-d).

In general, these images refer to mythological fights and exotic animals, showing parallels with other examples which reveal a similar conception of the outside to the communities of other nearby territories. This is the case of two examples located in the region of Jaén (Andalusia). The first is the site of

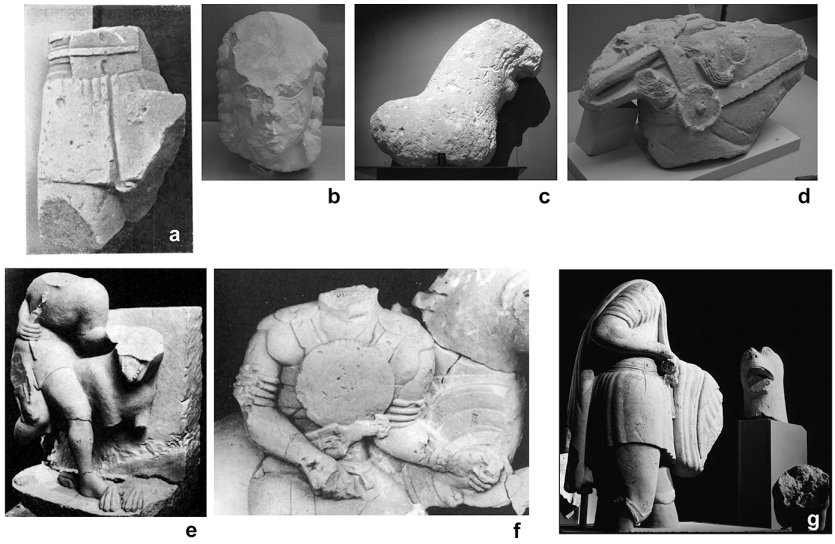


Fig. 2. **a-d** ***Sculptures from the study area (a after*** **Muñoz Amilibia 1981*;*** **b-d** ***Photos by the author),*** **e-f** ***Cerrillo Blanco (after*** **Blanco Freijeiro 1987; 1988*), and*** **g** ***El Pajarillo (after*** **Ruiz *et al.* 2010.Fig. 4*).***

Cerrillo Blanco, in Porcuna. Here, a group of sculptures consisting of more than 40 figures dated to the 5th century BC has been documented (Fig. 2.e-f). They mainly represent warriors, as well as mythological creatures and animals such as bulls, lions, and sphinxes. The second example is the site of El Pajarillo, which provided another interesting group of sculptures, in this case dating back to the beginning of the 4th century BC (*Molinos* et al. *1998; Ruiz, Rueda 2009*) (Fig. 2.g). In this case, as indicated by R. Olmos, a key element is the fact that the group of sculptures from Porcuna was located on the site of a former necropolis dating from the 7th century BC, in an attempt to link the ruling lineage to the individuals buried there (*Olmos 2003a.21*). Moreover, the complex iconographic program of this site justifies and explains how the group ruling over this territory achieved power (*Olmos 2002; Ruiz, Molinos 2007.157–173*), with the intention of representing the appropriation of all the different spheres of nature, of the undomesticated world, by the elite (*Ruiz, Rueda 2009.78*). In the same vein, the fight scenes against potential enemies such as the wolf documented in El Pajarillo have been interpreted as a symbol of the struggle of the elites to maintain power and control the territory (*Sala 2007*).

These earlier examples allow us to understand how power was conceived during the initial centuries of the Iberian period, mainly with a cosmogonic and mythical base, where ancestors and heroes linked to the ruling lineage played an active role. Moreover, these images confirm the existence of a dual conception of the world by these communities, divided into two different realms (*Grau 2011; Olmos 1998.153; Ruiz, Rueda 2009.71*). On the one hand, there is domestic space, including the *oppidum* and the territory exploited by the community. Not only was it delimited by the walls of the *oppidum* (*Bonet, Mata 2009. 124*), but also through the selected location of certain necropolis and cult places. In this sense, some rural cult places located in the near territories of Granada have been also proposed as key points which defined the limits of that domestic space from the end of the 5th century BC (*Adroher, Caballero 2012*). On the other hand there is also a wild realm, consisting of undomesticated and unmarked space that was represented through different symbols, mainly animals.

More examples of fantastic and exotic animals such as lions or gryphons, expressions of the external realm, have been documented in the south-east of the Iberian Peninsula, dating to the end of the 5th century and to the first half of the 4th century BC. Furthermore, along with the sculptures, the first decorated pottery documented in the study area also provides interesting data. An early example is the so-called Campillo Vase, found in an unknown location of the district of Calasparra (Murcia), where amongst other figures a lion and a gryphon are represented (*Lillo Carpio 1990*) (Fig. 3.a). However, it is from the end of the 3rd century BC when painted images become the main vehicles of expression of both the outside and its links to the local elites. This change in the main support used for the images was joined by new forms of expression by the local elites, and must be associated with cultural and socio-political transformations that took place in the Late Iberian period (*Grau, Rueda 2014*). During this period, figurative painted vases constitute one of the most characteristic products from the south-east Iberian Peninsula, and some main production centres of these vessels have been located in the study area, such as the sites of Elche (Alicante) and Cabezo del Tío Pío (Archena, Murcia).

These items express the ideology of the community, in the same way as other elements did before, and

consequently they were highly appreciated by individuals seeking to maintain or promote their status (*Brumfield, Earle 1987.9; Earle 1990.74–76*). In this sense, it is not only the concentration of these products in the main sites that relates them to local elites. The figurative motives used to decorate them have been linked to specific codes that would have encompassed the socio-political ideology of the ruling elite (*Tortosa 2006*). In fact, some vases have been defined as 'bespoke vases', based on the argument that the images and scenes represented were ordered by persons of certain social status (*Olmos 1987.24; Page, García 2021.251; Tortosa 1996.145*). Consequently, the artisans who made them were well aware of the symbolism of the iconography and the particular codes represented, meaning that the motifs were not randomly picked, but specifically chosen. Some well-known vases of the study area reflect the clear symbology of the selected images and their socio-political meaning. A good example is the decorated vase found at Cabezo del Tío Pío, the so-called 'vase of the warriors' (Fig. 3.b), whose analysis has demonstrated how the artisan changed a few details of the painted scene. Since they had a clearly symbolic meaning, it has been explained as an attempt by the artist to adapt it to the preferences and interests of the individual who commissioned it, who would have been a member of the elite (*Olmos 1987.41*).



Fig. 3. Painted vases from:* a *El Campillo (after* Lillo Carpio 1989–1990. 141*);* b *Cabezo del Tío Pío (photo by Spanish Ministry of Education, Culture and Sport, National Archaeological Museum);* c *Cabecico del Tesoro;* d *El Cigarralejo;* e *Bolvax (photos by the author, Archaeological Museum of Murcia).

Considering the special nature of the painted vases, it is easy to understand why we can very frequently find symbols, images and scenes related to the outside. Bearing in mind the iconography of the previous centuries, it is essential to consider the figure of the wolf. Previously represented in sculpture, it becomes one of the most repeated painted images in the south-east Iberian Peninsula during the Late Iberian period (*Mata 2021*). Amongst their various characteristics, also linked to the afterlife, this animal usually appears as symbol of the undomesticated realm (*García 2014; 2016; Robles* et al. *2021*), becoming one of the main iconographic expressions of the first level of the outside (Fig. 3.c). Moreover, its character as a symbol of the external dangers and the wild world located beyond the community is underlined during this final period by the appearance of a new image that is also represented on the vases of this area: the feminine divinity. Unlike the wolf, she is an expression of the 'inside', of the community and the civilized world ruled by the local elites, emphasizing in this way the opposition between both realms. She is represented through specific symbols that become very frequent in the decorated pottery of the study area, where we can find a wide number of examples (*Tortosa 1996.157–159; 2006.162–163*). In general, these iconographic changes reflect the interest of the local elites in legitimizing their status in a changing scenario. However, the world is still divided into two realms, and ruling groups are represented as leaders and protectors of the community, against the outside and its dangers.

Along with the figure of the wolf, and regarding the first level of the outside, it is also interesting to pay attention to the representation of specific scenes and activities. In the study area we can find very good examples of vases on which scenes of hunting and war are linked to the ruling groups. On such vases

these activities are represented together, with the aim of highlighting the significant social roles of the related individuals (*Olmos 2003b.88*). Two excellent examples documented in the study area are the so-called 'wase of the warriors and the musicians' from El Cigarralejo (Mula, Murcia) (Fig. 3.d) and the aforementioned vase from Cabezo del Tío Pío (Archena, Murcia). In both of these, the figures they show are clearly characterized as members of the elite, as expressed through their clothes (cross braces, v-neck tunics) and showing them as warriors and in a hunting scene, activities linked to the ruling groups and which were carried out on the outside. In this sense, and returning to Helms' arguments, both war and hunting are associated with the outside, as they take place in the wild, undomesticated space beyond the *oppidum*. Hence, it is easy to understand why they are very common images on painted vessels from the Late Iberian period and have usually been associated with the Iberian elites (*Tortosa 2006.162–163, 179*).

In the case of hunting scenes, these were not exclusive to painted vases, as reflected by the aforementioned sculpture group from Porcuna (*Olmos 2003a. 25–27*) where a young man is shown hunting with his dog. However, the painted pottery provides us with some interesting examples to approach this activity in the study area, where it is frequently represented (*Tortosa 2006.162–163*). A good example is the fragment found at the site of Bolvax (Cieza, Murcia) with a scene where two horsemen are practicing falconry, as indicated by the birds of prey on their shoulders (*Olmos 2003b.88*) (Fig. 3.e). Another example is the vase of Cabezo del Tío Pío, on which a warrior is shown with his horse, indicating his social level, and hunting in the outside, in the limits of the territory of the *oppidum*, indicated through the presence of wild boars (Fig. 3.b). As noted by Helms, the undomesticated character of the outside is expressed through this liminal activity. The fact that it is carried out between both realms associates this activity and the people who practice it with the outside, facing wild nature and unknown dangers (*Helms 1993.8, 153–156*). Once again, these scenes express control over the territory by the ruling groups, who appropriated the natural realm in this way (*Olmos 2003a.25–27*). The elites are shown carrying out an activity that would not have been open to all of the members of the community.

A similar role could be suggested for warfare. A prime example of the links between this activity and social prestige is provided in the study area by the previously mentioned 'vase of the warriors and the musicians' of El Cigarralejo (Fig. 3.d). The scene has been interpreted as a ritual march, possibly associated with a rite of passage or other important moment for the community, where music also played a significant social role, becoming one more element linked to the elite (*González 2008.77; Tortosa 2006. 179*). A group of warriors with spears, shields and masks are shown marching accompanied by musicians. All of them have clothes and symbols which allow them to be identified as members of the ruling elite. According to Helms, warfare is necessarily associated with the outside and consequently those who shared the warrior ideology would have also had a certain link with this realm (*Helms 1993*). The fact that war took place either in territories that were not directly controlled by the community, or in distant and exotic locations, means that it was an activity with a prestige that was enjoyed by those who took part in it. Consequently, it would have legitimized the social role of certain individuals, and in the case of the local elites, their political and ideological control over society.

Beyond these painted images, the link between war and the 'outside' is also expressed in the archaeological record of the study area. In particular, the analysis of important funerary sites such as El Cigarralejo reveals the existence of a group of individuals who took part in this activity and achieved a certain social prestige and influence (*Santos 1989; Luley 2016.30*). In the case of the funerary record, it is interesting to note that from the end of the 5th century BC and during the first half of the 4th century BC, an increase in the number of weapons found in the tombs has been documented in the study area (*Quesada 1997.611–613*). Amongst them a number of imported weapons have been found, a particularly exciting aspect as this once again associates warfare and the people who took part in it with the outside, in this case with the second level of this external realm, beyond Iberia.

In summary, different symbols and symbolic scenes allow us to consider the first level of the outside from the beginning of the Iberian Iron Age, finding its first and most direct expressions in sculpture. All of the examined images, including those documented in the nearby Andalusian territories, show the elites acting between the inside and outside, fighting with external forces, domesticating outside powers and, consequently, legitimating their authority over the limits of the territory controlled by the *oppidum*. As indicated by Helms for other contexts,

the outside seems to have been perceived by the Iberian societies as "*supernatural, mythical and more powerful*" (*Helms 1988.4–5*), functioning as a crucial element in the legitimation of the local elites. In Iberian Iron Age societies, this natural and undomesticated space located beyond the *oppidum* was usually related to power, a place where there was room for myths and all that is supernatural and hazardous. Since this space was not claimed or controlled by anybody, it became an ideal scenario for individuals, lineages or groups seeking to express their power and control over nature and, finally, over the territory. Not only do these images show the significance of the outside in the ideology of Iberian societies, but also how ruling groups took advantage of it in social and political terms. From this perspective, all of these images became powerful tools within the analysed communities serving to create discourses of power, and later as a means of legitimizing and demonstrating status in the society.

Distant places and Mediterranean connections: the 'outside' beyond Iberia

The second level of our analysis leads us to widen the scale beyond the *oppidum* and the territories surrounding it, inserting the Iron Age Iberian communities within a broader framework. Throughout the analysed centuries, participation in the exchanges and interactions intended to obtain long-distance goods has been mainly linked to the ruling groups in the study area. This issue is not exclusive to the south-east Iberian Peninsula. In fact, studies dealing with very different areas and chronological contexts coincide in the remarkable role of the elites in these types of interactions (*Wells 2016.172*), and how they used certain symbolic goods in order to achieve their objectives and interests (*Knapp 1988; Mann 1986*). There is a wide number of specific anthropological and archaeological studies focused on these issues which have analysed the role of specific objects as active indicators of social prestige and the role played by the long-distance exchanges (*Aubet* et al. *1996; Frankenstein 1997; Frankenstein, Rowlands 1978; Sahlins 1983.244, 246; Schortman, Urban 2011*). Since those imported goods constitute only some of the aspects analysed in this second level, our purpose here is not so much to examine these aspects from a theorical perspective, as done by those earlier studies, but more importantly to focus on the role played by the goods, images and symbols that originated beyond the *oppidum* and its surrounding territories, as another key power strategy of the south-east Iberian communities. Hence, at this second level we will address very different aspects such as the Greek and Attic pottery, foreign weapons, bronzes and amulets, the presence of mercenaries and foreign traders and craftsmen, and finally the related iconography, paying special attention to the adoption of Roman symbols. Of course, we are aware of the wide diversity of artisans developing their work in the Iberian communities. We focus here on those working on some particular activities such as architecture, sculpture or the decoration and production of painted vases, activities which have been clearly defined in some sites of the study area such as El Cigarralejo (*Blech, Ruano 1998.305–307*).

Firstly, regarding the imported pottery, we assume that every object should be mainly understood and considered according to the specific context in which it was used (*Chang 2008.55; Flad, Hrubi 2007.9–11; Thomas 1991.35–36; Tripcevich 2010.59; van Wijngaarden 1999.4–5*). Therefore, since prestige was by no means a static or essential attribute, we assume that foreign items did not have the same prestige and symbolism during all the focal period. However, their continued appearance in burials indicates that they maintained a certain social significance from the 6th to 4th centuries BC, although it is likely that it was not exactly the same throughout this period, an issue that is more complex to clarify.

Having these ideas in mind, studies dealing with chiefdoms and princeps in the European Iron Age have highlighted the significance of the goods provided by long-distance exchanges and the redistribution of foreign objects, associating them with the increasing power of elites during this period (*Baray 2003.386–387; Brun 2001.34–35; Dietler 2007. 272–273; Herring 1991.122*). They have usually been linked with richer tombs belonging to individuals with high social status, showing their prestige and use as objects for achieving social distinction (*Bagley, Schumann 2013.126; Brumfiel, Earle 1987.5*). Unlike other objects documented in the study area (such as bronze belts, ritual braziers, curved knives, or jewellery), one of the reasons for the symbolism and power of imported goods as legitimating elements would have been related to their foreign origin (*Earle 1991.5–7; Schortman, Urban 2011.165–166; Thomas 1991.35–36*). Of course, as we will explain later, we are aware of the fact that they were not high-status goods simply because they were not local, but that their foreign origin was further aspect used by local elites in order to achieve their legitimating goals. In a similar vein, Helms' ana-

lyses of traditional societies outline how distance becomes a dimension full of symbolic meaning, power and value for these societies, and how objects and individuals related to distant lands, peoples and situations acquired an aura of prestige that made them powerful (*Helms 1993.8–9*).

Examples of long-distance interactions are documented from the 6th century BC in the main necropolises as well as in the most important cult places from the study area, even though they have hardly ever been analysed from the proposed perspective. Studies dealing with the Iron Age communities of the south-east Iberian Peninsula have mainly focused on funerary areas, providing us with an extensive and complete knowledge of a large number of foreign goods documented in the burials from this period. Amongst them, it is essential to pay attention to Greek products since some interesting examples have been documented in the region in question from the beginning of the study period, such as a krater attributed to the Painter of Black Tirso from El Cigarralejo (Mula), a droop cup from Cabezo del Tío Pío (Archena) or the Greek vessel from La Luz (Murcia) dating from the 6th century BC. The social significance of this imported pottery is widely accepted for the Iberian communities of this period and clearly expressed in the archaeological record, as most of these vases were documented as part of the grave goods from the tombs of wealthier individuals (*Adroher, Rouillard 2017*) (Fig. 4.a). From this perspective, they could be defined, following Hirsch's expression, as 'positional goods', since it is precisely their rarity and the difficultly of accessing them which would explain that social value (*Hirsch 1976*). We also have examples of vessels that were repeatedly repaired, such as an Attic vase (825-842-incurved rim bowl (*Sparkes, Talcott 1970*)) located in tomb 29 of Castillejo de los Baños (Fortuna). These therefore appear as symbolic objects, with the ability to be inherited and transferred (*Earle 1997.155; Castillo, DeMarrais, Earle 1996.21*). Moreover, as has been indicated for other European regions during the Iron Age, exchanges, and especially the arrival of Greek products, have also been traditionally defined as key aspects in both the socio-political and economic development of Iberian societies and the geopolitical consolidation of the local elites (*García 2003*). This is not to say that there were not other factors that played a significant role in their development (*Chapman 1990.265*), although these foreign commodities must be seen as part of the trappings of power that were used within these communities to mask relationships of inequality and dominance (*Brun 2001; Earle 1990.75; Loren 2010*). From this perspective, the differences in the funerary record seen through the presence of these goods clearly denote their relevance as markers and, ultimately, as elements that sanctioned the individual's status within the community, presenting them as agents who played an active role in society.

Special attention has been given to Attic pottery in the south-east Iberian Peninsula, although the reasons behind the interest in acquiring these goods has not been examined in the study area. Studies have usually highlighted the scarcity of these vessels and the limited access to them for most of the members of the community in order to explain their significance. This could be accepted for the first few centuries of the Iberian period, but not in the later stages. The changes that took place from the end of the 5th century BC suggest other factors are needed to explain the interest in these foreign goods. Studies have highlighted the increasing number of these products that arrived in the region from the Middle Iberian period, and particularly during the first half of the 4th century BC. An analy-



Fig. 4. Elements with Mediterranean influences and imported goods documented in the study area:* a *Attic pottery and other imported products (photos by the author, Archaeological Museum of Murcia);* b *Bronze cuirass from Cabecico del Tesoro and detail of its decoration (after* Graells 2012.Figs. 49–50*);* c *Helmet from El Cigarralejo (photo by the author, Archaeological Museum of El Cigarralejo).

sis of the funerary record of some of the main necropolises of the area has provided quite remarkable data: for example, 60% of the Attic vessels documented in the region arrived during this period, reaching as high as 80% in sites such as the necropolis of Cabezo del Tío Pío (Archena) (*García 1982.87*).

In general, this increase in the number of Attic goods found in the funerary record is indicative of a larger number of individuals having access to them, even though they were not members of the ruling groups. Good examples of this can be found in the necropolis of Castillejo de los Baños (Fortuna), not far from the Segura Valley, where these Greek products are present in half of the tombs, and that of El Cigarralejo, where they are documented in almost a third of the burials (*Santos 1994*). This has been interpreted as a result of the development of clientelism (*Ruiz, Molinos 2007*): this meant that although the redistribution of those goods continued to be controlled by the local elites, kinship ties would have allowed more individuals to have access to them. Also in this context is the notable appearance of local imitations of some of the most characteristic Attic vases in the study area, such as kraters, clearly linked with a local preference for those imported items. Considering this scenario, an interesting fact is that this change does not seem to have affected the importance of these elements. They continue to appear as an expression of social status, even when they increased in number and were no longer exclusive to the local elites. This suggests another factor to be taken into account in order to understand their significance in this new context: it was mainly their geographically distant origin that gave both these goods and the people who acquired them a certain aura of prestige. From this perspective, we can understand the continued presence of these vessels in the grave goods throughout the whole of the 4th century BC.

Together with these Attic products, other interesting imported elements have been documented in the study area. Although not all of these exotic goods came from other Mediterranean areas, such as a number of special swords documented in Castillejo de Los Baños and El Cigarralejo which probably came from other Iberian regions, most of them were a result of long-distance exchanges and links with the Mediterranean. Unfortunately, considering their scarce number, it is difficult to address the significance of those items coming from other Iberian regions. However, their appearance in a reduced number of burials, where we find also other exotic elements, could suggest a similar importance to those objects coming from more distant places. In general, all these items are excellent examples of the symbolic role these foreign goods played within the societies we are analysing, and were associated with rich burials of people with a certain social status. The most remarkable examples are a Greek bronze lion from tomb 277 and the Etruscan bronze cauldrons from tomb 200, in El Cigarralejo, the Greek bronze centaur in Los Royos (Caravaca de la Cruz), and the Egyptian amulets found at the richer tombs of Coimbra del Barranco Ancho (Jumilla) and Cabecico del Tesoro (Murcia) (*Padró 1983.129–138*).

Amongst the goods that originated from the Mediterranean regions, it is also interesting to note the presence of a number of imported weapons, whose type and decoration connect them with the Mediterranean area. Examples are the ivory handles documented in some main sites of the study area such as El Cigarralejo and Coimbra del Barranco Ancho, which have been defined as prestige goods (*Mata* et al. *2020.83*). Along with these, perhaps one of the most interesting examples is the bronze disc cuirass found in the tomb of Cabecico del Tesoro (Fig. 4.b). A detailed analysis of its decoration and style have led to it being identified as having connections with the Central Mediterranean region. In fact, the main motif, showing an eagle hunting a pigeon, comes from this area, as revealed by similar designs on coins from Agrigento (Sicily, Italy) dating from the end of the 5th century BC (*Graells 2012*). Other weapons documented in the study area, such as the helmet from tomb 277 in El Cigarralejo (Fig. 4.c) and horse trappings found at Coimbra del Barranco Ancho reveal a foreign origin.

At this point we should return to Helms' ideas. As she has argued, the acquisition of these products for local elites became a "*mark of exceptionality, exclusivity and ability to control, and allows the cultivation of a kingly image*" (*Helms 1993.165*). Considering the examined archaeological record, there is no doubt that in the Iberian Iron Age, individuals who joined the networks bringing and redistributing long-distance goods took socio-political and ideological advantage of the values associated with distant places. However, there is one aspect that is not usually indicated by related studies that we should note: the acquisition of these long-distance goods is also connected with the 'outside'. In fact, as noted above, we assume that these objects cannot be defined as goods that conferred status simply because they were not local, and the relationship be-

tween other aspects such as distance or the socio-political context of which they formed a part must also be considered (*Tripcevich 2010.59*). Therefore, in the case of the region in question, they obtained their prestige and power from their links to the outside, consequently becoming of interest for individuals seeking legitimation. All the indicated goods have something in common that transformed them into valuable objects: they were brought from the outside to the inside, from other foreign, symbolically charged places to the community. Once there, they could have been modified or symbolically reinterpreted in order to adapt to specific political and ideological requirements (*Helms 1993.4*), as probably occurred with the previously mentioned amulets and Etruscan cauldrons. In any event, regardless of the specific meaning they had within these Iberian communities, the individuals whose tombs contain all these elements participated in this process by acquiring them and possessing their symbolism and prestige. As Helms has indicated, not only did the objects themselves have a political value, but also the intangible knowledge of the distant regions they represented, which was acquired directly or indirectly (*Helms 1988.3–4*). The elites acquired power in this second way, through their connection with long-distance networks of exchange, and by monopolizing the foreign contacts and the goods obtained through these transactions (*Schortman, Urban 2011.165*).

In addition to all the indicated elements and Mediterranean influences, it is important to note two interesting aspects related to the acquisition of these foreign goods in the study area. On the one hand, it has been suggested that Iberian mercenaries took part in the hostilities that took place in the Central Mediterranean area during this period (*Graells 2012. 159–160*), something that is quite likely if we consider the images of Iberian warriors on Italian vessels, and the similarities that can be seen in certain elements. By bringing these weapons and symbols to inside their communities, Iberian mercenaries would have established a clear connection with the external world. On the other hand, a second aspect to be borne in mind is the presence of foreign traders and craftsmen working in the coastal areas, who would have played a key role in the production and acquisition of certain goods. From the 7th and 6th centuries BC, the south-east Iberian Peninsula was characterized by being an area of great dynamism, with the presence of Greek and Phoenician people who had a definitive impact on the development of the communities settled in these territories. Either as itinerant traders or settlers living together with indigenous peoples, the presence of Phoenician and Greek traders has been documented in the site of La Picola (Santa Pola), and possibly in other settlements such as Peña Negra (Crevillente) and Los Nietos (Cartagena) (*Dietler, Ruiz-López 2009.301–302*), meaning cultural interactions were frequent in these areas from the start of the Iberian period and throughout the centuries we are analysing here. Their presence could have been the reason for the appearance of certain exotic types of decorations, perhaps local reinterpretations of other Mediterranean motifs, as well as the Mediterranean influences documented in sculpture, pottery, and craftmanship in precious metals. This would explain the rich iconography and impressive material record of these territories, where sculptures representing male heads, enthroned individuals, horses, lions, bulls and sphynxes, together with a wide variety of painted pottery with exceptional representations of wolves and winged figures, have been found in Iron Age sites such as El Cigarralejo, Coimbra del Barranco Ancho and Cabecico del Tesoro (*Page, García 1993; 2021.240*). Analyses of the painted vessels and sculptures in the study area have revealed that the artisans who created them were well aware of different Mediterranean motifs and, in some cases, could have even came from distant lands. In fact, based on the previously cited example of Porcuna, it has even been proposed that specialists from the Greek colonies of southern Italy lived in this area and worked for the Iberian elites at the end of the 6th century BC (*Blánquez 1993; Blázquez 2014. 116–117*). In the case of craftmanship in precious metals, these Mediterranean influences and interactions are well documented in the south-east Iberian Peninsula and, in particular, in the lower basin of the Segura Valley. Here, studies have revealed the wide assimilation of Mediterranean models and the high technical capacity of the craftsmen working with precious metals, resulting from interactions with other Mediterranean artisans and the large amount of imported goods (*Graells 2012.159–160*).

One final aspect we would highlight with regard to this second level of the 'outside' refers to the changes that can be seen in the iconography. They must have been related to the socio-political and ideological transformations these communities experienced from the second half of the 4th century BC, and especially during the 3rd century BC. The links to a heroic and mythical ancestor that marked the initial Iberian period (6th and 5th centuries BC) were displaced by a different social framework defined by new situations of dependence (*Ruiz, Molinos 2002;*

Santos 1994). Moreover, the permanent presence of Punics in the coastal areas from the 3rd century BC, together with the later Roman conquest of the Punic city of *Qart Hadasht* (whose name was changed to *Carthago Nova* (Cartagena)) also entailed significant changes to the communities in question, and an increasing Roman presence throughout the entire study area.

Amongst the most remarkable changes at the iconographic level, and considering the second level of the 'outside', it is essential to highlight those that affected the way in which the local elites were represented during the Late Iberian period. They are particularly well defined in certain votive figurines, as well as in the sculptures found in the sanctuaries of the study area, which are characterized by the adoption of Roman symbols. Defined as 'hybrid,' these images constitute one of the main expressions of this second level of the 'outside', revealing how it was used by the ruling elites as part of a renewed strategy to maintain their status. Although these images were found in indigenous sites and within local contexts, it is striking that they show typically Roman clothing and symbols. A number of examples of these images can be found in the south-east Iberian Peninsula: the sculptures located at Cerro de Los Santos (Montealegre del Castillo, Albacete) and the bronze figurines of Monteagudo and La Luz (Murcia), all of which represent the local elites, are shown wearing typical Roman clothing such as the *toga, calcei* and *bulla* (Fig. 5) (*Noguera, Rodríguez-Oliva 2008; Jiménez-Díez 2011. 105–107*). Adopting these symbols allowed the local elites to be linked to the new Roman power, whose presence challenged their status and authority within the community. So once again, these new external elements appear to have played a key role in socio-political terms within these communities.

To summarize, all the indicated goods, from Attic pottery to Roman symbols, including a large number of prestigious and symbolic objects, constituted a clear expression of that second level of the outside, mainly identified in these territories with the Mediterranean world. From this perspective, they should be understood as useful tools for legitimating the power of the local elites.

A diachronic approach to the 'outside' from the Iron Age until the arrival of the Romans

Having reviewed the different elements, images, symbols, and activities linked to the 'outside' as well as their influence and significance in Iron Age Iberian society, it is clear that social prestige and configuration of the socio-political situation were undoubtedly more complex issues than traditionally thought, and that the outside was another of the factors which played a significant role in both of them. Of course, it was not the only strategy of power and social control of the Iberian elites, but they exploited the domain of the 'outside' as another key tool to legitimize and to retain their status. However, as seen in the previous pages, it did not play the same role during the long period considered and was expressed and used in different ways during these centuries, which were marked by significant

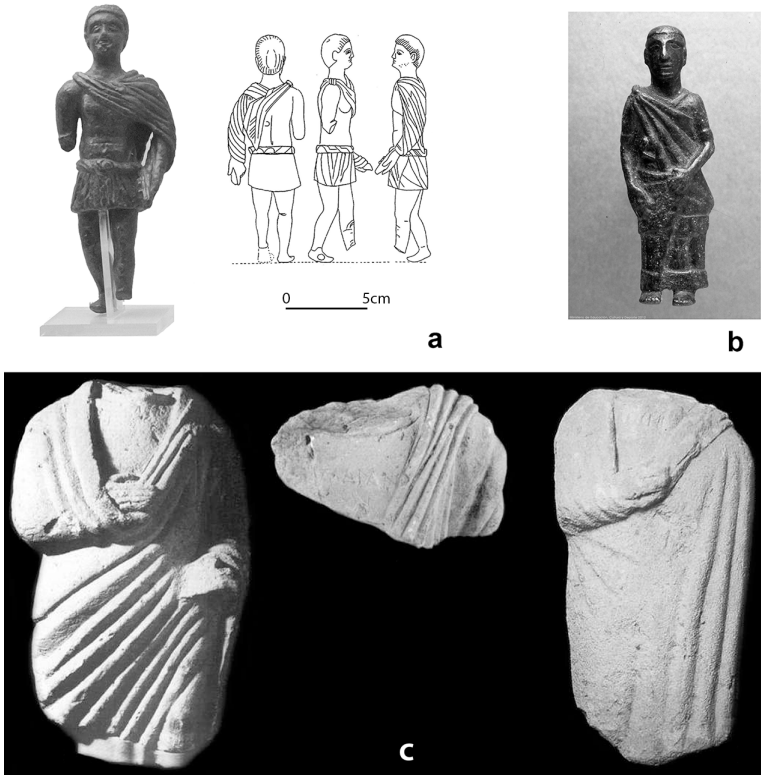


Fig. 5. Bronze votive statuettes and sculptures documented in the south-east of the Iberian Peninsula: **a** ***Bronze statuette from La Luz representing a high-ranking Roman military man dressed in a very short cloak that evokes the legionary*** **paludamentum** ***(after*** **Lillo Carpio 1991–92.131, 133***);*** **b** ***Bronze warrior with cloak from Monteagudo (photo by the Spanish Ministry of Education, Culture and Sport, National Archaeological Museum);*** **c Togati** ***from el Cerro de los Santos (after*** **Uroz 2008.Fig. 7***).***

changes and transformations in the socio-political organization of these communities. Therefore, in order to complete our approach, it is essential to consider the 'outside' and how it was exploited by the local elites from a diachronic perspective. Of course, we are aware of the different chronologies of elements such as those painted vases and the earlier sculptures, however, all the analysed examples constitute expressions of the society and illustrate how that external realm was key for these communities throughout the analysed centuries. From this perspective, all of them allow us to approach the focal question diachronically.

As we have seen in the different examples, during the Ancient Iberian period (6th and 5th centuries BC) and until the end of the 5th century BC, the 'outside' was mainly associated with the mythical time and space where heroes and ancestors legitimated the ruling lineage. Although it is not exactly located in the south-east Iberian Peninsula, Porcuna in the nearby region of Andalusia is the clearest and most representative example of this expression of the 'outside', which played a visible role in legitimizing the ruling lineages throughout these early centuries. The presence of that undomesticated realm, as well as the symbols associated to it, such as the wolf, and their legitimating power within the Iberian societies continued throughout the whole of the Iron Age in the study area (*García 2014*). The appearance of the wolf in painted pottery from the Late Iberian period is the best example. However, from the end of the 5th century BC and during the following centuries, new symbols, activities and elements also expressed this same 'outside', playing a vital role within these communities.

From the beginning of the 4th century BC, and during the Middle Iberian period (4th and 3rd centuries BC), the transformations that took place in the societies of the south-east Iberian Peninsula and which were expressed through the material record in the new distribution of the tombs within the funerary areas and the development of cult places, led to a change in the previous ideological and socio-political framework. These transformations were also reflected in how the 'outside' was expressed during this new period. On the one hand, warfare, as an activity carried out beyond the *oppidum* and, in some cases, even in other Mediterranean territories, along with the material record and symbols related to it, became links to this external realm. On the other hand, the increasing number of imported elements documented in this area reflects the development of long-distance interactions and exchanges, and consequently, the importance acquired by individuals who obtained these exotic products. People who became familiar with these objects and the distant lands from where they originated partook in their prestige and significance. In any case, it is clear that the relationship between both aspects, the warrior ideology and the long-distance exchanges, with the outside is essential in order to understand their social importance during these centuries, and how they also played an essential role in these communities, legitimizing the elite, creating links of interdependence and, finally, configuring the new clientele society that defined these centuries in the study area.

In the case of the Late Iberian period (from the 2nd century BC), and bearing in mind Helms' ideas, there is one main activity that allow us to address the concept of the 'outside': craftsmanship and, in particular, in the case of the study area, its figurative decorated pottery. New and ancient symbols continue to emphasize a dual conception of the world documented from the beginning of the Iberian period, underlining the role of the elites to protect and lead the community against external dangers and enemies.

Precisely in connection with this idea, there is one last aspect to be considered, where the 'outside' took shape indirectly during this final period, and during the process of integration of this local communities in the Roman sphere. While the 'outside' had been identified with the undomesticated realm and with exotic distant lands in the previous centuries, at the end of the Iberian period and with the Roman presence it came to be identified with a 'new,' different external world, that was now represented by Rome. The previously mentioned examples of Cerro de Los Santos (Montealegre del Castillo, Albacete), Monteagudo and La Luz (Murcia), amongst others, clearly illustrate the appropriation of Roman elements by certain individuals. By embracing these external symbols, creating a 'hybrid' iconography, the elites sought to be associated with Rome, the new power located outside the community but whose influence was increasingly tangible from the end of the 3rd century BC throughout the whole of the study area. In any case, what is clear is that the elites created new links to this outside world by adopting these elements, and continued to use them to legitimate their position within this changing framework, seeking to retain their status and power in the eyes of the community.

Based on this, it seems that although the symbols and expressions of the 'outside' were transformed during the period in question, its powerful social and legitimating role was still evident at the end of the Iron Age in the study area. As a result, the legitimation of the elite was defined, albeit in different ways, by its relationship with this external realm. Initially linked to the figures of the mythical hero and fantastic animals, this relationship would soon be defined by the arrival, acquisition, and redistribution of Greek products. Finally, the 'outside' evolved to justify the elites' leadership of the community in opposition to other developed and consolidated Iberian cities and, finally, in opposition to Rome.

Conclusions

All the issues analysed in this article allow us to go beyond the traditional view of the Iron Age communities in the south-east Iberian Peninsula. They provide us with a new image of them, in which the 'outside' appears as a key element to be considered in order to understand the processes of legitimation, and how they were expressed through the rich Iberian iconography. Although the 'outside' had been previously indicated as framework through which the local elites justified their power and identified with a mythical space, especially during the Ancient Iberian period, a close analysis of this concept has allowed us to reveal its significance beyond these initial centuries and throughout the Iberian period, displaying the variety of its expressions within the societies in question. Several interesting ideas have arisen from our analysis.

Firstly, it is evident that the elites derived part of their power from this external realm during the Iron Age in the study area. It was used as one of the tools to legitimize their authority and their socio-political status within the community. This role is visible throughout the whole of the analysed period, and during the early moments of the Roman presence in the south-east Iberian Peninsula. However, every one of these facets of the 'outside' acquired a different prominence in each century, and different aspects can be remarked at each given moment.

Secondly, this relationship was not only direct and associated with a mythical space where ruling lineages acquired their status, as indicated by some studies based on examples provided by iconography. It was much more complex, as there were diverse elements linked to the outside, and two levels of this realm can be defined. In this sense, and beyond the territory of the *oppidum*, usually identified with this external realm, these communities must be inserted within a wider framework that links them to the Mediterranean world. The examples we have analysed, such as the appearance of Attic pottery in the funerary record or the Mediterranean influences reflected by the iconography, clearly reveal these connections and cultural contacts (*Page, García 2021*). Consequently, in order understand how the links to the outside were organized, it is necessary to keep all of these elements in mind, including craftsmanship, long-distance exchanges, and foreign goods, which were used to negotiate power and status.

Thirdly, the 'outside' is not a space that was exclusive to the elites, as is usually suggested for these societies. Other actors benefited from its prestige and advantages, albeit to a different degree than the ruling groups. These included the clients who were dependent on the elite, as well as certain long-distance traders and craftsmen who had a close relationship with this ruling group. These can be considered amongst the 'liminal' specialists indicated by Helms, who carried out their activities between the 'outside' and the community. The codes represented through the painted vases from the study area are one of the best examples. They reveal the special status of craftspeople and artisans, expressed through the specific goods deposited in their graves intended to highlight the special social status they enjoyed, and the prestige they would have acquired within Iberian society.

Finally, from a more global perspective, and even though the presence of these other factors and actors also played a significant role, it is clear that the transformations that affected how the 'outside' was expressed during the centuries in question must have been associated with the changes in how power was represented and expressed in the Iberian societies. These progressed from the mythical and heroic narrative of the Ancient Iberian period, through to the urban and civic discourse of the following centuries (*Domínguez 1998*). As a result, the transformation of how the 'outside' and its associated elements were represented went hand in hand with the consolidation of different types of urban organization. Consequently, it is not possible to approach the Iron Age period as a whole, but instead we must analyse the particular situation of this area during the different centuries, taking into account the transformations these communities experienced in order to understand the processes that configured their relationship with the outside and, finally, the socio-political organization of these societies.

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Implements of wild boar canines during the Neolithic and Chalcolithic at the Lower Danube

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ABSTRACT – *This paper discusses the technological exploitation and transformation of wild boar teeth into tools during the Neolithic and the Chalcolithic north of the Lower Danube. Four main variables were taken into consideration: raw material procurement, blank production, object manufacture, and equipment maintenance. Tool finds from various prehistoric sites in Romania were compared, aiming to identify their impact on the economy of the prehistoric communities, and to determine possible variations in their number/ways of use during early prehistory. Tool typology is poor. The finds studied showed different degrees of use-wear, as well as systematic re-sharpening of the active front. In addition, finished tools are predominant in comparison to the sub-products of the* chaîne opératoire*. The almost total lack of blanks may suggest no stocking was taking place. The entire tooth was used, resulting at times in several implements. Our experimental program, by following closely the technical transformation schemes indicated by the archaeological specimens, suggests that such tusk tools were used for woodworking.*

KEY WORDS – *Neolithic; Chalcolithic; Lower Danube; Romania; wild boar; canines; tools; technological and use-wear analysis; experimental replicas*

Orodja iz podočnikov divjih prašičev v neolitiku in halkolitiku v Spodnjem Podonavju

IZVLEČEK – *V prispevku obravnavamo uporabo in tehnologijo preoblikovanja zob divjih prašičev v orodja v neolitiku in halkolitiku na območju severno od Spodnjega Podonavja. Upoštevali smo štiri ključne spremenljivke: zagotavljanje surovin, proizvodnjo polizdelkov, izdelavo predmetov in vzdrževanje opreme. S primerjavo orodij iz različnih romunskih prazgodovinskih najdišč smo ugotavljali njihov vpliv na gospodarstva prazgodovinskih skupnosti in variabilnosti v številu/načinu uporabe v starejši prazgodovini. Tipologija orodij je slaba. Analiza je pokazala različne stopnje obrabe in ponovno ostrenje. V produkcijski verigi je v primerjavi s polizdelki več končnih izdelkov. Majhno število prvih kaže na to, da njihove zaloge ni bilo. Zob je bil uporabljen v celoti, včasih za izdelavo več orodij. S pomočjo našega eksperimentalnega programa smo lahko sledili tehničnim transformacijam orodij, ki kažejo, da so bila uporabljena za obdelavo lesa.*

KLJUČNE BESEDE – *neolitik; halkolitik; Spodnje Podonavje; Romunija; merjasec; podočniki; orodje; analize tehnologije in sledi uporabe orodij; eksperimentalne replike*

Introduction

Tools of wild boar canines were frequently used by Mesolithic communities throughout Europe (*e.g., Marquebielle 2014*), but during the Neolithic (*e.g., Sidéra 2012*) their presence is rarer, although they were never totally absent. The same phenomenon was noted north of the Lower Danube, in southern and eastern Romania. The earliest wild boar canine tools were documented at the Mesolithic sites in the

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Iron Gates on both banks of the Danube (*e.g.,* Vlasac (*Srejović, Letica 1978), Icoana (Mărgărit* et al. *2017a*), Ostrovul Banului (*Mărgărit* et al. *2017b*)), as an important component of the toolkit of the local foragers. At Icoana (*Mărgărit* et al. *2017a*), the number of wild boar canine tools is comparable to that of bone and antler implements; the total osseous assemblage (n=484 items) reflects a well-balanced use of the available osseous raw materials (bone 36%, antler 35%, and tooth 29%). Debitage waste was present at the site (*Mărgărit* et al. *2017a*) and blanks were recovered from the Ostrovul Banului downstream site (*Mărgărit* et al. *2017b*), suggesting that tusk processing took place *in situ*. While Mesolithic tusk artefacts in our area of interest have received extensive publication (*Mărgărit, Boroneanț 2017a; 2017b; Mărgărit* et al. *2017a; 2017b*), the situation is somewhat different for the Neolithic and Chalcolithic assemblages.

Taking this into consideration, the aim of this paper is to further explore the transformations of the wild boar canine tools[1] during these two periods in southern and eastern Romania. Our objective was to characterize wild boar canine exploitation patterns during the Neolithic and the Chalcolithic through the analysis of four main variables: raw material; blank production (debitage method); manufacture of implements and maintenance of the toolkit, as well as initiate a discussion on the economic and technological implications of wild boar tusk exploitation, starting from our own experimental reconstructions. Several sites attributed to different cultural groups were selected, based mainly on the availability of tusk artefacts and size of the assemblage. The paper focuses on our own study of the material, but also takes into account previous work (Tab. 1, see below).

Archaeological and cultural framework

The Neolithic

Radiocarbon dates for the Early Neolithic – the Starčevo-Criș-Körös cultural complex – cluster between *c.* 6000–5400/5300 cal BC, although a handful of dates fall outside both ends of the interval. The only assemblage directly studied here originates from Măgura *Buduiasca* (Teleorman County), south-western Romania. Previous technological studies referred to a few sites in Oltenia at Cârcea-La Hanuri and Cârcea-*Viaduct*, and eastern Romania at Trestiana and Grumăzești (*Marinescu-Bîlcu, Beldiman 1997; Beldiman 2007; Beldiman, Sztancs 2013*). Tusk implements were mentioned at least at two Early Neolithic sites on the right bank of the Danube in the Iron Gates (Alibeg, Cuina Turcului). In most cases, such artefacts originated from pithouses (whether the floor or the infill is not always clear) and only rarely from the cultural layer.

The Dudești culture (*c.* 5500–4800 cal BC) and later on the Boian followed the Starčevo-Criș in southern Romania, while in the Iron Gates the latter culture was succeeded by the Vinča (*c.* 5700–4800 cal BC). The only Dudești assemblage studied came from pit-features at Măgura *Buduiasca* (Teleorman County, *c.* 5300–5000 cal BC; *Mirea 2011*). Some interesting tusk implements (grave goods) came from the Late Dudești/Early Boian necropolis from Cernica (Ilfov County, *c.* 5200–5000 cal BC; *Stratton* et al. *2019*). One artefact came from a Vinča B2 context at Liubcova-*Ornița* where the occupation was dated based on one charcoal sample to *c.* 5230–5000 cal BC (*Luca, El Susi 1989*).

The Precucuteni culture followed the Starčevo in eastern Romania. Two sites from Iași County offered data pertinent to the present study: Isaiia – *Balta Popii* and Târgu Frumos – *Baza Pătule*. The technology of the tusk implements from the latter site were detailed and both presented by Andreea Vornicu (*2014a*). The former site was assigned based on pottery typology to the Precucuteni culture, phases II and III; occupation of the site falls within the interval between 4620–4440 cal BC (*Ursulescu* et al. *2020*). The only date from the latter site (seen as Precucuteni III) indicates occupation during the 4800–4550 cal BC interval (*Ursulescu* et al. *2005*). The artefacts originated from features identified as house-platforms.

The Chalcolithic

Four assemblages originating from sites of the Gumelnița culture (*c.* 4600–3850 cal BC; *Bem 2001*) were studied: Bordușani-*Popină* (Ialomița County), Căscioarele (Călărași County), Hârșova (Constanța County) and Vitănești (Teleorman County). Earlier publications report wild boar tusk tools from house features at Grădiștea-*Fundeanca* (*Dumitrescu 1933a*) and Gumelnița (*Dumitrescu 1924; 1925*), while more recently their presence in funerary contexts was reported at Pietrele (*Hansen* et al. *2011*).

For the Cucuteni culture (*c.* 4650–3450 cal BC; *Bem 2001*), the assemblage the present author studied di-

1 The paper does not discuss adornments manufactured from this particular raw material unless they were derived from former tools.

rectly, came from Drăgușeni (Neamț County). Pottery typology indicated the site as Cucuteni A4 (*Marinescu Bîlcu, Bolomey 2000*). Previous technological studies focused on the small assemblages from Costești – *Cier* (*Vornicu 2014b*) dated to the Cucuteni A2-3, with no radiocarbon dates available (*Boghian* et al. *2014*) and Berești – *Dealul Bulgarului*, Galați County (*Beldiman* et al. *2012*) a Cucuteni A3 site.

A small number of implements were reported mainly from old excavations at Bodești – *Cetățuia Frumușica*, Neamț County – Cucuteni A, A-B and B (*Mătasă 1946*); Poienești, Vaslui County (*Vulpe 1953*) – Cucuteni A; Ruginoasa, Iași County (*Dumitrescu 1933b*) – Cucuteni A. The only recent finds came from Fulgeriș – *La trei cireși*, Bacău County, a Cucuteni A3 site (*Iațcu* et al. *2016*). All Cucuteni finds were associated with house features/platforms.

Methods

The methodology employed is based on the macroscopic and microscopic analysis of the technological and wear marks present on the archaeological artefacts, supplemented by experimental data. During the first stage of our research, we focused primarily on the preforms, blanks and manufacturing waste, and then on the finished pieces. All artefacts were observed under the microscope for the correct characterization of the technological marks. The second stage aimed to reconstruct the sequence of the manufacturing gestures and the transformation scheme from the raw material to the finished implement.

Microscopic examination and photography were undertaken using a Keyence VHX-600 digital microscope at magnifications between ×30 and ×150. Our methodologies for recording morphological and morphometric attributes, and for the analysis of the technological and use-wear marks, were developed with reference to previous studies on tooth tools from prehistoric contexts (*e.g., Chiquet* et al. *1997; Maigrot 2001; 2005; Marquebielle 2009; 2014; Sidéra 2012*). None of the artefacts available for study has been directly dated. Therefore, period assignments are based on the reported archaeological context and associations.

Starting with the data obtained from the archaeological assemblages, replicas were created to assess all the variables involved in the techniques of processing the tusk implements (technological gestures, time required for each operation, tools employed, re-sharpening actions, *etc.*). This allowed for the correct evaluation of the material costs and the energy invested in the manufacture of these types of artefacts, from the acquisition of the wild boar canines, to the use and the discard of the finished tools. Subsequent to their production, the experimental implements were used in the manner suggested by the relevant archaeological publications. Finally, various parameters of the two categories of implements (archaeological and experimental) were compared (*e.g.,* the morphology of the active end following use, the use-wear marks, their resilience over time, *etc.*) in order to assess the validity of the previously suggested functions of the archaeological artefacts.

Raw material

Wild boars are adaptable mammals, mostly omnivorous (*Albarella* et al. *2006*). A characteristic of the wild boar dentition is the presence of large, rootless and continuously growing permanent canines (tusks) in males (*Schmid 1972*) which serve for defence, finding food and as powerful weapons used against other males during the mating season. When the up-

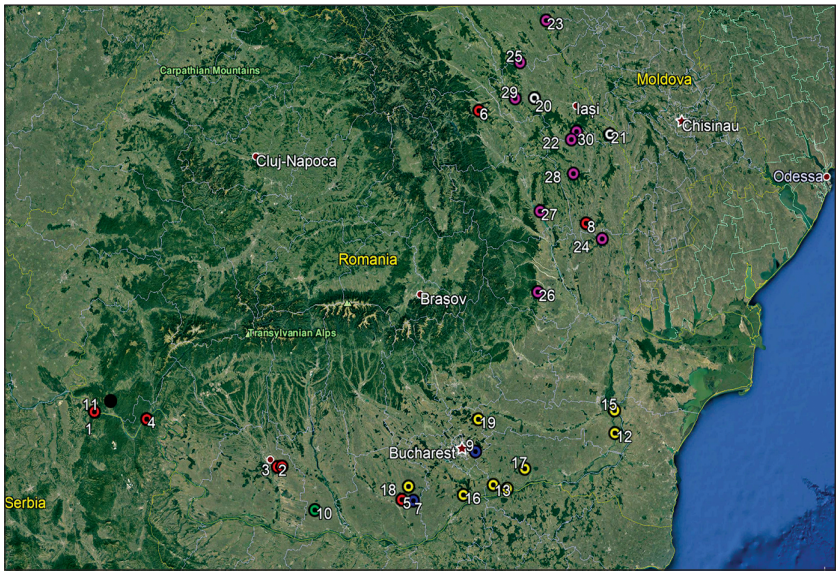


Fig. 1. Map of the sites mentioned in the text: **red *Starčevo Criș;* blue *Dudești;* green *Vinča;* black *Vădastra;* yellow *Gumelnița;* white *Precucuteni;* magenta *Cucuteni.***

per canine is absent, the lower canine can reach an enormous length (*Konjević* et al. *2004*).

They are triangular in section, curved and directed towards the exterior. The proximal end is hollow. Only the anterior internal and external faces are covered with a thin layer of enamel. The lower canines – used for toolmaking – have a natural wear facet towards the distal extremity, resulting from the abrasion against the upper canines (*Marquebielle 2014*).

At the sites in discussion, only wild boar teeth (*Sus scrofa* Linnaeus, 1758; *Gentry* et al. *2004*) seem to have been used to make various tools, those of domestic pig (*Sus domesticus,* Erxleben, 1777; *Gentry* et al. *2004*) do not bear any marks of technological modifications. The situation has both economic and technological explanations. According to certain archaeozoological studies (*Bălășescu* et al. *2005a*), at the Neolithic and Chalcolithic sites in the Lower Danube region male domestic pigs generally did not live beyond 1.5 years. It is extremely unlikely that prior to that age they developed canines of the size we identified at the tusk artefacts we present. Female domestic pigs reach maturity, and cases of rather old sows have been documented, but their canines are too small for such purposes.

The archaeological assemblages

The Starčevo-Criș culture

Significant information was provided by the site at Măgura-*Buduiasca*, Teleorman County (*Beldiman, Sztancs 2009; 2013*). The only blank (Fig. 2.a) still preserving part of the proximal end of the tooth indicates the tooth was extracted from the bone complete. The tip of the tusk was sawn off with a flint tool (Fig. 2.b-c). Subsequently, the blank was bipartitioned longitudinally by percussion.

Finished tools included scrapers (six) and bevelled tools (1). The scrapers (Fig. 2.d; see also *Beldiman, Sztancs 2009.Fig. 14*) were also made on blanks obtained by splitting the canine longitudinally. The cutting edges were adjusted by abrasion over variable areas. At two specimens, the interior surface was regularized by longitudinal scraping. The active front with a concave facet was created exclusively by scraping. The concavity developed longitudinally, is of variable depth on different artefacts, and ends in a false point.



Fig. 2. Teeth artefacts from Măgura*-Buduiasca *(Starčevo-Criș culture):* a *blank;* b-c *sawing marks;* d *scraper;* e *grooving marks;* f, i *scraping marks;* g *bevelled tool;* h *abrasion marks.

A single specimen was obtained by bipartition, combining grooving and indirect percussion (Fig. 2.e). The technological marks left by this operation are still visible. Subsequently, the entire interior surface of the piece was shaped by longitudinal scraping (Fig. 2.f). The active front displays a convexo-concave area and a point, which created two scraping edges.

The only bevelled tool (Fig. 2.g) was made from the proximal extremity of the tooth. It is fractured both longitudinally and transversely. The tooth was bipartitioned by percussion, with the abrasion of the cutting edges (Fig. 2.h). The active front creat-

ed by the transversal scraping of the distal extremity is present only on the interior surface. The visible technological marks overlap areas of use-wear, indicating re-sharpening (Fig. 2.i).

From Grumăzești (Neamț County) was recovered one tooth broken from the jaw by direct percussion/fracturing using a lithic tool (*Marinescu-Bîlcu, Beldiman 1997; Beldiman 2007.156*). Two 'polishers' from Trestiana were also reported (Vaslui County; *Popușoi, Beldiman 2001; Beldiman 2007.93, type I B7; Beldiman, Sztancs 2013*). Their manufacturing stages were similar to what we observed in the Măgura assemblage.

In south-western Romania sporadic finds were mentioned at the Early Neolithic sites at Cârcea-*Viaduct* (Dolj County; *Marinescu-Bâlcu, Beldiman 1997; Beldiman 2007; Beldiman, Sztancs 2013*), Cârcea-*Hanuri* (*Marinescu-Bâlcu, Beldiman 1997; Beldiman 2007; Beldiman, Sztancs 2013*), and Alibeg (Caraș-Severin County; *Boroneanț 2012*). The exact number of finds is unknown. Flat blanks were used, obtained by longitudinal debitage by direct percussion. The resulting pieces were scrapers or short end-scrapers (*Marinescu-Bâlcu, Beldiman 1997.294*).

The Dudești culture

Some information of technological nature comes from Măgura-*Buduiasca* (*Mărgărit* et al. *2016*) and the necropolis of Cernica (*Cantacuzino, Morintz 1968; Comșa, Cantacuzină 2001; Mărgărit, Vintilă 2015*).

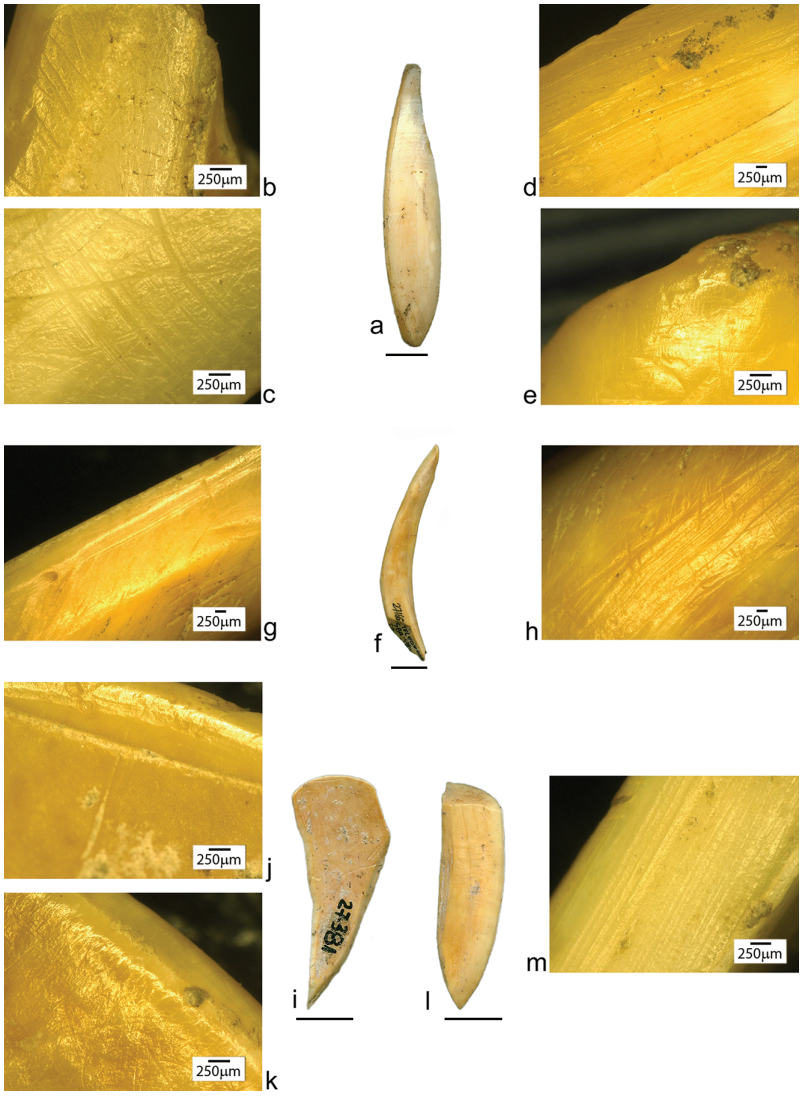


Fig. 3. Teeth artefacts from Măgura*-Buduiasca *(Dudești culture);* a, f *scrapers;* b-c *abrasion marks;* d, h, m *scraping marks;* g *grooving marks;* i *combination tool;* j *sawing marks;* k *use-wear marks;* l *preform.

At Măgura-*Buduiasca*, five scrapers (Fig. 3.a,f) were obtained from flat blanks extracted by various methods of bipartition: percussion (two items), grooving combined with indirect percussion (one item – Fig. 3.g) and indeterminate (where the shaping operation had removed all previous technological marks – two items). Shaping the tools was acquired by two methods: scraping of the cutting edges only at the distal extremity (three pieces) and scraping of the entire interior surface, followed by abrasion (two pieces – Fig. 3.b-c). When preserved intact (two pieces), the proximal end was regularized by abrasion. Deep scraping on the area of the distal end created a deeper or shallower concavity (Fig. 3.d,h) ending in a thin point (Fig. 3.e), in most cases fractured (four items). It is this concave area that represents the active front (and not the false point). Marks visible on the active front indicate periodic re-sharpening.

A sixth piece is a combination tool with two active ends (Fig. 3.i). The procedures employed for obtaining the flat blank could not be determined as all marks were erased by subsequent scraping of the cutting edges when the

artefact was shaped. Similar to the items described above, it has a concave active edge at one end – the result of repeated re-sharpening. At the other end, the marks left by the segmentation by sawing (Fig. 3.j) are hardly visible as they were almost erased by the abrasion of the active front. The exterior surface exhibits one area covered by polish with longitudinal scratches (Fig. 3.k), resulting exclusively from use.

The last piece is seemingly a preform for a bevelled-tool (Fig. 3.l). Longitudinal debitage with regularization of the interior surface was the first operation (Fig. 3.m). At one end, oblique abrasion created a chisel-like (bevelled) facet. No use-wear was detected, and thus it is not conclusive whether this was really intended as the active end. Boar canines are also present in funerary contexts, within the necropolis from *Cernica*. All specimens were scrapers. One specimen (Fig. 4.a) was made of a complete tooth, extracted from the mandible. The blank was flat, obtained by bipartition in percussion. The lower surface was regularized by scraping (Fig. 4.b), more visible on the concave edge (Fig. 4.c) representing the active front. In other cases scrapers were made from the distal end of the tooth such as the specimens in graves 81, 216, 250 (Fig. 4.d). The cutting procedure could only be determined for one specimen: a combination between grooving and indirect percussion (Fig. 4.e). The other two items had the lower faces regularized by abrasion (Fig. 4.f). The extremities were fractured except for the specimen in grave 250, preserving the proximal extremity regularized by abrasion (Fig. 4.g). On the concave edge there are obvious scraping marks (Fig. 4.h). According to the published data (*Comșa, Cantacuzino 2001*) such artefacts occurred both in men's and women's graves.

Moreover, one of the scrapers, later transformed into a pendant (Fig. 4.i), was found alongside a male individual. The technological procedures observed are similar: the integral abrasion of the lower face (Fig. 4.j); the concave edge was thinned by repeated scraping rendering the active front inefficient (Fig. 4.k-l), and thus the tool was recycled and turned into a pendant. The perforation was carried out by unifacial rotation, initiated from the lower face. The rotation marks are slightly blurred, indicating that the pendant was worn for a while (Fig. 4.m) prior to burial. In grave M241B, an unmodified boar canine was deposited next to the shoulder blade. The specimen preserved almost the entire length of the tooth, indicating it was extracted from the mandible complete.

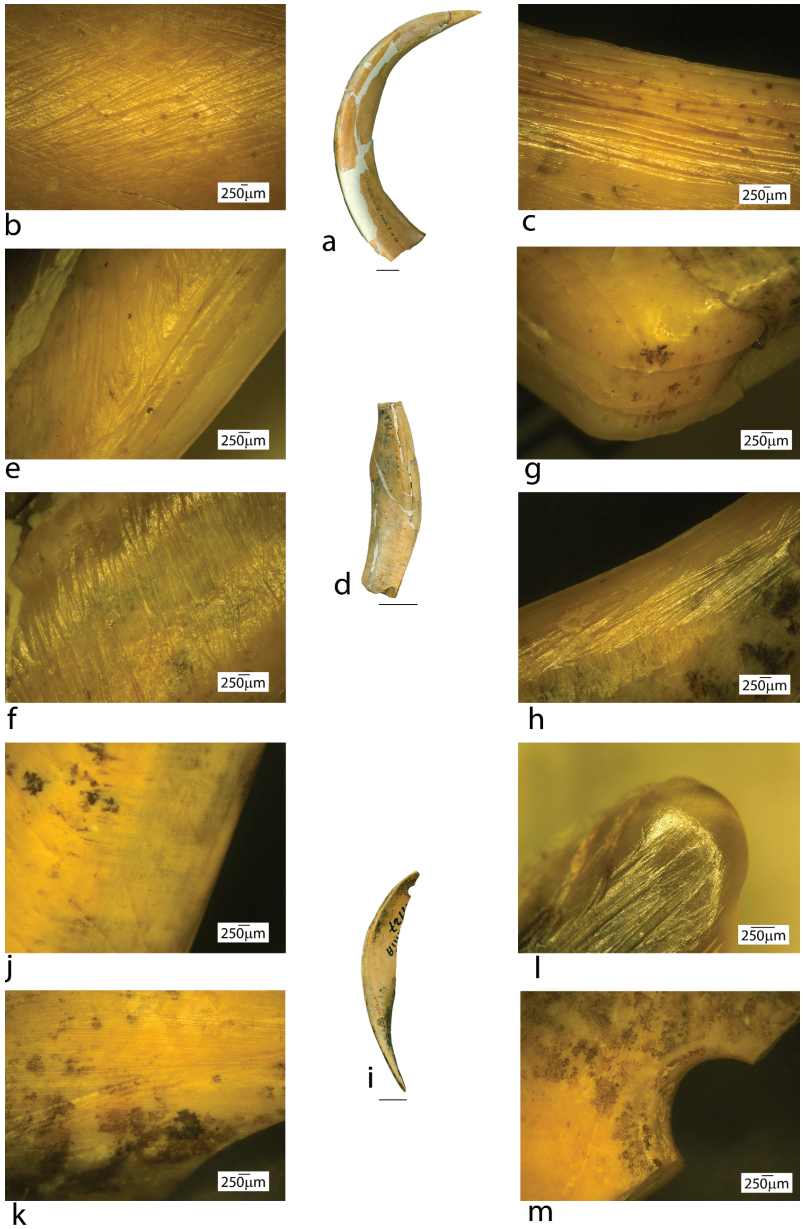


Fig. 4. Teeth artefacts from Cernica necropolis (Final Dudești/Early Boian culture);* a, d, i *scrapers;* b-c, h, k-l *scraping marks;* e *grooving marks;* f-g, j *abrasion marks;* m *perforation detail.

The Gumelnița culture

Assemblages from four tell-settlements were directly studied by the present authors: *Bordușani-Popină*, Căscioarele, Hârșova and Vitănești. At two other sites the presence of wild boar implements was noted: Pietrele and Grădiștea Fundeanca.

Two scrapers came from the tell-settlement of *Bordușani-Popină*. One was made from the central area of the tooth (Fig. 5.a). A flat blank was first obtained by longitudinal bipartition, initiated by grooving (Fig. 5.b) on the concave facet and continued by indirect percussion. Subsequently, the concave edge was scraped longitudinally (Fig. 5.c). The active front has not acquired the usual morphology, indicating the artefact had not been used prior to discard. The second piece was made on the proximal end of the canine (Fig. 5.d). The flat blank was obtained by percussion (Fig. 5.e), and its proximal extremity was shaped by abrasion (Fig. 5.f). Scraping was carried on along the cutting edges to create the desired morphology. The presence of two concavities located bilaterally suggests the existence of two active fronts. Despite the fact the tip of the implement broke at a certain moment in time, the artefact continued to be used, and use-wear formed on the fractured area (Fig. 5.h). There are no re-sharpening marks on the two active fronts, only polish and functional scratches, indicating the implement was used unmodified prior to being discarded (Fig. 5.g).

The Căscioarele assemblage consists of 13 implements, of which 12 are scrapers. Nine were made from the proximal part of the tooth (Fig. 5.i, 6.a) and three from the distal one (Fig. 6.f). All blanks were flat, obtained by longitudinal bipartition in percussion. The cutting edges (Fig. 6.c) and the proximal end were adjusted by abrasion (Figs. 5.j, 6.b). The deep concavity exhibiting scraping marks (Figs. 5.k, 6.d,e) located towards the distal end is associated with a point that was intentionally created and not the result of use. On most of these artefacts, the tip of the point broke during use. Six specimens were intensely used, until the active front which had been repeatedly shaped by scraping was exhausted, and the items became very thin in this area (Figs. 5.i, 6.a), and further use would have led to their breaking.

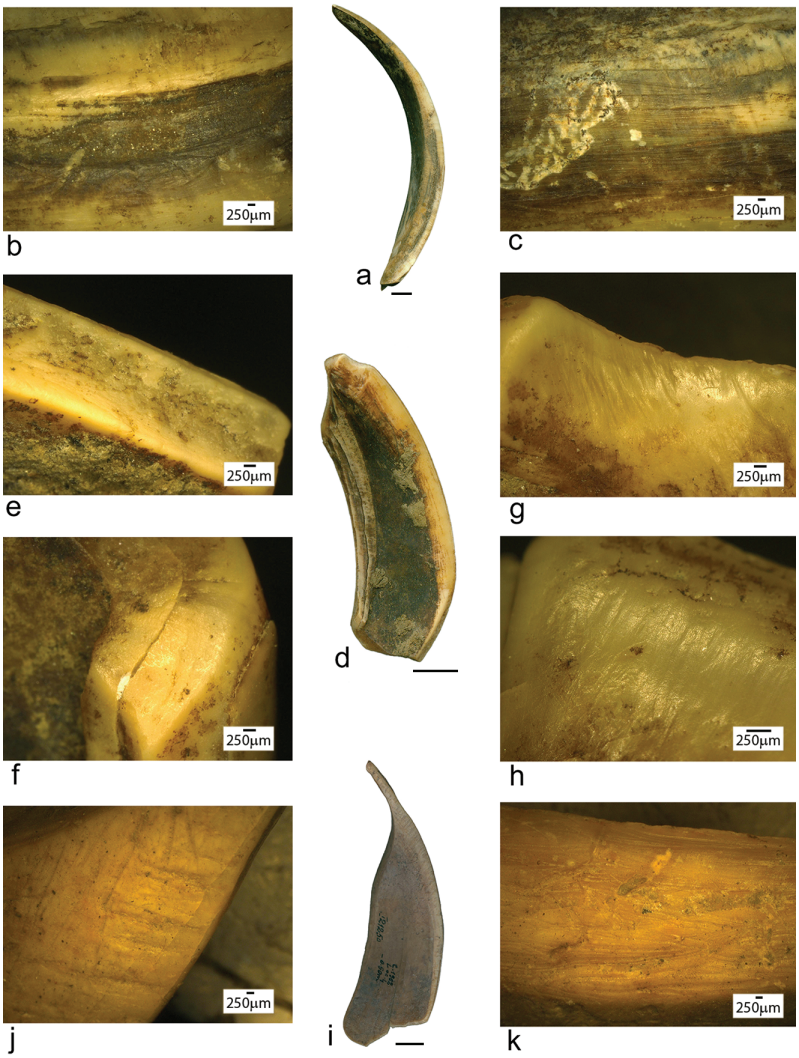


Fig. 5. **a, d** ***teeth artefacts from Bordușani-*****Popină** ***(Gumelnița culture);*** **i** ***tooth artefact from Căscioarele (Gumelnița culture);*** **b** ***grooving marks;*** **c, k** ***scraping marks;*** **e** ***unshaped edge;*** **f, j** ***abrasion marks;*** **g-h** ***use-wear area.***

Two implements (made on the distal end of the tool) are extremely narrow (Fig. 6.f); the concave edge had barely formed but reached its maximum depth (Fig. 6.g-h). They were also used as scrapers, their particular morphology possibly pointing towards a different type of action or their use on a different type of material.

The thirteenth piece was recycled and transformed into a pendant (Fig. 6.i). Originally a scraper obtained in the same way as the other 12 (on a flat blank, obtain-

ed by longitudinal percussion; shaping by abrasion applied both to the cutting edges and the proximal end; active front with a deep concavity located on an area of narrow breadth; broken tip), when it became unusable, the initial tool was perforated by unifacial rotation initiated from the interior face. It had not even been re-sharpened after its last use, as the scraping marks are blurred (Fig. 6.j). The rotation marks inside the perforation are still visible but blurred, suggesting its long use as a pendant (Fig. 6.k).

The tell-settlement of Hârșova yielded four implements: two preforms and two finished tools. A fractured preform was extracted from the central area of the tooth. The tooth was split longitudinally by percussion. The edges were shaped by scraping. The functional edge had not been created, suggesting the item was still in the process of modification. A second preform was made from the proximal area (Fig. 7.a). Shaping of the distal end by longitudinal scraping along the edge was started, but not finalized (Fig. 7.b). Irregular scraping took place at the proximal end, both on the interior and the exterior faces. Two cuts made by sawing (Fig. 7.c) are visible on the exterior face, but further observations are not possible given the fractured state of the artefact.

Both finished pieces were made from the proximal area of the tooth. In the first case, the tooth was cut longitudinally but the identification of the procedure was rendered impossible by the abrasion of the cutting edges. The proximal end was cut transversally by sawing as shown by microscopic marks, despite the extremely rigorous shaping by abrasion of the area. The concave edge was scraped on the mesodistal area creating the active front.

At the second implement (Fig. 7.d), the fracture edges and the inferior face were fully abraded (Fig. 7.e). At the distal end, the inferior face and the concave edge were rigorously shaped by scraping (Fig. 7.f). The tip broke sometime during use, but the area of the fracture was abraded and the item remained in use. The concavity of the active front is deep, narrowing the width of the artefact in this area.

The Gumelnița B1 level from the settlement of *Vitănești* yielded three artefacts, a preform and two finished implements, probably combination tools. Pieces made from this raw material seem to be present in the A2 level of the same site (*Torcică 2017. Fig. 62*) but we did not have the opportunity to analyse the archaeological material. The median area of the tooth was used for the preform, detached from the mandible by percussion. Longitudinal bipartition was achieved by indirect percussion. The concave edge was adjusted by abrasion. There are no signs of use-wear or scraping.

One finished (and used) piece was manufactured from the proximal area of the tooth, indicating the

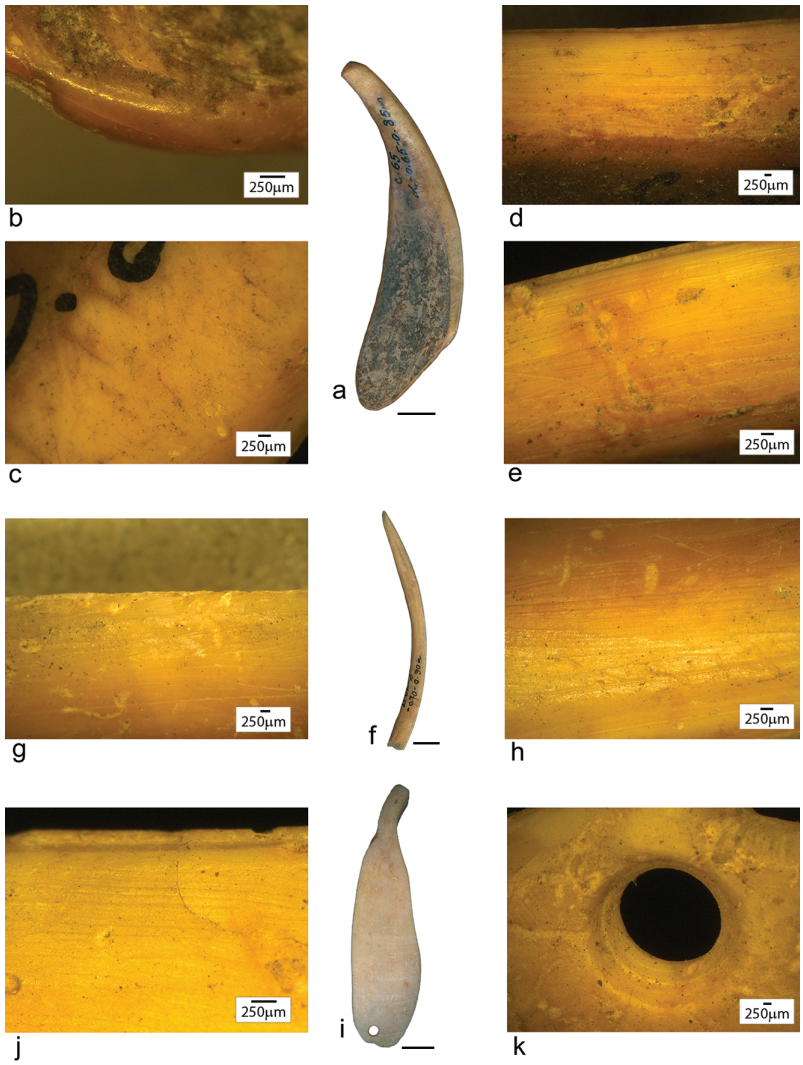


Fig. 6. **a, f, i** ***teeth artefacts from Căscioarele (Gumelnița culture);*** **b-c** ***abrasion marks;*** **d-e, g-h, j** ***scraping marks;*** **k** ***perforation detail.***

tooth was extracted complete. The blank was obtained by percussion, followed by scraping to regularize the concave edge. The rest of the cutting edge remained unshaped. The concave edge was not the only active front, the fractured distal extremity seemingly had a bevelled morphology. The small area still preserved shows strong wear, with rounding of the surface and the erasure of technological marks. The second item also had two active fronts (Fig. 7.g). The procedure for longitudinal bipartition remains obscure, as the interior face was rigorously abraded. Transversal segmentation was performed by sawing (Fig. 7.h). Atypically, scraping marks on the convex edge indicate it to be the functional edge. It acquired an oblique rectilinear morphology. The distal end, shaped by abrasion, also has a convex morphology. The erasure of the abrasion marks towards the distal extremity and the smoothness of this area suggest the distal end might have also been active (Fig. 7.i). No re-sharpening of the tip is visible.



Fig. 7. **a, d** ***teeth artefacts from Hârșova (Gumelnița culture);*** **b, f** ***scraping marks;*** **c, h** ***sawing marks;*** **e** ***abrasion marks;*** **g** ***tooth artefact from Vitănești (Gumelnița culture); i use-wear area.***

The Cucuteni culture

The assemblage studied directly by the present authors originated from Drăgușeni (Neamț County) and comprises 10 pieces: two blanks and eight finished implements.

The two flat blanks were obtained by bipartition by percussion. The central area of the tusk was used for their manufacture, between the proximal end and the tip, an area partially hollow inside.

Scrapers were the only typological category present. They were all manufactured on flat blanks obtained by bipartition by percussion retaining the entire length of the tooth (n=1), from the middle area of the tusk (n=4), and the tip (n=2). At two specimens the debitage edges and the inferior side (n=2) were shaped by abrasion (Fig. 8.a-b), while at two other specimens only the debitage edges (n=2) were abraded. In one case the debitage edge was adjusted by scraping. The proximal end (preserved in two cases) was created by abrasion. The opposite end was arranged by scraping (Fig. 8.c). The scrapers display little use-wear, given the fact the active front had not yet acquired the concave morphology. However, there are visible re-sharpening marks.

One scraper was made on the entire length of the tooth (Fig. 8.d). The blank was obtained by bipartition by percussion, with the abrasion of the inferior face (Fig. 8.e-f). The active area was created by scraping (Fig. 8.g) towards the proximal part of the tooth. The shallow concavity that had formed indicates the implement was used for only a short while.

One artefact (a double point) has two functional areas (Fig. 8.h). The blank is flat, extracted from the distal area of the tooth. The bipartition was performed by percussion, and the inferior face was abraded (Fig. 8.i). Two concave active fronts are visible, most likely used alternately. The piece shows extensive use-wear at the active ends, and both ex-

tremities probably fractured during use. Light scraping marks (Fig. 8.j) indicate the piece was likely never sharpened before being discarded.

The experimental program

Our experiment involved both working wild boar canines and using the resulting tools. The presence of archaeological artefacts made from the proximal end of the tooth shows that at least some were extracted complete from the mandible. By testing different methods, we observed that in order to achieve this and not damage the tooth, the best method was to carefully break the mandible around the tooth. We also identified the main reason for the exclusive use of flat blanks: following dehydration, canines extracted from the mandible tend to crack longitudinally, starting from their proximal part (Fig. 9.a). The crack facilitates obtaining two similar flat blanks by striking a few blows by percussion. This has been highlighted previously by other studies (*Maigrot 2005; Marquebielle 2014*).

For the *debitage*, both procedures observed on the archaeological specimens were tested: percussion and combined grooving + indirect percussion. *Percussion*: the natural crack of the tooth was hit with a hammer a few times, followed by detachment by bending (Fig. 9.b-c). Most likely, bipartition by *grooving* was used for fresher teeth, to facilitate the propagation of the crack along the entire length of the tooth. Using a *burin*, a groove was initiated by unidirectional movement of the tool (Fig. 9.d). Several attempts showed that no great depth or length (*e.g.,* along the entire tooth) were necessary (Fig. 9.f-g). The entire bipartition took *c.* 5 minutes. The two blanks thus marked were detached using a bone pointed tool (prepared beforehand) and a stone hammer. The tip of the bone tool was fixed in the groove and hit with the hammer; if necessary the same action was repeated along the groove. Generally, the crack spread along the tooth after only a few blows. This entire procedure took only a few seconds (Fig. 9.e).

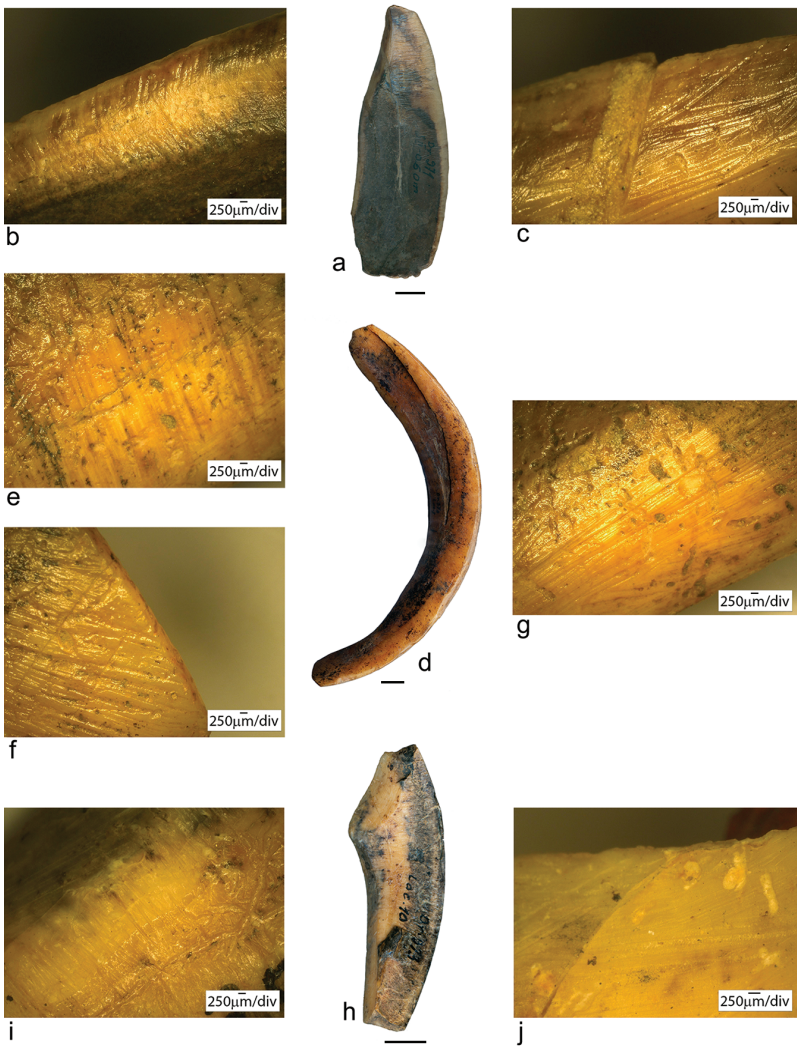


Fig. 8. **a, d, h** ***teeth artefacts from Drăgușeni (Cucuteni culture);*** **b, e-f, i** ***abrasion marks;*** **c, g, j** ***scraping marks.***

The obtained blanks were then transformed into (1) bevelled tools and (2) scrapers, as with the archaeological specimens.

Bevelled tools. The active bevelled front was obtained by a combination of unifacial sawing and bending. Segmentation was achieved using a lithic implement with a sharp edge, employed in a bidirectional movement (Fig. 10.a). When the cut was deep enough (depending on the thickness of the tooth), bending was applied (Fig. 10.b). Our experiments indicated that when bending took place prematurely, accidents occurred damaging the morphology of the active front. This procedure lasted *c.* 10 min.

The active front thus obtained had a V-shaped section morphology, and displayed long, deep and regular microscopic scratches (Fig. 10.c). It was then shap-

ed to acquire the bevelled morphology. The procedure was performed by transverse scraping of the active end, using a flint blade (Fig. 10.d). In about one minute, the surface became regular, with long and irregular scratches (Fig. 10.e-f).

The experimentally obtained implements were then used to remove wood bark (Fig. 11.a). Tools were highly efficient for approx. 10 minutes, then the active front became blunt, acquiring a strong polish. Re-sharpening by transverse scraping was applied (Fig. 11.b). After *c.* 40 minutes of use in all, the active front changed from a rectilinear (Fig. 11.c) to a concave morphology (Fig. 11.d), suggesting that the different morphologies observed on the archaeological artefacts were not caused by different manufacturing processes, but by variable degrees of use. A more concave morphology suggests longer usage. No use-wear marks were left on the active front, having been eliminated by the periodic re-sharpening.

Scrapers. Segmentation by unifacial sawing, followed by bending were the initial procedures (Fig. 12.a). Segmentation was applied obliquely to the axis of the tooth. To shape the tool, scraping along the cutting edges (Fig. 12.b-c), combined with abrasion (Fig. 12.d) on one of the sides (as identified at the archaeological pieces) took place; the active front was regularized by longitudinal scraping. This entire procedure was completed in 5 minutes. The scrapers thus obtained (Fig. 12.e) were used for stripping bark for 40 minutes. Since only the central part of the active front actually touched the wood, the wear developed along this surface. Moreover, being re-sharpened every ten minutes, a concavity appeared in the central area. It evolved gradually (Fig. 12.f) according to the degree of wear, hence the differing morphologies of the active fronts on the archaeological scrapers.

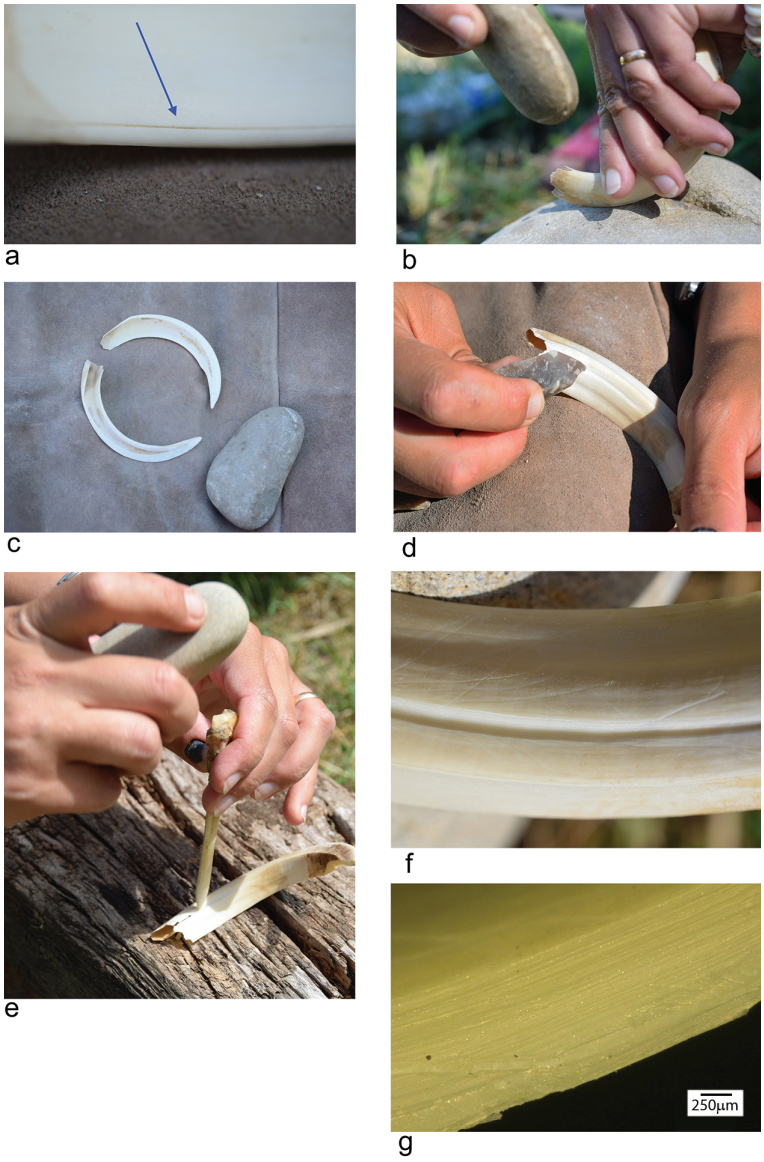


Fig. 9. Experimental debitage operation:* a *natural crack;* b *bipartition by percussion;* c *blanks;* d-e *bipartition by grooving and indirect percussion;* f-g *groove details.

Discussion

Acquisition of raw material

Wild boars live in groups of 10–20 individuals, consisting of females and sub-adults, led by a female (*Leduc* et al. *2015*). Males, on the other hand, are solitary most of the time, the separation from the group occurring between 11 and 16 months (*Nivois* et al. *2014*). Two types of hunting expeditions can thus be distinguished at the prehistoric communities, based on their goal: (1) for the group of females and sub-adults (allowing the capture of several individuals) and (2) for the solitary male (allowing the capture of a single specimen). The two implied different hunting strategies and in the second case it could have turned more dangerous (although chasing a mother defending her young might also prove lethal). The latter expedition type aimed at collecting tusks for tools (in addition to procuring meat),

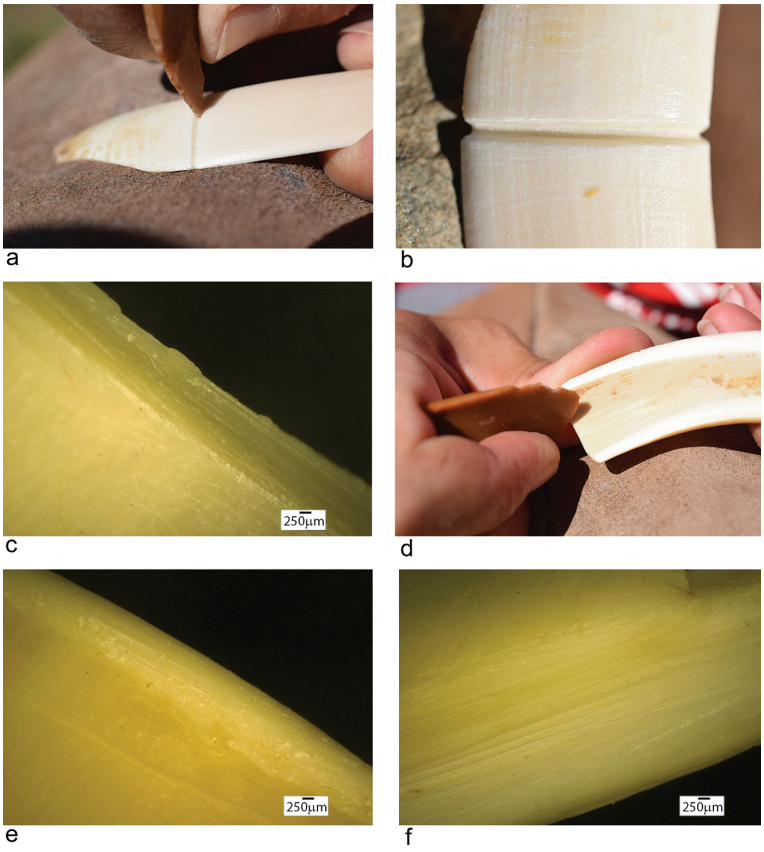


Fig. 10. Experimental shaping operation:* a *sawing procedure;* b-c *groove details;* d *shaping of the active end;* e-f *active end details.

as only adult males could provide canines as large as those found in the archaeological collections. The larger/older the animal, the longer the canines.

Hunting might thus have been a *selective choice* between the mere procurement of meat and the procurement of a certain type of raw material (tusk). A certain limitation of the available tusk is also suggested by the use of complete canines and the continuous re-sharpening of the tools obtained. Moreover, many of the finished items are made on thin blanks, which means they derive from the base of the tooth, indicating the tooth was extracted from the mandible undamaged and complete. The acquisition of the raw material in the case of the wild boar tooth thus requires an additional effort related to both the hunting of the animal and the obtaining of the raw material.

Also indicative of possible constraints regarding the availability of tusk, is the transformation of exhausted tools into pendants. During the Chalcolithic this occurred both in funerary contexts (at the Cernica necropolis and Pietrele; *Hansen* et al. *2011.Abb. 22*) and in settlements (Căscioarele, Grădiștea-Fundeanca, Gumelnița in the Gumelnița culture, and Bodești-*Frumușica*, Bonțești, Fulgeriș-*La trei cireși*, Poienești, Ruginoasa and Scânteia in the Cucuteni area). According to the published illustration, the Pietrele canine fragment preserves a thin active end with a deep concavity (indicating a former scraper), but is also perforated. Similar artefacts came from earlier Hamangia (Cheia, Constanța County; *Voinea* et al. *2014*) and Precucuteni contexts (Târgu-Frumos, Iași County; *Iațcu* et al. *2016*). It is our belief that such artefacts were not meant initially to be ornaments, as such pendants (originating both from occupation layers and funerary contexts) do not show any traces of scraping/specific active edges for scrapers as we have identified at the items discussed. This indicates a prior stage in the artefact's biography, that of a functional tool. Their transformation does not seem to be a systematic process, though.

Wild boar appliqués or pendants, manufactured as such, were recorded both in funerary contexts at Cernica (*Mărgărit, Vintilă 2015*) and Chirnogi-Șuvița Iorgulescu (*Mărgărit, Dimache 2019*) and in the occupation layers at Măgura-*Buduiasca* (Dudești level; *Mărgărit* et al. *2016*), Radovanu (*Mărgărit* et al. *2014*), Vidra (*Mărgărit, Vintilă 2018*), Târgu Frumos (*Ursulescu* et al. *2006*), Fulgeriș (*Iațcu* et al. *2016*), Scânteia (*Mantu, Țurcanu 1999*) and Drăgușeni (*Marinescu-Bîlcu, Bolomey 2000*). Those pieces had been worn as ornaments, and display use-wear.

The scarcity of wild boar implements in Neolithic/Chalcolithic assemblages

Although apparently less frequent than during the Mesolithic, artefacts made of wild boar canines are nevertheless present in most Neolithic and Chalcolithic cultures at the Lower Danube. The Mesolithic 'abundance' is in fact restricted to the area of the Iron Gates, with other Mesolithic/Tardenoisian sites yielding no implements other than lithics. The assemblages we studied clearly indicated that the technological knowledge of tool-making does not disappear, despite the fact they are no longer essential in the toolkits of the community members.

Without getting into much detail, our research into previous publications suggests that the scarcity of

the Neolithic/Chalcolithic sites with finds of wild boar implements may be the result of a series of factors: the manner of excavation (no wet/dry sieving employed), the size of the areas actually excavated at a particular site, their selection as mere faunal remains (which often remained unpublished) and their lack of inclusion among the archaeological materials selected for brief excavation reports. It is noteworthy that most of the artefacts we traced (and there are probably more) came from earlier publications from the 1930s and 1940s when field reports were more detailed and rigorous. Undoubtedly, such finds occurred at those sites in later excavations but were not reported.

Other than the excavation and publication bias, there is also the question of the intensity of the hunting practices among these later prehistoric communities, and the availability of wild boar in various areas during prehistoric times.

The NMI of wild species from Early Neolithic Măgura-*Buduiasca* amounts to *c.* 55% of the faunal remains. Wild boar holds second place (after deer) with a hunting preference for adult individuals. During the Dudești occupation of the same site, domestic animals prevail (76.6%), and wild boar falls fourth among the wild species (after deer, aurochs and roebuck). The frequency of wild species rises again during the Gumelnița culture: at Căscioarele (level B1) they amount to 84.1% with a quantitatively significant number of wild boar remains at sites such as Gumelnița and Hârșova (*Bălășescu* et al. *2005a; 2005b*). In contrast, at the sites in the Teleorman Valley wild boar does not exceed 4% throughout the Neolithic, but reaches 14% during the Chalcolithic Gumelnița A2 phase (*Bălășescu, Mărgărit 2014*). Important variations in the percentages of the hunted species were noted during different chronological stages. Still, the number of tools made of wild boar canines stays constantly low despite all these variations recorded in the faunal assemblages.

The technological analysis of wild boar implements

The typology observed is poor: wild boar teeth were used mostly to manufacture scrapers with different morphologies, followed by a much smaller number of combination tools and bevelled implements. Within these three categories there are several subtypes resulting from variations/combinations in the morphology of the active end. It is noteworthy the prevalence of the longitudinal debitage, favoured by the mechanical characteristic of the material. Being hollow inside and triangular in section, longitudinal natural fracture lines occur along the tooth. Following the death of the animal/extraction of the tooth, the tusk tends to crack, especially in dry environments (see the *Experimental program* above).

Productivity appears to be high in these prehistoric assemblages and little of the tooth was left unused. Longitudinal bipartition allows the extraction of two similar blanks, both to be transformed into finished items. The main technique was longitudinal splitting by percussion, combined at times with grooving and indirect percussion. Transversal debitage took place by direct percussion and, more rarely, by sawing.



Fig. 11. Use of tooth bevelled tool:* a *wood bark removal;* b *re-sharpening of the active end;* c *unused bevelled tool;* d *used bevelled tool.

Surface modification was almost universally accomplished by scraping, with abrasion used more rarely. These techniques were combined on different artefacts, in order to shape the sides of the blank. Alternatively, scraping was used for the development of the active front.

A comparison between the studied Mesolithic and Neolithic/Chalcolithic assemblages shows continuity both typologically and technologically. Scrapers were predominant both the Mesolithic and Neolithic/Chalcolithic

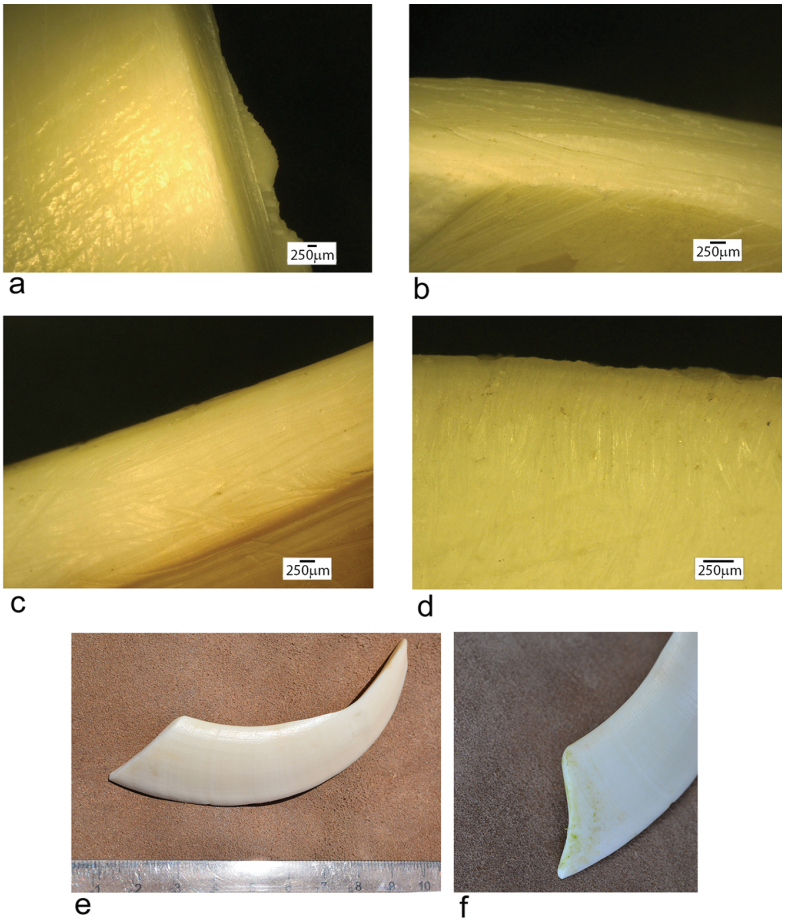


Fig. 12. Processing and use of tooth scraper:* a *sawing marks;* b-c *scraping marks;* d *abrasion marks;* e *unused scraper;* f *used scraper.

assemblages, followed by bevelled and combination tools. During all periods, the prevalence of longitudinal exploitation of the tooth was noted. However, during the Mesolithic, volume blanks were also used and only flat blanks were observed during later prehistory. The main technique used for longitudinal debitage remained percussion, and sometimes also a combination of grooving and percussion. Surface modification was almost universally accomplished by scraping, with abrasion used more rarely throughout the entire earlier prehistory.

Functionality

Over time, the terminology employed for the tools made of wild boar canines varied, as did the functionality assigned to them. Initially, starting strictly from their morphology, a double function was suggested, associating their use in cutting and drilling actions, and the tools were thus called *perçoirs* with sharp edges (*Barbaza 1989*). Éva David (*2000*) called them chisels given the lateral morphology resembling that of a chisel flank, used for scraping while the tip (when existing) was used for grooving, like a *burin*.

Romanian terminology followed the trends of the international one. Earlier publications illustrate points (in Romanian '*vârf*'), tools for pottery decoration/smoothening (in Romanian '*netezitor*'), *etc.* The functional interpretation of the artefacts was further complicated in many cases by the presence of the false points (see above, in the section on morphology), seen as the active parts, and thus those pieces were erroneously interpreted by non-specialists as piercers/perçoirs –'*străpungătoare*'. The perforations on some of the tusk artefacts saw them automatically catalogued as pendants/adornments ('*pandantive*'), and thus the previous biography of the object was completely disregarded.

More recent publications, based mainly on comparisons with ethnographic data collected from Indonesia, indicate their use in scraping wood and removing bark (*Maigrot 2001; 2005; Legrand, Sidéra 2007; Sidéra 2000; 2008; 2012*). Our own experiments pointed towards the same conclusion. Moreover, experimental studies related to the archaeological materials of northwestern Russia and northeastern Belarus (4th–2nd mill. BC) have proven that the pieces of wild boar canines were used for the working of wood and bark, skin, and the drilling of abrasive materials (*Malyutina, Charniauski 2021*). The very fresh aspect of the scraping marks existing on some artefacts encouraged us to suggest the periodic restoration of the active front. This is also confirmed by the ethnographic studies of Patricia Anne Chiquet *et al.* (*1997*).

Conclusion

The experimental examples presented above confirm the high efficiency of these tools in wood processing activities. Boar canine scrapers proved resistant enough not to break during use. The tools' endurance was proven experimentally, and their use was possible until the active front was exhausted with no possibility of further re-sharpening. As shown in some cases, when the active front was inefficient, the pieces were turned into pendants. A

second important conclusion of our experiments was that all tools had the same functionality regardless of the morphology of the active front, and the items were efficient in the same wood processing actions. Additionally, there was a permanent concern for maintaining an effective active front by periodically re-shaping it. Few sites have yielded waste products/blanks, so no definite conclusion can be reached regarding their place of manufacture, but the site seems to be the place for their use and discarding.

In addition, finished items are generally fractured and significantly more numerous in relation to the by-products of the operating chain. The fact that the blanks are almost absent means that there was no stock of blanks to be processed as needed. The tooth was probably completely transformed into the finished objects after extraction.

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Culture	Site	Scraper	Bevelled tool	Combination tool	Preform	Blank	Raw material	Tool (generic)	Total	References	Comments
Starčevo-Criș	Alibeg						*		*	*Boroneanț 2012*	
	Cârcea-*Viaduct*							*	*	*Marinescu-Bâlcu, Beldiman 1997; Beldiman 2007; Beldiman, Sztancs 2013*	
	Cârcea-*Hanuri*							*	*	*Marinescu-Bâlcu, Beldiman 1997; Beldiman 2007; Beldiman, Sztancs 2013*	
	Cuina Turcului							*	*	*Boroneanț 2012*	
	Măgura-*Buduiasca*	6	1			1			8	*Beldiman, Sztancs 2009; 2013*	
	Grumăzești						1		1	*Marinescu-Bâlcu, Beldiman 1997; Beldiman 2007*	
	Trestiana	2(?)							2	*Popușoi, Beldiman 2001; Beldiman 2007; Beldiman, Sztancs 2013*	described as 'polisher/short scraper', type I B 7
Dudești	**Măgura-*Buduiasca***	5		1	1(?)				7	*Mărgărit* et al. *2016*	
	Cernica	5					1		6	*Cantacuzino, Morintz 1968; Comșa, Cantacuzină 2001; Mărgărit, Vintilă 2015*	
Vădastra	Vădastra							2	*	*Christescu 1933*	one with perforation, in illustration only
Vinča	Liubcova-*Orniț a*	1							1	*Luca, El Susi 1989.Fig. 1/17; Beldiman 2007*	
Gumelnița	**Bordușani-*Popină***	2							2	–	
	Căscioarele	12		1					13	*Ștefan 1925; Dumitrescu 1965; 1968*	
	Gumelnița	4(?)							*	*Dumitrescu 1924; 1925*	
	Hârșova	2			2				4	–	
	Pietrele	1+*							*	*Berciu 1956.Fig. 34/1; Hansen* et al. *2011*	
	Sultana								*	*Dumitrescu 1925.footnote 2*	
	Vitănești			2	1(?)				3	–	
	Grădiștea *Fundeanca*							2	*	*Dumitrescu 1933a*	
Precucuteni	Târgu Frumos *Baza Pătule*	*						*	90(?)	*Ursulescu* et al. *2002; Bejenaru* et al. *2013; Vornicu 2014a; Iațcu* et al. *2016*	five published as pendants (probably used as scrapers), one point, one 'technical piece', one point and two 'worked' pieces
	Isaiia-*Balta Popii*	1							1/*	*Ursulescu* et al. *2020*	
	Drăgușeni	7		1		2			10	*Marinescu-Bîlcu, Bolomey 2000*	
	Costești – *Cier*	1				4			5	*Vornicu 2014b*	

Cucuteni	Berești – *Dealul Bulgarului*						1	1	2	*Beldiman* et al. *2012*	awl probably for perforating hides
	Bodești – Frumușica	1							*	*Mătasă 1946; Iațcu* et al. *2016*	with perforation, possibly re-used as pendant
	Bonțești							1	*	*Dumitrescu 1933*	with perforation, reused as pendant
	Fulgeriș – *La trei cireși*	2							*	*Iațcu* et al. *2016*	with perforation, re-used as pendant
	Poienești						*	3	*	*Vulpe 1953; Lazarovici, Babeș 2015*	
	Ruginoasa							1+4	*	*Dumitrescu 1933b; Lazarovici, Lazarovici 2012*	one point, one tool with perforation, reused as pendant
	Scânteia							1	*	*Lazarovici, Lazarovici 2012*	similar to an artefact from Ruginoasa

* Indicates the presence of artefacts, with no information on the exact number; bold characters: technological study by Monica Mărgărit.

Tab. 1. Neolithic and Chalcolithic sites with published wild boar canine assemblages from the area of interest.

Bone tools at the Late Pre-Hispanic site Boyo Paso 2 (Sierras of Córdoba, Argentina)

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ABSTRACT – *The aim of the article is to assess the role played by bone tools at Boyo Paso 2 (Sierras of Córdoba, Argentina), an open-air site interpreted as a basecamp seasonally occupied by mobile mixed foraging and farming people* c. *900–700 years BP. The results suggest that diverse activities were carried out on-site, including hunting or warfare, tool production, food processing and rituals. Bone tool analysis may enable reconstruction of the technological level, social organization, and cultural attitude towards the environment among people neither wholly foragers nor wholly farmers, a category for which archaeology currently lacks sufficient archaeological understanding and that merits further research.*

KEY WORDS – *South America; Late Holocene; bone tool technology; raw material; mixed foraging and cultivation economies*

Koščena orodja na najdišču Boyo Paso 2 (gorovje Sierras de Córdoba, Argentina) iz poznega predšpanskega obdobja

IZVLEČEK – *V članku ocenjujemo vlogo koščenih orodij na najdišču Boyo Paso 2 (gorovje Sierras de Córdoba, Argentina), tj. najdišču na prostem, ki ga razlagajo kot bazni kamp, ki so ga v času ok. 900–700 pr. sed. sezonsko obiskovale mešane skupine nabiralcev in poljedelcev. Rezultati kažejo, da so se na tem najdišču odvijale različne aktivnosti, vključno z lovom ali bojevanjem, izdelava orodij, predelava hrane in rituali. S pomočjo analize koščenih orodij lahko rekonstruiramo tehnološko raven, družbeno organizacijo in odnos do okolja te skupine ljudi, ki niso ne povsem nabiralci, ne povsem kmetje, kar pa je kategorija, za katero arheologija trenutno še nima zadostnega arheološkega razumevanja in si zasluži nadaljnje raziskave.*

KLJUČNE BESEDE – *Južna Amerika; pozni holocen; tehnologija izdelave koščenih orodij; surovine; mešano nabiralniško in poljedelsko gospodarstvo*

Introduction

Bones are a common raw material for tool manufacturing in traditional societies partly because of working proprieties of bones and partly because of their abundance as a food by-product that provides an unending supply of pieces from which to choose (*Moore 1999; Stone 2011; Xie, Stiner 2018*). The Late Pre-Hispanic Period of Sierras of Córdoba (1500–360 years BP, Argentina) was no exception, and bone tools constitute the third most numerous artefact group-type collected on the archaeological record after pottery and lithic technology. The majority of bone tools were projectile points, spindle whorls, awls, pin-like tools, spatulas, knives, smoothers, needles, tubes, flakers and manufacturing by-products,

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showing that they played a key role in those societies where a broad-spectrum foraging and cultivation base took over daily subsistence and dominated the activities of adults (*Argüello de Dorsch 1983; Berberián 1984; González 1943; 1949; Laguens, Bonnin 2009; Marcellino* et al. *1967; Medina* et al. *2014; 2019; Medina, Balena 2020; Serrano 1945*).

However, to date studies of bone working have been relatively neglected due to the greater interest of archaeology regarding chronological questions focusing on lithic projectile technology or the adoption of crop farming. Manufacture debris was thus usually ignored and use-wear analyses were rare. Indeed, Late Pre-Hispanic bone tool assemblages were only exceptionally described or analysed from a typo-functional of sometimes chronological or comparative perspective, with the focus on unusual cases from which functional hypotheses or the activities carried out on-site were assessed (*Buc* et al. *2016; Laguens, Bonnin 2009; Medina* et al. *2014; 2018; 2019*).

The aim of the article is to identify the raw materials chosen and the working methods used for making bone tools at Boyo Paso 2, an open-air site interpreted as a base-camp seasonally occupied by mobile mixed foraging and farming people *c.* 900–700 years BP. Bone tool technology is compared here with the zooarchaeological record to link the economic life with the social life of Boyo Paso 2 people. Another related goal was to identify the possible activities carried out on-site and the role played by bone tools during the site's seasonal occupation. Briefly, the aim of this paper is to provide a full morphological, physical, and functional description of the bone tool assemblage recorded at Boyo Paso 2, exploring the nature of the activities performed and their relation to the socioeconomic intensification process observed at the end of the Holocene (*Buc* et al. *2016; Medina* et al. *2016; Rivero 2009*).

The site

Boyo Paso 2 is an open-air site located at 1160m a.s.l. in the eastern Salsacate valley (Fig. 1). Today, it might be considered one of the best archaeologically investigated sites from the Late Pre-Hispanic Period. In addition to four test-pit works over 2m^2, a specific section of the site was investigated, uncovering 55m^2. Horizontal excavation revealed two overlaying archaeological floors formed by packed sediments (see *Medina* et al. *2020.Figs. 3–4*). The living floors have post-moulds and abundant domestic refuse, including the bone tools analysed here.

The faunal remains found at Boyo Paso 2 were in several publications (*Medina* et al. *2019; 2019; Medina, Rivero 2020*). *Lama* sp. was the largest readily consumed faunal resource assigned to genus or species level. They were tentatively assigned to the wild camelid *Lama* cf. *L. guanicoe*. Two species of deer and diverse small vertebrates were the most consumed animals after *Lama* cf. *L. guanicoe*. *Rhea* sp. eggshells prevail among bird remains and, along with the identification of domesticated plant remains and wild fruits, support the site was occupied during the growing season – *i.e.* from October to April (*Medina* et al. *2019; 2020*). Lithic tool assemblages were dominated by expedient tools manufactured on local lithic raw material (*Balena, Medina 2020; Medina* et al. *2019*). Pottery vessels were dominated by medium-sized rounded morphologies with a versatile and transportable design, better able to withstand the stress of a mobile semi-sedentary lifestyle (*Medina* et al. *2016*). The existence of a wide range of subsistence and processing activities is evidenced by both artefacts and food refuse, including farming, foraging wild resources, storing, and grinding.

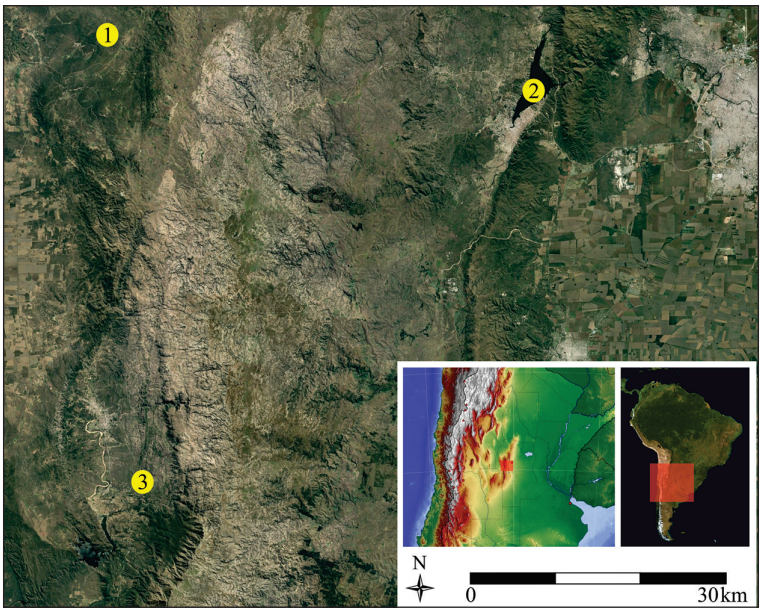


Fig. 1. Geographic locations of the archaeological sites referred to in the text:* 1 *Boyo Paso 2;* 2 *San Roque;* 3 *Carrupachina.

Signs of a full-sedentary farming economy at Boyo Paso 2 are question-

able, as this also occurred during the Late Pre-Hispanic Period, making it difficult to evaluate the reliance on crops over foraging due to the fragmentary nature of the archaeological record. The presence of habitational structures like pit-houses, huts or brush windbreaks was inferred by the detection of post-moulds. The absence of well-defined hearth features makes the identification of the shape and size of the structures more difficult, reinforcing the hypothesis that they were not durable habitational residences for long-term occupation. Artefacts left as abandonment stage refuse or as a site furniture were found on the living floors, including bone tools, suggesting that people planned to return to this location (*Medina* et al. *2014; 2016; 2018; 2020*). Seven radiocarbon dates have been obtained for the site (Tab. 1). The dates overlap roughly when two dates from the upper floor that are considered outliers – 1060±50 and 1500±80 years BP – are excluded, placing the archaeological floors between the range of 900–700 years BP, and confirming that they were formed over a relatively short period (*Medina* et al. *2016*).

Such evidence looks like a result of frequent seasonal reoccupation of the same site year after year or every few years, supporting the interpretation that Boyo Paso 2 was a seasonally reoccupied encampment where small groups of people with a mixed foraging and cultivation economy coalesced to do a wide range of activities. As such, the bone tool and manufacture debris assemblage of Boyo Paso 2 offers a viable match and an excellent opportunity to assess the process of bone raw material procurement, working method and tentative use of bone artefacts, where tactics, actions and decisions were repeated at an evolutionary scale resolution.

Materials and methods

The bone tool assemblage was formed by 87 items collected from fieldwork between 2011 and 2018. Although a few pieces were recovered during test-pit works, most of the bone tools were found on living surfaces or in the semi-subterranean feature of the upper archaeological floor, linking their use to the deposit in which they were found. Pieces were examined with a 20–10X hand lens. This approach was sufficient to confirm that the pieces were artificially modified by manufacture or use on at least one surface. Some of the bone tools discussed here were mentioned in Matías E. Medina *et al.* (*2018*) and Medina *et al.* (*2019*), but they were never studied from the whole worked bone assemblage perspective.

In order to organize the diverse set of objects, the assemblage was classified into morpho-functional groups based on visual inspection of the pieces following the French archaeological school (*Camps-Fabrer 1967*) adapted for South America prehistoric assemblages (*Buc 2012; Cahiza* et al. *2012; Capriles 2014; Medina* et al. *2014; Moore 1999; Pastor, Moschettoni 2018*). The anatomical and taxonomical identifications were based on the reference collections. The physical and metric data (maximum length, width and thickness), as well as the presence and orientation of polish and striae, were recorded to identify the manufacturing processes and tentative functionality of tools. Evidence from wear traces on active edges or ends, ethnographic analogy and archaeological context were used to link the tool type to the function and possible social significance of the objects (*cf. Berenguer, Acevedo 2015; Borella, Buc 2010; Buc 2012; Gates St-Pierre 2007; D'Errico* et al. *2012; Horta* et al. *2019; Legrand 2007; Legrand, Sidera 2007; Luik 2006; Nami, Scheinsohn 1997; Soressi* et al. *2013; Stone 2011*). Thus, the assignment functions of the bone tool assemblage are speculative until use-wear analysis are completed.

The use and performance of the projectile points as spears, arrows or darts were assessed based on the gross weight following Fenenga (*1953*), assuming that pieces with a weight lighter than 4g were used on arrows. The system of hafting projectile points

Stratigraphic unit	Material dated	^{14}C years	Sigma	Lab. code	Calibrated age
Upper archaeological floor (37–40cm)	Wood charcoal	750	70	LP-2932	549–744 BP
	Phaseolus vulgaris	866	39	AA110929	658–908 BP
	Zea mays	878	18	AA110928	716–774 BP
	Wood charcoal	1060	50	LP-3122	796–987 BP
	Wood charcoal	1500	80	LP-3107	1261–1538 BP
Lower archaeological floor (49–56cm)	Wood charcoal	870	50	LP-3577	666–808 BP
	Wood charcoal	970	40	LP-3567	757–924 BP

Tab. 1. Radiocarbon dates from Boyo Paso 2 taken from Medina* et al. *(2020). The calibration of ^{14}C ages was done using Calib Rev. 7.0.1 (*Reimer *et al.* 2013*).

and the size of the shaft were assessed by the morphology of the proximal end of the projectile point following Heidi Knetch (*1993.34*), mainly considering the characteristic of the stem (section, width-thickness, additional technological element associated, *etc.*). Traces of burning on artefacts were recorded using the same taphonomic scheme as that applied to zooarchaeological remains (see *Medina* et al. *2019*). Lastly, the zooarchaeological record described above was used as a baseline to evaluate the selection of raw materials for bone tool production.

Results

Raw materials chosen for making artefacts

The intense anthropic modification and post-depositional fragmentation of the assemblage made it difficult to identify the body parts and taxa selected to make most the bone tools. The species whose bones were most often used for making tools were *Lama* cf. *L. guanicoe* followed by Cervidae cf. *Ozotoceros* (Tabs. 2 and 3 (see Appendix)), readily available and in large quantities as kitchen waste (*Medina* et al. *2019*). Most of the bones identified as the body size classes Mammalia indent (medium-large size) or Macrovertebrate indet presumably also came from these Cetartiodactyla species. Cut marks on an artefact made of Camelidae scapula confirm that at least a portion of the bones used to fashion tools came from animals killed for food, probably those that remained on site after primary butchering. Cathartidae bones were also used for tool manufacturing. Although the meat of Cathartidae was not valuable for food (see *Kozák* et al. *1979*), a few bones of this species were probably sought for symbolic reasons, mainly for fashion specific tools for ritual paraphernalia.

The choice of raw material for manufacturing bone tools was rather standardized. Most often, splinters from macro vertebrate long bones were used to shape the tools, especially metapodials – judging from the pieces BP2-49, BP2-74 and BP2-82 – and perhaps also tibiae, because of their long and straight shape (Tabs. 2 and 3 (see Appendix)). Antler, rib, radius-ulna, scapula, carpals-tarsals, phalanges or axial bones were seldom used (Tab. 3). One particular type of bone tool – flakers – were made from antler, maybe because they required little alteration to produce a flaker. However, flakers were also made on long-bones. It is noteworthy that working traces on antler were ambiguous and could be assigned to a natural origin according to Alejandro Alberto Acosta *et al.* (*2020*). Thus, the functional assignation of antler flakers needs further exploration through use-wear analysis to determine whether they are expedient tools or simply pieces of raw material collected for later use.

In general terms, the raw materials selected to manufacture the worked bone at Boyo Paso 2 are similar to the osseous materials selected for making tools at other Late Pre-Hispanic Period sites (*Berberián 1984; González 1943; 1949; Medina* et al. *2014; Serrano 1945*). The subsistence strategies at all these Late Pre-Hispanic settlements were quite similar and this is also reflected in the exploitation of animal bones for making tools. Artefacts or manufacture debris made from bird bones are extremely scarce at Boyo Paso 2, and only three pieces were found (BP 2-1, BP2-70 and BP2-83). These are also rare at other Late Pre-Hispanic sites, even when bird long bones were used in neighbouring regions to produce bird bone tubes, tubular beads, pendants and pin-like tools (*Bonomo 2013; Del Papa* et al. *2019; Escoste-*

Tool type	Frequency (No.)	Burned (No.)
Projectile points		
Blade fragments	3	3
Serrated stems	2	–
Notched bone tool		
Notched bone tool	1	–
Flakers		
Antler-Flakers?	4	1
Long bone-Flakers	3	2
Smoothers and Scrapers		
Rib- Smoother	1	–
Long bone-Scrapers	4	1
Long bone-Longitudinal scraper	1	1
Pointed tools		
Pin-like tools	2	1
Awl	1	–
Spatulas		
Pin-shaped subtype spatula	1	1
Pin-shaped subtype spatulas?	4	2
Undecorated fragments of spatulas?	3	1
Indeterminate artefacts		
Artefacts on indeterminate taxa	45	23
Artefact on Cathartidae bone (mastic)	1	–
Artefacts on camelid bone	3	1
Artefacts on cervid bone	2	1
Unfinished items and waste by-products		
Pieces on Cathartidae bone	2	1
Pieces on camelid bone	3	–
Piece on cervid bone	1	1
Piece on macrovertebrate bone	1	1

Tab. 2. Summary of bone tool types from Boyo Paso 2.

guy et al. *2017; Horta Tricallotis* et al. *2019; Perez Jimeno, Del Papa 2016; Rusconi 1933*).

Tool types and tentative functions

The bone tool assemblage from Boyo Paso 2 shows different morpho-functional groups, including projectile points, awls, pin-like tools, spatulas, serrated edge tool and blunt points (Tabs. 2 and 3 (see Appendix)). Most tools showed clear signs of wear. Other items were considered manufacture debris by-products or artefacts with unknown functionality. The metric and physical data of the assemblage is presented in Table 3.

Five fragments of projectile points were found (Fig. 2). They were represented by three fragments of blades and two of stems assigned to a class of artefact relatively common in Late Pre-Hispanic Period assemblages characterized by the long triangular-shaped blade (*c.* 62.1mm), straight or slightly contracted stem with serrated edge and barber shoulders (*Medina, Balena 2020; Medina* et al. *2014; 2019; Pastor* et al. *2005*). Although abrasion makes bone identification difficult, nutrient foramida, an element-diagnostic feature, indicated that BP2-82 was fashioned on a metatarsal roughly assigned to Cetartiodactyla cf. Camelidae-Cervidae. The pieces BP2-39, BP2-64, BP2-75 and BP2-84, with a biplane cross-section, thickness of *c.* 3mm and diagonal manufacture traces or finally abraded surfaces, resemble the physical structure known for bone projectile points, which would thus increase the frequency of this tool-type in the assemblage. The gross weight of the nearly complete pieces suggests that these projectile points were hafted to a bow-and-arrow weapon delivery system, mainly because their light weight (*c.* 2–4g) needs speed to increase their effectiveness and penetration capacity (*Pastor* et al. *2005*). Moreover, they have a complex hafting system that involve shafts with a distal end being whittled down to match a stem with a serrated edge to reduce the slippage of the ligature and fasten the point firmly to the shaft (see *Medina* et al. *2019.Fig. 5*).

Hunting and warfare projectile points differ in that the former are produced to obtain meat, while the primarily intent of the latter is to kill or wound enemies. As a result, different constraints exist for these two tasks. Hunting points were made to kill as rapidly as possible to avoid the effort of tracking the prey (*Loendorf* et al. *2015*). In contrast, warfare points were designed to maximize the probability that injury or death resulted, regardless how long this might take (*Loendorf* et al. *2015; Luik 2006*). Nevertheless, such classification of warfare and hunting weapons is subjective, and if necessary warfare arrowheads could be used in hunting and vice versa (*Loendorf* et al. *2015; Luik 2006*). According to these assumptions, the bone arrow points from Boyo Paso 2 were interpreted as weapons designed for using against people in warfare, although the most abundant tiny lithic arrowheads could have been used with the same purpose. The capacity of bone tips to pierce the rib cage, the addition of barbed tangs that resist removal from the wound, and a securely hafted fastening method, all mean that if the projectile enters the body of an enemy then it is unlikely to be easily withdrawn, with the point being attached to an arrow creating a more serious internal haemorrhaging (*Christenson 1997; Loendorf* et al. *2015; Luik 2006*). The recent discovery of Late

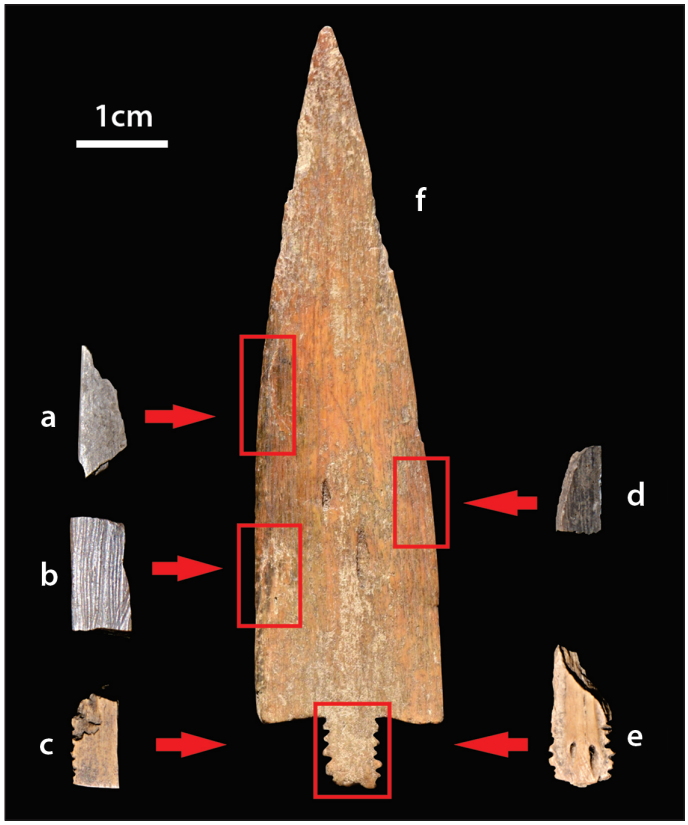


Fig. 2. Bone projectile points referred to in the text:* a, b *and* d *fragments of blades (BP2-29, BP2-56 and BP2-78, respectively);* c *and* e *fragments of stems (BP2-82 and BP2-81, respectively);* f *complete bone projectile point recovered at San Roque locality and housed in Museo Arqueológico Numba Charava (Villa Carlos Paz, Argentina).

Pre-Hispanic human skeletal remains with clear evidence of death caused by bone-tipped projectiles similar to the ones described here reinforce this functional hypothesis (*Fabra* et al. *2015; Pastor* et al. *2012*).

A notched bone tool was found on Boyo Paso 2 (BP2-58). The tool was manufactured on the posterior border of a *Lama* cf. *L. guanicoe* scapula, conserving the axillary border, the subscapular fossa and the posterior angle (Fig. 3.a). Fifteen closely spaced notches or denticulations were retouched on the infraspinatous fossa to create a serrated edge (Fig. 3.a). The notched use edge appears shiny to the naked eye. Starch grains recovered from the shiny area by sonication were identified as aff. *Oxalis* sp. tuber, although their taxonomic status as domestic or wild requires further investigation (*Medina* et al. *2018*). Based on this evidence, it is argued that the notched bone tool was used for peeling *Oxalis* sp. tubers, an activity with low archaeological visibility due to the poor preservation of underground plant organs.



Fig. 3. Different tool-types referred to in the text:* a *notched bone tool (BP2-58);* b *bone tool used for scraping hides in a transversal motion (BP2-79);* c *similar to BP2-79 nearly complete scraper recovered at Carrupachina (*Rivero *et al.* 2015*).

Most antler tines were tentatively identified as flakers. They have their natural tine tips presumably transformed into small, rounded surfaces, blunt and worn from use (Fig. 4.a). However, as it was mentioned above, such functions have not been verified so far through use-wear analysis and require further exploration. Fragments of blunt points made from elongated macrovertebrate long bone splinters slightly regularized were also identified as flakers (BP2-13, BP2-14 and BP2-45). They presented transversal and parallel striations on the apical end, inclusively visible under the naked eye, being short, deep and wide, similar to those observed in tools used as flakers (*D'errico* et al. *2012; Nami, Scheinsohn 1997; Borella, Buc 2009; Vitezović 2018*).

The greatest share of bone tools were connected to hide, leather or fibre processing. Presumably, the bone tool BP2-8, made from a macromammal rib, was used as a smoother for hides or similar, related activities (Fig. 4.b). The tool has been lightly shaped to blunt it into an pointed tip. The edges of the medial cortical side of the rib were scraped, exposing the spongy structure of bone for unknown function. Cortical bone at the very tip and around the edges was polished by use. Moreover, spongy bone is exposed and polished at and near the tip by use-wear. The anthropic modifications of the tip look like the result of abrasive pressure against a softer material, such a dry hide, with a repetition motion transverse to the active edge or longitudinally to the long axis of the bone. Rib smoothers are common in Late Pre-Hispanic contexts (*Medina* et al. *2014*) and are also related to pottery or basketry making (*Buc 2011; Medina* et al. *2014*). The small fragment of rib BP2-31 also has the edge of the cortical medial side scraped, but its fragmented characteristic impedes its secure classification as a rib smoother. Five fragments of macro mammal and Cervidae cf. *Ozotoceros* ribs with manufacturing traces can be linked to this type of tool or their manufacture by-products. On the other hand, the small fragments of long bone (BP2-6, BP2-48 and BP2-85) were identified as hide scrapers (*sensu Legrand, Sidera 2007*). They presented a flat side, bevelled and sharp-edged with polished spongy bone on the area affected by wearing and a set of parallel striations running longitudinally to the edge (Fig. 4.c). Something similar occurred with BP2-32 which, despite its small size and frag-

mented character, has a bevelled and polished by use edge. All these characteristics are consistent with their use against softer material such as a hide, producing a smoothly shifting pressure over a small area to result in a more impermeable and lustrous hide (*D'Errico* et al. *2012; Mozota Holgueras 2007; Soressi* et al. *2013; Vitezović 2011*). Finally, the long edge of a lengthwise split long bone of a large-medium size mammal (BP2-79) was classified as used for scraping or cleaning hides in a transversal motion (Fig. 3.b), as described by Heidi Luik and Giedrė Piličiauskienė (*2016*) for seal bone scrapers. As a result of this activity, the long edge of the diaphysis and trabecular bone of the epiphysis were polished and look shiny to the naked eye (Fig. 3.b). Similar tool-type scrapers were also common in the Late Pre-Hispanic context of the Carrupachina site (Fig. 3.c; *Rivero* et al. *2015*).

An awl and pin-like tools were probably multi-use items (*sensu Gates-St. Pierre 2006*), *e.g.*, for hide-working, corn husking and basketry making. In general terms, pointed tools were poorly standardized. They were not only made of long bones, and simple, opportunistically chosen ad hoc points with sharp tips were used with minimal modification as pointed tools, as exemplified by a sharp point tip fashioned on a camelid malleolus (BP2-54; Fig. 4.g). BP2-3, BP2-55 and BP2-80 are small indeterminate artefact fragments that can be classified as pin-like tools by their circular and fine cross-sections, but their apical areas were broken to verify this assignation. The sharp characteristics of the apical areas of BP2-19 (Fig. 4.f), BP2-20 (Fig. 4.e) and BP2-54 (Fig. 4.g), suggest drilling activities in soft materials such as hides or for making mats, nets and baskets, perishable tools crucial to many subsistence activities that are rarely preserved in today's archaeological record but comprise up to 95% of the material culture in ethnographically documented groups (*Stone 2011*). Ethnographic analogy is consistent with this functional assignation (*Moore 1999; Stone 2011*). The evidence of plant-based technologies impressed on the clay of Late Pre-Hispanic vessels reinforces these arguments. Moreover, the use of pointed tools to peel the husk of corn cob needs to be considered in horticultural groups, but this is never easy be recognize and only use-wear analysis can allow a valid identification of this activity (*Gates-St. Pierre 2006*).

There are few artefacts in Boyo Paso 2 that can be connected to cults, rituals or religions rather than a technological function. The most spectacular finding of this type is a fragment of pin-shaped subtype spatula (*sensu Pastor, Moschettoni 2018*) with decorative lateral fins (presumably shaped like animals). It is made of a long bone that is finely polished, smoothed and has incised decoration, mainly circles, triangles and dots, made in a positive relief (Fig. 5.a). Small fragments of artefacts with a dot-and-circle pattern (BP2-25, BP2-26, BP2-27 and BP2-28) and three distal ends of spatulas without incised decoration (BP2-18, BP2-42 and BP2-86) were assigned to the same ritual object, even when it is not clear if most of them were really spatulas, ornaments or other small personal objects related to clothing (Fig. 6). A few such decorated spatulas were also found at Sierras of Córdoba, but they are common at several sites in Norte Chico of Chile with similar chronologies, where they were imitated according to Pastor and Moschettoni (*2018*). They related pin-shaped subtype spatulas to the inhalant paraphernalia used in the consumption of hallucinogen substances such as cebil (*Anadenanthera colubrina*), and they are thought to have had important ritual functions. Tubes for *A. colubrina* consumption were not found,

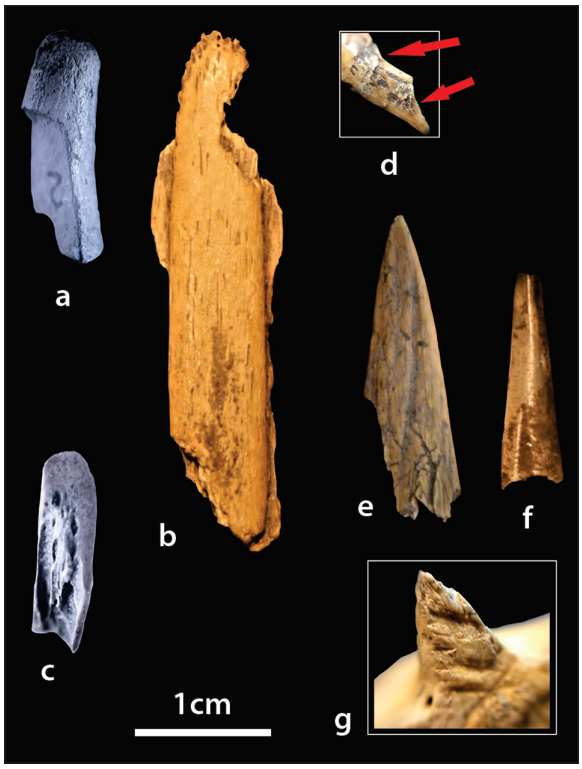


Fig. 4. Different tool-types referred to in the text:* a *antler tine tentatively identified as a flaker (BP2-2);* b *smoother made from a macromammal rib (BP2-8);* c *hide scraper (BP2-48);* d *Cathartidae cf.* Cathartes-Coragyps *distal radius splinter (BP2-70) with arrows showing the mastic residues;* e *pin-like tool (BP2-20);* f *pin-like tool (BP2-19);* g *awl (BP2-54).

but the by-products of its manufacture using Cathartidae long bones were recorded at Boyo Paso 2. The possible meaning of these tools in term of Pre-Hispanic networks and the significance of hallucinogens in the pre-Hispanic cultures and religions of the southern cone of South America have recently been discussed in several publications (*Berenguer, Acevedo 2015; Horta 2012; Horta* et al. *2019; Pastor, Moschettoni 2018; Perez Gollán 1994; Sprovieri 2008–2009*).

A high number of worked or shaped pieces (n=51) were too fragmentary to permit any useful speculation as to the function of the tool, or even the orientation of the working edge. These pieces were classified as indeterminate artefacts. The category includes an unciform of *Lama* cf. *L. guanicoe* (BP2-11) and a cervical vertebrae of a deer (BP2-12) that presented abraded surfaces, but with an unknown function. It also includes a Cathartidae cf. *Cathartes-Coragyps* distal radius splinter with mastic residues (BP2-70; Fig. 4.d).

Bone working method

The presence of unfinished items and waste by-products suggests that at least a portion of the bone tools were manufactured on-site. The techniques used to manufacture bone tools at Boyo Paso 2 were simple and have much in common with those practiced through prehistory (*Álvarez 2014; del Papa* et al. *2019; Legrand 2007; Vitezović, Bulatović 2013*). One method used for splitting bones was grooving, where a transversal or longitudinal groove was cut into the diaphysis of long bone with a flint tool and then the bone was split to obtain a blank or a tube. As a result, a groove incised into the bone is visible at some split bones. The technique is exemplified by a proximal humerus of Cathartidae cf. *Cathartes-Coragyps* (BP2-1), a proximal metatarsal of *Lama* cf. *L. guanicoe* (BP2-49) and a proximal rib of Cervidae cf. *Ozotoceros* (BP2-5) with cut-and-break marks around the circumference of the diaphysis. More examples are available in Table 3 (see Appendix) and Figure 7, including a Cathartidae cf. *Vultur* proximal radius (BP2-83). Fracturing bone was also frequently used to produce blanks or preforms, *e.g.*, breaking by direct percussion. Moreover, some pieces could have been produced during cracking of bone to release marrow and not specifically for tool manufacturing.

After the blank was obtained, several bone working methods were observed. Many pieces have been so modified in finishing and use – *i.e.* projectile points – that the initial shaping trace has not been observed. Most common, though, was shaping by grinding against an abrasive surface, perhaps a ground stone, a common item found in Boyo Paso 2 layers (*Medina* et al. *2020*). Pieces were treated in this way to produce a uniform, smooth result. Conversely, many bone tools were identified by the traces of wear on a broken or natural surface, not by any deliberated shaping or cutting. Pointed tools show longitudinal coarse striations interpreted as manufacture traces made with abrasive coarse-grained material (Fig. 4.e). The pin-like tool BP2-19 suggests that the surface was more finally abraded (Fig. 4.f), whereas the awl BP2-54 shows manufacture traces as a scraped surface (Fig. 4.g). The fragments of bone projectile points presented longitudinal and oblique coarse striations suggesting that they were shaped by a combination of scraping and abrasion with a coarse-grain material. Blades were more finely abraded to increase the drag coefficient, reduce resistance and secure deeper penetration of the rib cage of the tar-

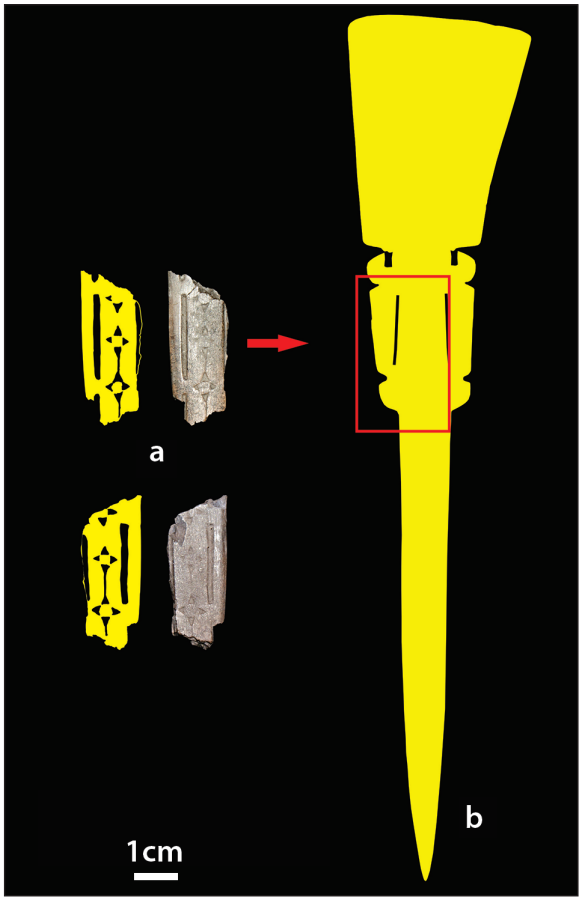


Fig. 5. Pin-shaped subtype spatulas referred to in the text:* a *and* b *fragment of pin-shaped subtype spatula recovered at Boyo Paso 2 (BP2-24);* c *outline of pin-shaped subtype spatula from the Norte Chico of Chile (modelled from* Pastor, Moschettoni 2018*).

get (Fig. 2.a,d). In decorated artefacts, a flint tool was used for carved circle, triangle and dot decorations and the surfaces were finely polished (Figs. 5 and 6). About 41 of the bone tools showed some sign of burning or heat treatment related to manufacturing or use, mostly when burning hardened the bone altering the crystal structures of the bone mineral (*Camps Fabrer 1967; Moore 1999; Vitezović 2018*). Burning also affected decorated tools (Figs. 5 and 6). It is thus open to question whether exposing the bone to fire was a deliberated practice, either to alter the appearance or working properties, or to finish its working life by discarding it in domestic fires. Burning damage could also be a response to accidental burning during the multiple occupation events that affected the deposit (see *Medina* et al. *2019*).

Discusion and conclusion

The bone tools of Boyo Paso 2 can be broadly divided into the group of artefacts made of suitable bone fragments – thus representing barely worked objects – and the group of artefacts skilfully or finally manufactured (*Choyke 1997*). The majority of bone tools belong to the first group, where the natural shape of bone or bone fragment has been exploited for making bone artefacts (pin-like tools, smoothers, notched bone tools, *etc.*). This tool-kit reflects that bone technology was related to short-term and low-risk activities (*Nelson 1991; Torrence 1983*), showing low-energy investment in manufacture and simple designs, without any features of curated technology. The raw materials for making bone tools were obtained from the by-product of faunal consumption and fashioned into tools by basic manufacture techniques such as cutting, fracturing and scraping. Moreover, the variability of pointed tools suggests that they were versatile tools that could perform different tasks with minimal labour investment (*Nelson 1991*). It seems likely that production took place in the household according to personal or domestic needs.

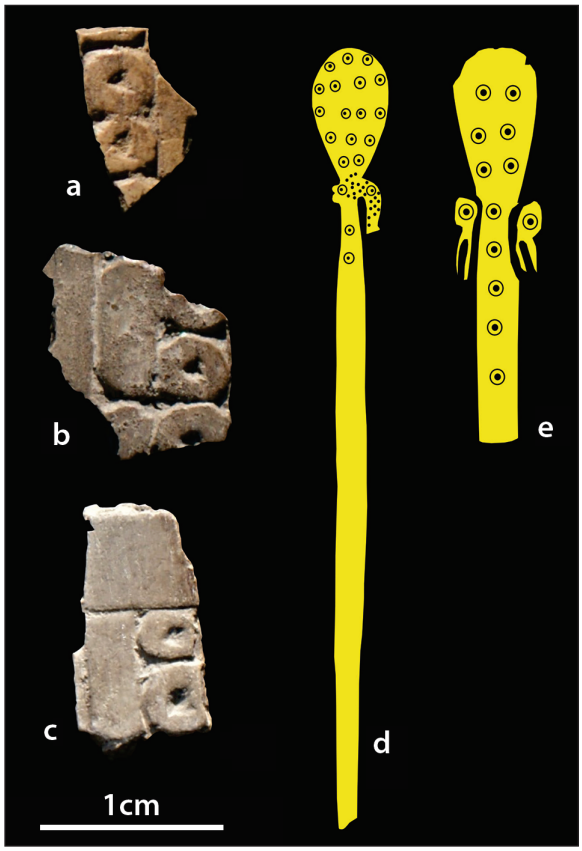


Fig. 6. Artefacts with dot-and-circle pattern referred to in the text:* a *BP2-26;* b *BP2-28;* c *BP2-25;* d *and* e *pin-shaped subtype spatulas from Caldera (Norte Chico, Chile) and Abaucán (Catamarca, Argentina) taken from Pastor and Moschettoni (*2018*).

Conversely, bone arrowheads and spatulas are outstanding among the Late Pre-Hispanic bone tools for their careful finishing, high energy investment and standardization, reflecting the importance of the task they were used for in the society as a whole. Pin-shaped subtype spatulas are particularly meticulously made, with very high skill, time and labour investment. They were produced through several stages of abrasion, cutting, carving, scraping and polishing. Even though they were probably used for special occasions, in Boyo Paso 2 they were found on living floors and in a semi-subterranean feature that looks likely to have been used for multiple functions, including trash disposal. Something similar occurs with projectile points: hours of work were needed to fashion one projectile point. In earlier archaic occupations, no similarly finished artefact types were formed (see *Rivero 2009*). Thus, these are culturally and chronologically specific artefacts. This means that arrow points and decorated spatulas were new types introduced to deal with the socioeconomic changes that occurred when crop plant cultivation was adopted *c.* 1500 years BP. They thus shed light on a time of high social dynamism during the Late Pre-Hispanic Period, which involved the intensification of social relations through prestigious technologies and inter-personal violence.

Some degree of standardization in the choice of raw materials is characteristic of the bone tools from the Late Pre-Hispanic. The long bones of macro vertebrates, probably *Lama* cf. *L. guanicoe* and deer, were used more often. Camelids and cervids were gene-

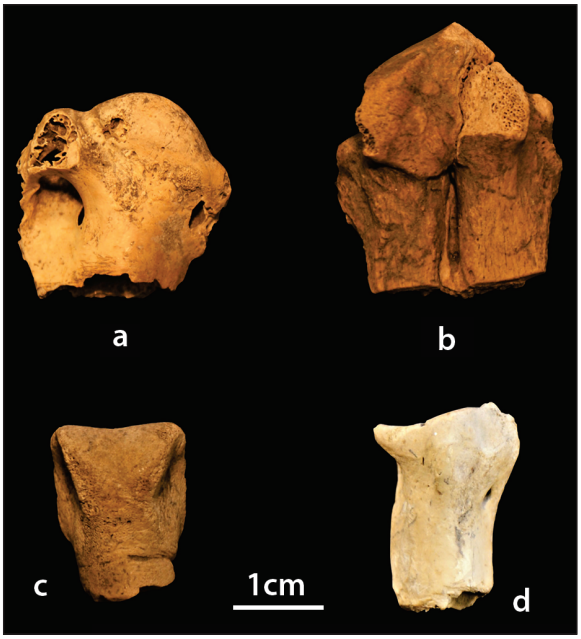


Fig. 7. Examples of waste by-products recovered at Boyo Paso 2:* a *proximal humerus of Cathartidae cf.* Cathartes-Coragyps *(BP2-1);* b *proximal metatarsal of* Lama *cf.* L. guanicoe *(BP2-49);* c *distal first phalanx of* Lama *cf.* L. guanicoe *(BP2-22);* d *Cathartidae cf.* Vultur *proximal radio (BP2-83).

rally the animals that were mostly hunted at Boyo Paso 2 (see *Medina* et al. *2019*), indicating that the acquisition of bone was embedded within subsistence activities. In other words, the prevalence of wild ungulate species in the raw material choices certainly points to cultural attitudes to hunting prey, which were included in all segment of life and in diverse aspects of consumption.

The study of the worked-bone assemblage of Boyo Paso 2 provides several insights regarding the daily use of bone tools by people with a mixed foraging and cultivation economy. The diversity of bone tools suggests that multiple activities were carried out at Boyo Paso 2, mainly related to hunting or warfare, food processing, hide-working, net or basketry-making, ritual activities, and lithic tool production. Bone arrow points were used for defence or attack, but also occasionally for hunting ungulate prey. The adoption of an effective weapon for individual defence probably increased the political self-sufficiency of families and encouraged the development of a more independent family-based political system, as the described by early colonial records (*Gonzalez Navarro 2009*). Pointed tool types were used in basketry or drilling activities when working with soft organic materials such as skins, whereas the smoother and scraper were used to smooth animal hides, technologies associated with the labour of woman that are frequently invisible in the archaeological record (*Stone 2011*). The notched bone tool was used for peeling *Oxalis* sp. tubers, highlighting the role of tubers, whether wild or domestic, in the daily seasonal life. Similar notched bone tools only occurred in Late Pre-Hispanic sites, suggesting that the adoption of a broad-scale foraging and cultivation base was accompanied by the development of new types of bone tool for processing the plant foods that were now included into subsistence. On the other hand, blunt points presented traces that were compatible with lithic flakers, reinforcing the hypothesis of Imanol Balena and Matías E. Medina (*2020*) that the manufacture and maintenance of lithic artefacts for hunting or food processing were common activities at Boyo Paso 2. Artefacts connected with cults, religions or expressing social identities are also represented among the bone objects from Boyo Paso 2, probably imitating foreign bone tool objects (*Pastor, Moschettoni 2018*). These objects comprised decorated incised pin-shaped subtype spatulas used in ritual paraphernalia along the southern cone of South America, and/or small fragments of probable ornaments related to clothing. It is particularly interesting that these tools and decoration patterns show an important South-Central Andean influence, although (and again) in a somewhat modified way, reflecting the wide distribution of ideologies or symbolic meanings across regions and the existence of social ranks whose status requirements these artefacts met. Residues of vulture and condor bones resulting from the manufacture of bird bone tubes, artefacts commonly used for the consumption of hallucinogens (*Horta-Tricallotis* et al. *2019*) or ritual paraphernalia (*Potter 1997*), may be conceived in the same way, even when such tubes have not been found yet at Boyo Paso 2. It is thus concluded that the analysis of bone technology makes it possible to explore a component of the subsistence and material culture that has to date been neglected, directly or indirectly, by its low visibility in the record. As a result, bone tools may enable reconstruction not only of the methods of subsistence, but also of technological levels, social organization, and cultural attitudes towards the environment.

While the analysis presented here must be considered a starting point toward resolving more complex problems that await further formal functional research, this should not be an impediment to communicating the results to the archaeological community interested in how neither wholly foragers nor wholly farmers dealt with technological prob-

lems using bone as a raw material. At the very least it contributes with a set of first conclusions, mostly to be viewed as hypotheses until use-wear studies have been established, providing data to improve the knowledge of the material culture associated with mixed foraging and cultivation economies, a category for which archaeology currently lacks sufficient archaeological understanding and which thus merits further research.

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Appendix

Tab. 3. Catalogue of the bone tools from Boyo Paso 2.

Bone tool (No.)	Tool type	Context	Max. width (mm)	Max. thick (mm)	Skeletal element	Taxa	Description	Cross-section
BP2-1	waste by-product	Upper floor	33.3	14.2	Proximal humerus	Cathartidae cf. *Cathartes-Coragyps*	End with cut-and-break marks around the circumference of the proximal diaphysis.	
BP2-2	flaker?	Upper floor	13.1	4.5	antler	Cervidae cf. *O. bezoarticus*	Burned tine with the natural tine tip presumably transformed into small. rounded surface, blunt and worn from use.	circular
BP2-3	indeterminate artefact	Upper floor	13.4	3.5	long bone splinter	Macrovertebrate indet	Burned fragment with manufacture traces.	circular
BP2-4	Indeterminate artefact	Upper floor	12.8	1.4	long bone splinter	Macrovertebrate indet.	Burned fragment with manufacture traces.	biplane
BP2-5	waste by-product	Upper floor	15.5	6.5	proximal rib	Cervidae cf. *O. bezoarticus*	Burned fragment of a long-bone cylinder with cut-and-break marks around or near the neck.	
BP2-6	scraper	Lower floor	20	4.5	long bone splinter	Mammalia indet. (medium-large size)	Fragment with a flat-side, beveled, sharp-edged with polished spongy bone on the area affected by wearing and a set of parallel striations running longitudinally to the edge.	
BP2-7	waste by-product	Upper floor	19.1	5.7	long bone	Mammalia indet. (medium-large size)	Burned fragment with cut-and-break and manufacture traces.	plane-convex
BP2-8	smoother	Test-pit 3	38.3	10	rib	Mammalia indet. (medium-large size)	Fragment with an ojival-shaped tip and with the edges of the medial cortical face of the rib scraped. The tip and around the edges were polished by use.	biplane
BP2-9	flaker?	Upper floor	46.9	9.4	antler	Cervidae cf. *O. bezoarticus*	Longitudinal fragment of a tine with the natural tine tip presumably transformed into small, rounded surface, blunt and worn from use.	
BP2-10	flaker?	Upper floor	14	4.5	antler	Cervidae	Longitudinal fragment of a tine with the natural tine tip presumably transformed into small, rounded surface, blunt and worn from use.	
BP2-11	indeterminate artefact	Upper floor	22.5	11.6	unciform	*Lama* sp.	Bone with manufacture or wear traces on one surface.	
BP2-12	indeterminate artefact	Feature of upper floor	19.2	7	cervical	Cervidae	Burned fragment with manufacture or wear traces.	
BP2-13	flaker	Upper floor	18.6	2.2	long bone splinter	Macrovertebrate indet.	Burned fragment of a blunt point with manufacture and wear traces on active end.	
BP2-14	flaker	Upper floor	20.7	4.2	long bone splinter	Macrovertebrate indet.	Burned fragment of a blunt point with manufacture and wear traces on active end.	
BP2-15	indeterminate artefact	Upper floor	10.7	1.8	long bone splinter	Vertebrate indet.	Burned fragment with manufacture trace.	
BP2-16	″	Upper floor	10.8	1.9	long bone splinter	Mammalia indet.	Burned fragment with manufacture traces.	
BP2-17	″	Upper floor	17.6	3	long bone splinter	Macrovertebrate indet.	Fragment with oblique manufacture traces.	

BP2-18	spatula	Upper floor	20.4	2.3	long bone splinter	Macrovertebrate indet.	Burned distal-lateral active end fragment with polished surface.	biplane
BP2-19	Pin-like tool	Test-pit 4	16	2.8	long bone splinter	Macrovertebrate indet.	Burned fragment of tip with use-wear traces.	circular
BP2-20	Pin-like tool	Test-pit 4	23	1.5	long bone splinter	Vertebrate indet.	Fragment of tip with manufacture and use-wear traces.	plane-concave
BP2-21	indeterminate artefact	Test-pit 3	8.8	3	long bone splinter	Macrovertebrate indet.	Burned fragment with manufacture traces.	
BP2-22	waste by-product	Test-pit 3	19.2	13.3	distal first phalanx	*Lama* sp.	End with cut-and-break marks around the circumference of the distal diaphysis.	
BP2-23	indeterminate artefact	Test-pit 3	75.5	6.5	radius-ulna	*Lama* sp.	Diaphysis splinter with manufacture traces.	
BP2-24	pin-shaped subtype spatula	Feature of upper floor	35.3	3.9	long bone splinter	Macrovertebrate indet.	Burned fragment finely polished with decorative lateral fins (presumably shaped like animals) and incised decoration, mainly circles, triangles and dots made on a positive relief.	biplane
BP2-25	pin-shaped subtype spatula?	Test-pit 3	14.3	1.8	long bone splinter	Mammalia indet. (medium-large size)	Burned fragment with incised decoration, mainly circles and dots made on a positive relief.	
BP2-26	″	Upper floor	10.5	1.6	long bone splinter	Mammalia indet. (medium-large size)	Fragment with incised decoration, mainly circles and dots made on a positive relief.	
BP2-27	″	Upper floor	13.4	2	long bone splinter	Mammalia indet.	Fragment with incised decoration, mainly circles and dots made. on a positive relief.	
BP2-28	″	Upper floor	14.2	1.9	long bone splinter	Mammalia indet. (medium-large size)	Burned fragment with incised decoration, mainly circles and dots made on a positive relief.	
BP2-29	projectile point	Feature of the upper floor	15	1.5	long bone splinter	Macrovertebrate indet.	Burned fragment of the edge of the blade with manufacture traces.	plane-concave
BP2-30	indeterminate artefact	Feature of the upper floor	19.4	1.9	long bone splinter	Mammalia indet. (medium-large size)	Burned fragment with manufacture traces.	
BP2-31	indeterminate artefact	Feature of the upper floor	28.1	2.7	rib	Mammalia indet. (medium-large size)	Fragment with manufacture and use-wear traces.	
BP2-32	scraper	Upper floor	12.1	2.5	long bone splinter	Vertebrate indet.	Fragment with a beveled and polished by use edge.	plane-concave
BP2-33	indeterminate artefact	Upper floor	9	2.3	long bone splinter	Mammalia indet.	Burned fragment with manufacture and use-wear traces.	biplane
BP2-34	″	Upper floor	7.3	4	axial bone	Mammalia indet.	Fragment with manufacture and use-wear traces.	
BP2-35	″	Upper floor	13.2	2.1	long bone splinter	Mammalia indet	Burned fragment with manufacture and use-wear traces.	
BP2-36	″	Lower floor	18.2	3.3	long bone splinter	Macrovertebrate indet.	Fragment with manufacture traces.	biplane
BP2-37	flaker?	Feature of the upper floor	34.3	10	antler	Cervidae cf. *O. bezoarticus*	Fragment of a tine with the natural tine tip presumably transformed into small, rounded surface, blunt and worn from use.	
BP2-38	indeterminate artefact	Feature of the upper floor	14.3	1.1	long bone splinter	Vertebrate indet.	Fragment with manufacture traces.	
BP2-39	″	Upper floor	17.7	2.9	long bone splinter	Macrovertebrate indet.	Burned fragment with oblique manufacture traces.	biplane

Bone tool (No.)	Tool type	Context	Max. width (mm)	Max. thick (mm)	Skeletal element	Taxa	Description	Cross-section
BP2-40	indeterminate artefact	Upper floor	12.6	3.7	long bone splinter	Macrovertebrate indet.	Burned fragment with manufacture traces.	plane-concave
BP2-41	indeterminate artefact	Upper floor	84.2	4.5	rib	Cervidae cf. *O. bezoarticus*	Fragment with manufacture traces.	
BP2-42	indeterminate artefact	Upper floor	14.4	3.1	long bone splinter	Mammalia indet. (medium-large size)	Fragment with manufacture and use-wear traces.	
BP2-43	spatula	Upper floor	16.4	2.3	long bone splinter	Macrovertebrate indet.	Fragment of a distal active end with manufacture traces.	plane-concave
BP2-44	indeterminate artefact	Upper floor	13.4	1.7	long bone splinter	Mammalia indet.	Fragment with manufacture traces.	
BP2-45	flaker	Upper floor	18.7	4	long bone splinter	Macrovertebrate indet.	Fragment of a blunt tip with manufacture and use-wear traces.	
BP2-46	indeterminate artefact	Upper floor	9.6	3.9	long bone splinter	Macrovertebrate indet.	Fragment with manufacture traces.	plane-convex
BP2-47	indeterminate artefact	Feature of the upper floor	20	1.4	long bone splinter	Vertebrate indet.	Fragment with manufacture and use-wear traces.	
BP2-48	scraper	Upper floor	14.5	5.4	long bone splinter	Mamifero indet.	Fragment with a flat-side, beveled, sharp-edged with polished spongy bone on the area affected by wearing and a set of parallel striations running longitudinally to the edge.	convex-concave
BP2-49	waste by-product	Upper floor	28.9	24.6	proximal metatarsal	*Lama* sp.	Longitudinal fragment of a proximal end and diaphysis (caudal side) with longitudinal-transverse grooves and manufacture traces.	
BP2-50	indeterminate artefact	Upper floor	11.6	1.6	long bone splinter	Vertebrate indet.	Burned fragment with manufacture traces.	
BP2-51	waste by-product	Upper floor	41.5	14.8	First phalanx	*Lama* sp.	Nearly complete diaphysis with cut-and-break marks around the circumference of the distal epiphysis.	
BP2-52	indeterminate artefact	Feature of the upper floor	28.4	3	long bone splinter	Macrovertebrate indet.	Fragment with manufacture traces.	
BP2-53	indeterminate artefact	Feature of the upper floor	9	4.2	long bone splinter	Macrovertebrate indet.	Burned fragment with rounded contour and polished surfaces.	biplane
BP2-54	awl	Upper floor	24.6	13	malleolus	*Lama* sp.	Fragment with manufacture traces (scraped marks).	
BP2-55	indeterminate artefact	Upper floor	13	4.7	long bone splinter	Macrovertebrate indet	Burned fragment with manufacture traces.	plane-convex
BP2-56	projectile point	Upper floor	13	2.7	long bone splinter	Macrovertebrate indet.	Burned fragment of a blade with manufacture traces.	biplane
BP2-57	indeterminate artefact	Upper floor	12.2	3.7	long bone splinter	Macrovertebrate indet.	Burned fragment with oblique manufacture traces.	
BP2-58	notched bone tool	Upper floor	140.1	49.2	scapula	*Lama* cf. *L. Guanicoe*	Fragment of the posterior border with cut-marks and fifteen closely spaced notches incised on the infraspinatous fossa.	
BP2-59	indeterminate artefact	Upper floor	11.2	2.8	long bone splinter	Macrovertebrate indet.	Polished fragment with manufacture traces.	

BP2-60	indeterminate artefact	Upper floor	25.9	11.9	long bone splinter	Mammalia (medium-large size)	Polished fragment with manufacture traces.		
BP2-61	indeterminate artefact	Upper floor	16.3	11.3	long bone splinter	Mammalia indet. (medium-large size)	Polished fragment with manufacture traces.		biplane
BP2-62	"	Upper floor	22.2	10.5	hueso axial	"	Polished fragment with manufacture traces.		
BP2-63	indeterminate artefact	Upper floor	15.5	4.5	long bone splinter	Mammalia indet. (medium-large size)	Fragment with manufacture and use-wear traces.		plane-convex
BP2-64	"	Upper floor	6.1	1.5	long bone splinter	"	Burned fragment with manufacture traces.		biplane
BP2-65	"	Upper floor	5.3	1.1	long bone splinter	Vertebrate indet.	Burned fragment with manufacture traces.		
BP2-66	"	Test-pit 4	28.3	7.7	long bone splinter	Macrovertebrate indet.	Fragment with manufacture traces.		
BP2-67	"	Test-pit 4	19.5	4.8	long bone splinter	Macrovertebrate indet.	Fragment with manufacture and use-wear traces.		
BP2-68	"	Test-pit 4	8	1.8	long bone splinter	Mammalia indet.	Burned fragment with manufacture traces.		
BP2-69	"	Test-pit 4	17.3	6.4	long bone splinter	Mammalia indet.	Fragment with manufacture and use-wear traces.		
BP2-70	indeterminate artefact (mastic)	Upper floor	23.8	6	Distal radius	Cathartidae cf. Cathartes-Coragyps	Diaphysis splinter with mastic residues.		
BP2-71	indeterminate artefact	Upper floor	22.4	11.8	Apendicular bone	Mammalia indet. (medium-large size)	Fragment with manufacture traces.		
BP2-72	indeterminate artefact	Test-pit 3	18.2	9.3	long bone splinter	Macrovertebrate indet.	Burned fragment of a blunt tip with oblique manufacture traces and shiny surface.		
BP2-73	"	Upper floor	16	4.3	long bone splinter	Mammalia indet.	Fragment with manufacture and use-wear traces.		
BP2-74	"	Upper floor	29.8	19.6	metacarpal	*Lama* sp.	Burned longitudinal end fragment with manufacture traces.		
BP2-75	indeterminate artefact	Upper floor	9	3	long bone splinter	Mammalia indet. (medium-large size)	Fragment with transversal grooves and manufacture traces.		biplane
BP2-76	"	Upper floor	14.4	2	long bone splinter	Mammalia indet.	Fragment with manufacture and use-wear traces on the spongy bone.		
BP2-77	"	Upper floor	9	1.9	long bone splinter	Vertebrate indet.	Burned fragment with manufacture traces.		
BP2-78	projectile point	Upper floor	9.9	2.6	long bone splinter	Macrovertebrate indet.	Burned mesial-lateral fragment of the blade with manufacture traces.		
BP2-79	scraper	Upper floor	42.6	15	long bone	Mammalia indet. (medium-large size)	Burned fragment with use-wear traces along the edge of the diaphysis and trabecular bone.		
BP2-80	indeterminate artefact	Upper floor	11	5.2	long bone splinter	Macrovertebrate indet.	Burned fragment with manufacture traces.		circular
BP2-81	projectile point	Lower floor	11.4	2.1	long bone splinter	Macrovertebrate indet.	Fragment of a straight stem with a serrated edge.		
BP2-82	projectile point	Upper floor	15.8	2.3	metapodium	Cetartiodactyla cf. Camelidae-Cervidae	Fragment of a straight stem with a serrated edge and manufacture traces.		
BP2-83	waste by-product	Upper floor	24.3	15.4	Proximal radius	Cathartidae cf. *Vultur*	End with cut-and-break marks around the circumference of the proximal diaphysis.		
BP2-84	indeterminate artefact	Upper floor	33.8	4	long bone splinter	Macrovertebrate indet.	Burned fragment with manufacture traces.		
BP2-85	scraper	Upper floor	13.4	1.7	long bone splinter	Mammalia indet.	Burned fragment with a slightly beveled edge affected by wearing.		
BP2-86	spatula	Lower floor	60	3.7	long bone splinter	Macrovertebrate indet.	Distal active end fragment with manufacture and use-wear traces.		
BP2-87	indeterminate artefact	Upper floor	23	5	long bone splinter	Macrovertebrate indet.	Burned fragment with manufacture traces.		

The archaeology of garlic (*Allium sativum*): the find at Akrotiri, Thera, Greece

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ABSTRACT – *Recent finds of garlic from Late Bronze Age Akrotiri, Thera have led to research related to the historical, economic and social aspects of its use in the archaeological narrative. Garlic is an important domesticated plant in our lore, medicine, mythology, cooking, and ethnography, and is now ubiquitous in everyday use. Previously, we knew of its importance in historical periods, especially since Roman times, when its use extended to all of Europe and beyond. Archaeobotanical investigations have extended the prehistoric and historical knowledge of this crop, providing some evidence as to how it was regarded, what were its possible uses and its changing status, diachronically. Here, therefore, it is an attempt to provide an overview of the related archaeological finds and, briefly, its references in ancient texts.*

KEY WORDS – *garlic;* Allium sativum*; onion;* Allium cepa*; Akrotiri; Thera; Aegean; prehistory*

*Arheologija česna (*Allium sativum*): najdbe iz Akrotirija, Thera, Grčija*

IZVLEČEK – *Nedavna odkritja česna na pozno bronastodobnem naselju Akrotiri na otoku Thera so privedla do raziskav, ki so povezana z zgodovinskimi, gospodarskimi in družbenimi vidiki njegove uporabe v okviru arheološke pripovedi. Česen, ki je dandanes vseprisoten v vsakdanji rabi, je pomembna kultivirana rastlina v našem izročilu, zdravilstvu, mitologiji, kuhinji in etnografiji. Pomen česna v zgodovinskih obdobjih že poznamo, predvsem od rimskega obdobja naprej, ko se je njegova uporaba razširila po vsej Evropi in širše. Arheobotanične raziskave so diahronično razširile naše poznavanje tega pridelka v prazgodovinskih in zgodovinskih obdobjih, saj prinašajo dokaze o tem, kako so česen v preteklosti obravnavali, na kakšne načine so ga uporabljali in kako se je njegova vloga spreminjala skozi čas. V članku ponujamo pregled s tem povezanih arheoloških najdb, pa tudi krajši pregled referenc iz starodavnih besedil.*

KLJUČNE BESEDE – *česen;* Allium sativum*; čebula;* Allium cepa*; Akrotiri; Thera; Egejski prostor; prazgodovina*

Origins and domestication

Garlic (*Allium sativum*) is a sterile and perennial plant. It is propagated through a vegetative method. The wild ancestry of garlic has not been definitely established yet, and nor has its place of domestication (*Fritsch, Friesen 2002. 26; Zohary, Hopf, Weiss 2012*). Daniel Zohary (*1998*) believes that garlic is a native crop of Southwest Asia, the Mediterranean and temperate Europe, but does not explain if its use of 'native' is equal to 'naturalised', and this remains a bone of contention for some. However it seems that this possible distribution agrees with Reinhard M. Fritsch and Nikolai Friesen (*2002*). The cultivars are believed to be the closest morphologically and molecularly to *A. longicuspis* Regel[1] (*Stearn*

1 *A. longicuspis* Regel is sometimes used as a synonym of *Allium sativum*.

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1978; Gi-An Lee et al. *2015*). Recent studies on DNA markers demonstrated that *A. longicuspis* Regel is not a distinct species from common garlic (*Ipek* et al. *2003*). It therefore makes sense that it is sometimes used as a synonym of *A. sativum* (The Plant List (Kew): http://www.theplantlist.org/tpl1.1/record/kew-295919). *A. longicuspis* Regel is found in east Turkey, Iran and Central Asia (one could call this area central to south and east Asia, which today also includes Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, Uzbekistan), which together seem to be the main centre of garlic diversity and most probably the area of its domestication. Another three species, *A. tuncelianum* (Kollmann) (native to south-east Turkey) (*Ipek* et al. *2008*), *A. macrochaetum* Boiss. & Hauskn. (native to south-west Asia) (*Zohary* et al. *2012.157*), and *A. truncatum* (Feinbr.) Kollman and Zohary (native to the Levant) have been suggested as possible candidates of being the ancestor of domesticated garlic, but this remains an unproven hypothesis.[2] All four smell, though, like domesticated garlic, and it remains to be proven if, in antiquity, these might have been used instead of cultivated garlic.

Agriculture of garlic

Garlic is now harvested from March to April, and historically *Alliaceae* were generally cultivated in gardens denoted by a special word in Sumerian which referred to 'garlic place' (*Stol 1987.65*). The harvested crop was measured in dry measure. For the onion *Allium cepa L.*, it is known that a 'container of onions' had a capacity of 5–40 litres, and they could have been counted using any of the related measuring units, such as container, sack, bundle or even by volume, but they were never measured by weight (*Donbaz 1999.150*). This could well have been the way garlic was measured and sold, too. After harvest, the bulbs could have been packed in baskets or strung into strings or bundles. This bundling was done by women, as shown in an Ur III text. After harvest, one had to dry garlic and onions, and this was done outside or on a roof[3] (evidence from texts) (*Stol 1987.66*). Onions, it seems, were sometimes plaited.

The archaeobotanical evidence

The archaeobotanical evidence of garlic is very rare in archaeology, as the cloves and bulbs consist of soft parts which are not parched or force-dried in an oven before storage, and if thrown in the fire (hearth) would most probably burn completely, or transform into an amorphous mass, instead of being charred and preserved with a recognizable morphology, due to both the consistency and essential oils contained in garlic. Another reason for its rarity in the archaeobotanical evidence could also be related to the way garlic was consumed, *i.e.* as an additive in foods, either sliced or mashed, as well as due to its storage needs, which do not benefit archaeological preservation. Specifically, garlic cannot be stored in pottery for a long time as humidity rots it and, instead, needs to be hung in an airy and shady place, often outdoors.

Syro-Levantine area

Zohary *et al.* (*2012*) claim that the earliest archaeobotanical finds of garlic (*Allium sativum* L.) come from the 'Cave of the Treasure', Nahal Mishmar, near Ein Gedi in Israel and has been dated to the Middle Chalcolithic period (Ghassulian Culture) (BM-140, reed (inner) (4425–3920 BCE; W-1341, reed (outer) (3885–3490 BCE) (*Moorey 1988*). Garlic was said to be found in two samples and onions in three samples by David V. Zaitschek (*1961; 1962*), who studied the archaeobotanical remains and said that they belonged partly to the Chalcolithic and partly to the Roman period. Due to the dryness of the environment, these samples were excellently preserved in a desiccated form. However, the mat which wrapped the objects of the hoard together with the organic remains was ^{14}C dated, and it provided a date of *c.* 3500 BCE (*Aardsma 2001*), which would refer to the Chalcolithic of the Syro-Palestine area. In Peter Moorey's (*1988*) publication though, it is claimed that the mat was centuries old when it was deposited, so the dates for the garlic are definitely more recent than *c.* 3500 BCE. It would probably be worth submitting the garlic to AMS dating, since these figures remain controversial. However, the find of Nahal Mishmar is rather broadly contemporaneous to the Egyptian Pedynastic (see below), if not proven to be dated later.

In the Hellenistic period, in the area which is today Israel, in Cave V/49, the remains of two garlic heads and six single cloves (bulbils) were found. The head had a diameter of *c.* 1.6cm and it was still covered by its tunic (*Melamed 2002*). In the Roman period,

2 *Allium ursinum* does not exist in Greece or in several Mediterranean countries.

3 This would have been very important as the slightest humidity would have led to their rotting.

in the Cave of the Pool (*Zaitschek 1962*) a 'disc-like bulb-stem with rootlets of garlic (*Allium sativum*)' was also identified.

India

Anurudh K. Singh (*2017*) believes that garlic might have been introduced into India through the land route via exchange/trade between Mesopotamia, Egypt and India during the Mohenjo-Daro period (*c.* 3000 BCE). With regard to the Mature Harappan (2000–1700 BCE), remains of garlic (*Allium sativum*) were found at the sites of Balu, Haryana and Farmana (*Singh 2017; Pokharia, Srivastava 2013*). According to Singh (*2017.196*) the evidence suggests multiple introductions of garlic into India from the Middle East at different periods. Singh believes that garlic was perhaps reintroduced during the conquest of Alexander the Great, in the 4th century BCE (327–325 BCE). This is indicated by one of its Sanskrit names, Yavanpriya, which means 'likings of the Greeks' (Yavan is used for the Greeks). Kajale (*1994*) reports some cloves from Indo-Roman levels (50 BCE–200 AD) from the archaeological site of Adam, in the district of Nagpur, in the Maharashtra State. However, Singh (*2017*) believes that in the area of today's Pakistan there might have been another (secondary) centre of origin, with garlic domesticated independently by ancient Indian communities, but this still needs verification. In brief, then, garlic could have been introduced into India through trade with Mesopotamia and Egypt *c.* 3000 BCE, and reintroduced several times, so the picture remains, to a great extent, hypothetical and needs further collection of archaeobotanical data from sites in the area, and from various time periods, in order to clarify the various routes of introduction.

Babylon

In sample PR 5206 from Sippar-Amnanum (modern Tell ed Der) (19th–17th BCE) about 350 charred cloves were identified, among other plants, (*Van Zeist, Vynckier 1984.125–128, Fig. 2*), and they were considered rather small in size, *i.e.* length 1.47cm (1.0–1.9cm), and their width 0.67cm (0.5–1.0cm). They were found in sounding E, from the rooms of the archives which were destroyed by fire *c.* 1630 BCE. From Tell al Rimah (13th century BCE) there is a contract recording 84 litres of garlic (*Postgate 1987. 98*). Other Old Babylonian texts (*Andersson 2008*) (2000–1600 BCE) also mention a fairly large cultivation at Larsa of a '36 000m² garlic garden', and the collection of garlic for tax. It is also interesting that the Old Babylonian texts refer to a 'plait of onions or garlic' (*Kroonen 2012.293*). This string/plait seems to have been used as a standard measure for garlic and onions by the speakers of Akkadian (*Kroonen 2012.294*). However, it is known that onions, in several varieties, were widely consumed in the whole Near East (*Waetzoldt 1987; Donbaz 1999.149*) as early as the Ebla texts (*c.* 2600–2450 BCE).

Egypt

Garlic has been found in its wild state in Egypt and, therefore, believed to have been naturalized there (*Darby* et al. *1977.657*). Egypt also provides early evidence of this crop found by Petrie at Naqada (Neqada culture), whereby at this Chalcolithic, Predynastic period (*c.* 4400–3000 BCE), a clay model of garlic was found (*Darby et al 1977.Fig. 17.1*). A clay model was also found in the Predynastic cemetery of Al-Mahasna (*Darby* et al. *1977.660*), and at the cemetery of Umm el Qabb at Abydos (*Murray 2000*). These finds were made of white unbaked clay in the shape of cloved garlic bulbs. The presence of clay models of garlic, rather than the actual crop, must mean something, which will eventually need to be explained. Was garlic in those early times a rare and expensive commodity, and, moreover, one which encapsulated a ritual symbolism of protection and/or apotropaic against evil forces, and thus important for rituals? In the Harris papyrus there is also references to garlic (20th dynasty). Moreover, the find at Nahal Mishmar, Israel, is, rather broadly contemporaneous with the Egyptian Predynastic find, if not proven to be later.

To date desiccated garlic has only been found from the 18th dynasty and in later tombs. Tutankhamun's tomb (*c.* 1325 BCE) provided excellently preserved desiccated remains (*Vartavan 2002; Vartavan, Amóros 1997; Hepper 1990; Germer 1989*),[4] and at Amarna there are also remains from the 18th dynasty. The Ebers papyrus (1550 BCE) describes about 800 medical formulas, 22 of which mention garlic as being an effective remedy for a variety of ailments such as headaches, heart problems, worms, tumours and bites (*Block 1985*), to mention just a few of the plant's medicinal uses at this time. At the Serapeum of Saqqara, northwest of the Pyramid of

4 In the Cairo Museum no. Sp.2795 garlic buds were identified by Jane Renfrew (*Vartavan 2002.32*), and in the same institution no. 1580 garlic bulbs were identified (*Vartavan, Amóros 1997.41*).

Djoser (*c.* 1350 BCE), garlic was also found in the sacred underground temple (*Aboelsoud 2010*). The remains of desiccated garlic were also located in the New Kingdom (18th dynasty) at Deir el-Medineh (Kha's Tomb) (*Darby* et al. *1977.Fig. 17.2; Vartavan, Amóros 1997*).

From Saqqara, in the Hellenistic period (*c.* 400 BCE), a bundle of garlic is housed at Kew Gardens, London (pers. communication Mark Nesbitt – Kew cat. no. 26541; 26548; 26848 (bundle of garlic)). Large scale garlic cultivation during the Ptolemaic period was conducted in the Fayum (3rd century BCE) (*Crawford 1973*). Several sites from the Greco-Roman period have produced garlic, such as Hawara, Mons Claudianus, Berenike, and Abu Sha'ar, as well as Roman and Islamic Quseir al-Qadim and Qasr Ibrim (*Murray 2000*; for a list of finds see *Vartavan, Amóros 1997*).

The site of Ismant el-Kharab (Dakhleh Oasis), Egypt, was occupied from the 1st to the 4th centuries CE and has burials of the Ptolemaic period (Kellis I), so the settlement might have been in use then too. The finds from Kellis include garlic cloves (*Thanheisser* et al. *2002.304*).

Substantial data has been preserved regarding garlic-growing under the Ptolemies in Graeco-Roman times, due to the references made by Greek and Roman writers, such Athenaeus, Herodotus, Dioscourides, Theophrastus, Pliny, Columella, and Palladius, and also due to the many preserved Egyptian papyri. Dioscurides (1st century BCE) reports that Egyptian garlic was white and not split into cloves (*Crawford 1973.351*), although this trait was not depicted on the clay garlics of the Predynastic period (*c.* 4400–3000 BCE). In the area of the Fayum, the Ptolemies had done major works related to reclamation of land and agricultural innovation (*Crawford 1973.351*), and they wished to introduce new strains of garlic, namely garlic with cloves. However, this aspect is still disputed as the early garlic clay models, mentioned above, showed cloves. Could this indicate that the strain preserved in the historical period was different from the prehistoric strains? Theophrastus and Pliny (*Crawford 1973.355*) refer to garlic varieties in Egypt which had short growing periods, such as 60 days. Various ancient agricultural writers such as Theophrastus, Columella, Pliny and Palladius describe the process of garlic cultivation in detail (*O.c.*). At Oxyrhyncha, Egypt, in the 2nd century BCE the cultivation of garlic must have been highly organized and exceedingly profitable (*Crawford 1973.361*). It is believed that a high percentage of the population was involved in this production, and therefore one could claim an early form of mono-culture and crop specialization.

The time-table of garlic cultivation was variable. Some garlic was grown in the summer in small market gardens, not reached by the Nile flood, or in among vines (*Crawford 1973.355, note 2*). When garlic was grown on a large scale, the planting of the cloves was done in areas where the Nile flood receded. Garlic-growing on a sizeable scale seems to have been introduced in the 3rd century BCE. This was planted in late November, whereas elsewhere it could have been planted earlier, as mentioned above. Lease agreements give us insight of when it was harvested, which seems to have been in January. In a papyrus (*Crawford 1973.360*) the growers seem to harvest and dispose of the crop by the end of the first week in January, which indicates a very quick growing variety of garlic and perhaps an early sowing date. In a papyrus from Euempolos to Zenon, Tloic and Oasitic garlic is mentioned (*Crawford 1973.356*). What is interesting is the phrase "*I'll bind it according to type...*" which would perhaps be an indication of the manner it was transported, *i.e.* plaited but also according to variety/quality. Moreover, there is mention of the importation and acquisition of a 'Lycian variety'. In the same papyri Euempolos mentions people cultivating foreign strains of garlic, so we can be sure that there was a market in Alexandria and elsewhere for garlic, especially as garlic growing continued in the northeast Fayum into the Roman period. In the Oxyrhyncha papyrus, second century BCE, there were two specialist garlic-sellers, so we are sure there was a special emphasis on the crop and that probably a sizeable number of people must have been engaged in the production and distribution of garlic. At Kerkeosiris (town) (111–110 BCE) 0.3% of the cultivated land was used for garlic for domestic use (*Crawford 1973.360*). Jobs related to garlic were specialized, such as garlic-sellers, or skordopoles (σκορδοπωλαι), and workers in the garlic fields were *skordeutes* (σκορδευται).

Anatolia

At Sardis (mid-6th BCE) (*Nesbitt 1995*) a group of cloves was found at the base of a wall which could have fallen from above (a shelf?). The Iron Age material was not been published but has been passed on to Erica Rowan for completion, at the Royal Holloway (Nesbitt pers. comm.). In Turkey, garlic does not seem to be found from other sites until around the 1st century BCE.

Northern Europe and finds in the Roman Empire

In the Roman period garlic must have spread to northern Europe, firstly in military camps, and then to other civilian sites (*Bakels, Jacomet 2003*) as the Roman armies travelled and traded with the lands north and west of Italy. It might have been used as a luxury, at first, but lost its status once it was cultivated locally (*O.c. 554*). From the 400 sites examined, only in under 10 sites was garlic found, which convinced the authors to conclude that this low number was due to the plant's bad preservation rather than to the rarity of its use. Manfred Rösch (*2008*) claims that several cultivated *Allium* species were introduced by the Romans, but he does not state which, and notes that all wild *Allium* species are edible, so they could have been consumed too. He is probably referring to *Allium* species which were of local origin, and were edible but were not related to cultivated garlic.

Garlic was found in Herculaneum (Italy), France (*Vandorpe, Jacomet 2011*) and in post-Roman Britain and Switzerland (*Badura* et al. *2013.4070*). It was likely widely propagated in the whole of the Roman Empire, but due to its low probability of preservation the actual garlic finds are few and far between. It was often hung in the entrance of houses, in the belief that it drove away evil spirits (*Pliny XIX.34*), a belief that still survives to the present in some cultures.

Archaeobotany and evidence from Greece

Conditions that would have enabled the preservation of soft tissue organic material remains at Akrotiri (Late Bronze Age, *c.* 1600 BCE) are rare, as the temperatures of ejected ash (*Braadbaart* et al. *2019*) would have worked against the preservation of such material.

In Building I at Palaikastro, Crete (*Sarpaki 2019. 358*), one clove from LM III B (≥1100 BCE) has been tentatively identified as garlic (*cf. Allium sativum*), but preservation on that site is exceptionally poor. In a recent publication though, on the archaeobotany of Tsoungiza (*Allen, Forste 2020*), in a domestic context dated to Late Helladic (LH) I levels (*c.* 1500 BCE), identified 21 cloves and 35 fragments (West Building room 2) and in LH IIB (*c.* 1400 BCE), in the dump deposit above wall 3, space 8, another 15 cloves were found. These are the earliest archaeobotanical finds of garlic in Greece, so far, together with the Akrotiri finds (LCI), although, in the Hellenistic, Classical and Roman periods, we assume that garlic was definitely circulating widely. Yet up until recently the tangible presence of garlic in the Aegean was elusive, although its annotation in the Linear B indicated, indirectly, its presence. Given the Pre-Greek names in Linear B of garlic, 'αγλις' (αγλιθος = clove of garlic) and *gelgis* 'γελγις' (γελγιθος), an interpretation of the terms as Akkadian loanwords has been put forward (*Kroonen 2012*). If this is accepted, it would be interesting to consider that Akkadian was used in the Mesopotamian Empires, in the area of Akkad, Assyria, Isin, Larsa and Babylon and, being the *ligua franca*, is also suggested to have been used in the Syro-Levantine coast and Anatolia (*Vita 2020*). Therefore, one would think that garlic might have been introduced in the Bronze Age from that part of the world. However, the ancient Greek term which was later used was changed to 'σκορ(ο)δον', a non-Indo-European word found in Old Armenian, and/or from a language in the Pontic area (*Beekes 2010.1358; Chantraine 1968–1980*). This implies at least two waves of garlic introduction into Greece and from different areas, and perhaps of different varieties. We are aware that the inhabitants of Greece in the Iron Age, and perhaps slightly earlier, settled in Sinope and along the coast and formed several colonies in the Iron Age on the shores of the Pontus Sea (Black Sea). The term 'σκορ(ο)δον' probably replaced the borrowed Akkadian Bronze Age term 'γελγις' at this time, when there might have been an intensification of trade to and from the Black Sea, and the Greek colonies, to Greece.

In Classical Greece, at the time of Aristotle and Hippocrates, garlic, 'σκορ(ο)δον', seemed to have been a staple (*Totelin 2015*) and was also used as a medicine (*Rivlin 2001*). At the women-only Athenian festival Skira (Skirophoria), women consumed large quantities of garlic in order to keep their husbands at bay, due to the smell, and abstain from sex (as reported by the historian Philochorus (3rd BCE) (*Totelin 2015*). However, there are frequent descriptions of the uses of garlic in herbalism by the Babylonians, Egyptians, Phoenicians, Chinese, Greeks, Romans and Hindus, and it is one of the most widely used plants in ethno-medicine, although this is a topic which cannot be dealt with here.

In the Hellenistic period, garlic was also consumed in large quantities (*Totelin 2015*). At Thasos, garlic (18 cloves and fragments) has been found in the necropolis (4th century BCE) (*Megaloudi* et al. *2007*),[5]

5 Fragkiska Megaloudi (*2005.80*) wrongly refers to 55 carbonized garlic cloves in a grave (Thassos) which is either a spelling mistake or else a wrong number. The real number is mentioned in her 2007 reference, and it is the number quoted in the text above.

and was also found in Italy and Bulgaria (*Hristova 2015*) in tombs indicating that the plants were used for the dead, as mentioned by Fragkiska Megaloudi *et al.* (*2007*) *inter alia*, whereas, it did not differ from food eaten by the living. The usage, though, might have had different and/or complementary connotations, and we still have no knowledge of the symbolism and role played by garlic in death rites. Its presence though must have played a protective role, amongst others, for the dead[6].

Akrotiri

At the site of Akrotiri (Fig. 1), it is cloves rather than bulbs of garlic that have been found (Fig. 2), although it is impossible to say whether these bulbs, with time, had disintegrated into their parts, *i.e.* bulbils/cloves. Some three cloves and fragments survived in Sector Delta (D), Room 1a in a small funnel-mouthed jar (Fig. 3), referred to as 'little amphora' in the diary. Sector Delta is an agglomeration of four buildings or a complex (Fig. 4) – private dwellings, we believe – which are not equally excavated. Therefore, this Sector still needs further excavation in order to complete its study. However, with the evidence at hand it is believed that the tenants of all four 'houses' of the Delta Complex were most probably merchants (*Michailidou 2008.247; 2013.146*). Storage of luxury items of all sorts seem to have been stored in Sector Delta (*Polychronakou-Sgouritsa 2000.80–81; Michailidou 2008.245*) In the houses a multitude of metal objects was found, such as the "*only known half-talent lead weight*" (*Michailidou 2013.idem*) found at Akrotiri, along with a cluster of lead balance weights, a pair of bronze tongs, two daggers with silver capped rivets, five vessels consisting of two lavers, found one inside the other, two jugs and a large hydria. Copper rings and bound strips were found in room Delta 1a, *i.e.* the same room where the garlic cloves were stored. In that very same room, scale pans No 7352 were also found. Similarly, in Delta Complex one of the Linear A tablet fragments which has been found records 200 textiles. The full list of items, indicating that the tenants of Sector Delta were traders, is too long to mention here.

Room D, 1a belongs to the western Delta building complex (Fig. 5), a ground floor storeroom (*Michaelidou 2001.321; Mathioulaki, Nikolakopoulou 2018. 66*), and possibly an area of the room was used as a kitchen as there was the presence of a hearth (along with a number of pottery vessels, and therefore it seems to have been, at least partly, a cooking area) (Fig. 6). However, it must also have been a storeroom, as seven lead weights and two scale pans were located among the finds, namely scale pans and a whole set of balance scales (*Michailidou 2008. 43, 51*). Its entrance was from the Pylon, on the Triangular Square, opposite the West House, that is one of the busiest streets of the settlement. The garlic finds were in a vessel which was placed near the western wall of the building and might have had a conical cup as a lid, as this was found broken within the vessel. It is worth noting too that Rooms 9 and 9.1 of the same building held a high number of imported wares (*Mathioulaki, Nikolakopoulou 2018. 66*) from Crete, the other Cycladic islands, the north-eastern Aegean islands, and the mainland. This indicates further the important position that was surely held by its owners in the trade networks of this period. The usage of garlic could perhaps indicate the remnants of a 'haute/exotic cuisine' and, hence added evidence about the high status of the inhabitants. This probably meant an enrichment of flavour which diverted from the 'archetypical' cuisine (*Hastorf, Bruno 2020*) that would have existed at Akrotiri, before the introduction of garlic.

Greek mythology

Garlic was scorned by the Gods, due to its smell, and one did not enter a temple after having eaten it. Similarly, a Babylonian omen says that a man who enters 'the house of his god' is impure if he eats garlic, onions, leeks, cress, beef or pork. During the festival of the Skirophoria, as was mentioned above, women chewed cloves of garlic, as is shown by Philichorus of Athens (*c.* 340–261 BCE), so that their breath should not smell sweet and that, in this way, they hoped to repulse their spouses and therefore abstain from the pleasures of love. Garlic was also known to have been placed by the ancient Greeks on the piles of stones at crossroads, as Hecate was associated with crossroads, and therefore it was provided as a supper for her (Theophrastus, *Characters, The Superstitious Man*). Indeed, Hecate was said to favour offerings of garlic, a vegetable closely associated to her cult (https://en.wikipedia.org/wiki/Hecate – cite_note-46). She is also sometimes associated with cypress, a tree symbolic of death, mourning and the underworld, and hence sacred to a number of chthonic deities.

6 See all the lore connected to garlic in medieval and post-medieval times.



Fig.1 Akrotiri, Thera: the excavated part of the site.

In Lemnos a New Year festival seems to have been celebrated yearly, in which they extinguished fires for nine days and made sacrifices to the chthonic deities. Their women chewed garlic, in order to keep their men away. Garlic was thus prominent among the various prohibited foodstuffs and classified under food taboos.

Ethnobotany

A tuncelianum has a mild garlic flavour and odour and has been called 'garlic' and consumed instead of the usual plan in the region it grows wild in in Eastern Anatolia (*Ipek* et al. *2008*). In Crete *Allium roseum* L. is known as wild garlic, as it has the same odour and is, sometimes, used in cooking instead of garlic. Moreover, it is also considered to have the same therapeutic properties (*Skoula* et al. *2011.64*). Garlic is said to have several therapeutic properties in the whole of Greece, and is used as an amulet against the evil eye as well (*Lykiardopoulos 1981*). In Egypt, Blackman (*Blackman 1968.209*), working amongst the 'Fellahin' (farmers) of Upper Egypt, discovered that rheumatism was cured with garlic. She goes on to describe the method used, whereby several cuts were made in both legs of an affected man (he had rheumatism in both legs), and garlic juice was squeezed as well as rubbed on the sores and into the cuts. This was repeated every day for a fortnight, and the mane was then completely cured.

There is, definitely, a wealth of ethnobotanical information on garlic from all the countries where it is used, but it is out of the scope of this study.

Garlic as value

Garlic is mentioned in Sumerian and Akkadian texts referring to plants used by the Babylonians (not Sumerians) (*Stol 1987.57*). The most ancient reference is from an Old Babylonian (*c.* 2000–1595 BCE) letter where garlic, leek, onion and bulb-leek are mentioned. It was originally believed that garlic was not mentioned in the Mari texts, but now this has view has been revised (*Stol 1987.58*) and it is also found in texts from Fara, Ebla, Pre-Sargonic Lagash, the Ur III dynasty and Hittite sources (*Michailidou 2008. 244, note 230*).

For the Ur III period (*c.* 2050–2000 BCE), it is interesting to compare the wages of workers as Robert K. Englund (*2012*) annotated them, so as to get an inkling of the value system of jobs and products. The lowest rank of workers have a normal wage of

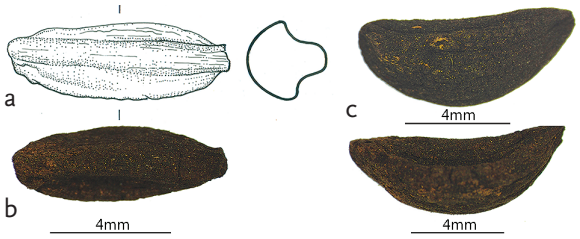


Fig. 2 Garlic remains, Akrotiri, Thera:* a *drawing of one bulbil;* b *photograph of the same bulbil;* c *two other whole bulbils.

c. 200 litres of barley per month (*c.* 6.6 litres/day), while upper management could have had 5000 litres of grain per month (167 litres/day), with 250 litres (8–9 litres/day) of grain monthly to gardeners, who one assumes would have been the people who tended the garlic fields. Two barig of garlic and garlic heads (where one barig is 60 litres), *i.e.* 120 litres, cost one shekel of silver (*c.* 8.33g). In this time period, the minimum wage would have been eight shekels of silver a year (*Englund 2012.443*). However, Englund states that informal markets could have made a variety of products affordable to workers, and claims that damaged garlic could have been exchanged with measures of barley at a ratio of 1: 11.1. Yet, of course, there would have been price fluctuations connected, among other reasons, to conflict, collapse of communication, and drought (which could have triggered prices of barley to rise to unforeseen heights), good harvests, and a high influx of silver.



Fig. 3 Photo of the funnel-mouthed jar in which the garlic remains were found. Akrotiri No. 7562.

Englund (*2012.444*) argues that throughout Mesopotamian history 1 gur of barley (*c.* 300 litres) was equivalent to one shekel of silver, which was a way of standardizing metrological systems and barley wages; two gur of salt (*c.* 600 litres) for one shekel of silver, as well as one healthy sheep for one shekel of silver. This provides a window into the relative values of products. Whether these prices referred to those in the Aegean is hard to tell, but it does provide some relative indication of value.

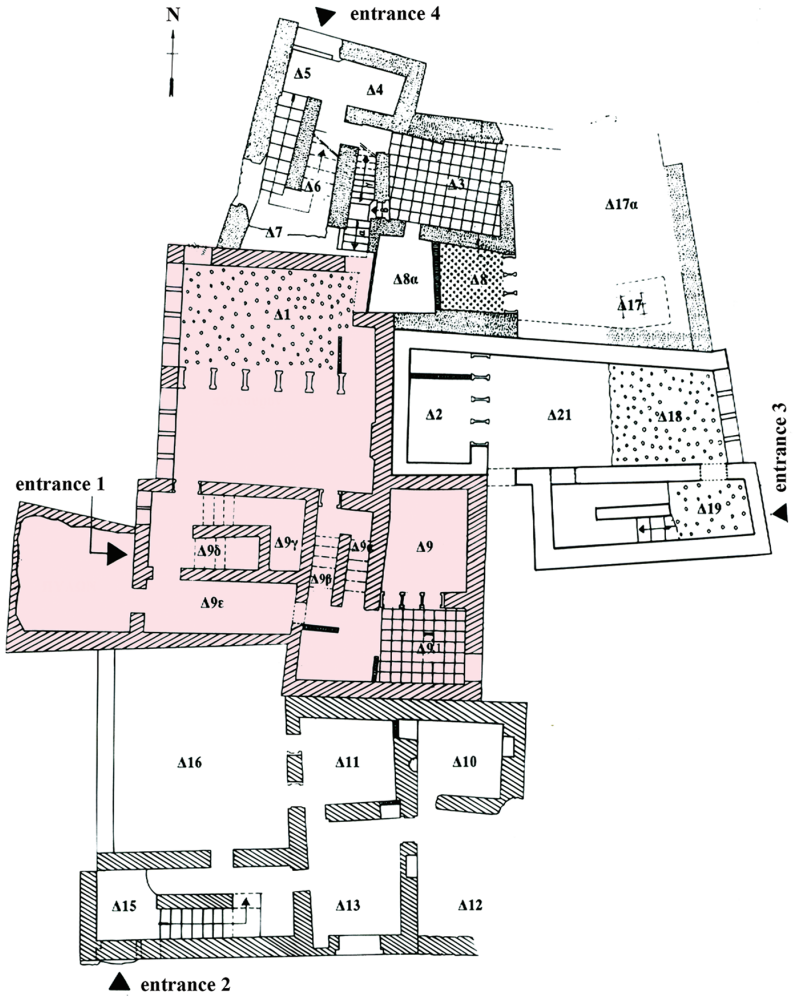


Fig.4 Sector Delta (Δ), Akrotiri, Thera: the agglomeration of four buildings, whose separation is shown here, and symbolized by different raster graphics for each building and the building discussed here is marked in pink.

When first introduced to Greece/Cyclades/Akrotiri garlic was probably a luxury food, as it was an import, and an open question still remains as to when it became locally cultivated. Food and its consumption has been especially investigated in anthropology, as it reflects very subtle aspects of human communication within a society. It reflects those who prepare the food, those who consume it and share it, and those who are excluded from its consumption, as well as those who are allowed to access it. We therefore need to deal with the term 'luxury' from an anthropological perspective. What is a luxury food and is garlic considered a luxury? In these terms, we could assume that a food that is "*desirable or hard to obtain but not essential to human nutrition*" is a luxury (*Van der Veen 2003.405*), and could thus be seen as an indulgence, an object of desire which could impress social competition and indicate various forms of conspicuous consumption/feasting. Such an object needs to be desired by many but affordable only by a few, and not concerned with meeting basic human needs in terms of food, shelter, clothing and leisure. This luxury status would probably refer to the time when garlic was imported as a high-status food enhancer and not cultivated locally. However, at Late Bronze Age Akrotiri we do not know for sure whether the garlic which was found was imported or cultivated locally, although we can assume that the latter was possible. Its name in Linear B was already well engrained in the culture (see above), and it was a plant that could easily become naturalized in the Mediterranean environment. Therefore, we might be seeing the 'trickle-down effect' sometime in the Late Bronze Age, when garlic, as a luxury, had changed status from an object desired by many but acquired by a few, to one available for most people and thus transformed to a commodity, seen as a common food enhancer. This could have been a time of a change in cuisine too, whereby garlic might have enriched a 'high cuisine' with the addition of more exotic aromatics. Was this the case for Akrotiri? Had garlic just been introduced – imported – in the Late Bronze Age Akrotiri, or had it arrived earlier and by the Linear B was already locally cultivated and naturalized? This cannot be answered at present, but at least the Akrotiri garlic find was found in a wealthy 'merchant's' abode, and thus might have been considered a high-status ingredient. Nevertheless, it is still interesting that on the miniature wall-painting of the West House, Room 5, north wall (Fig. 7), near the well, on its left, there is a line of plants which have

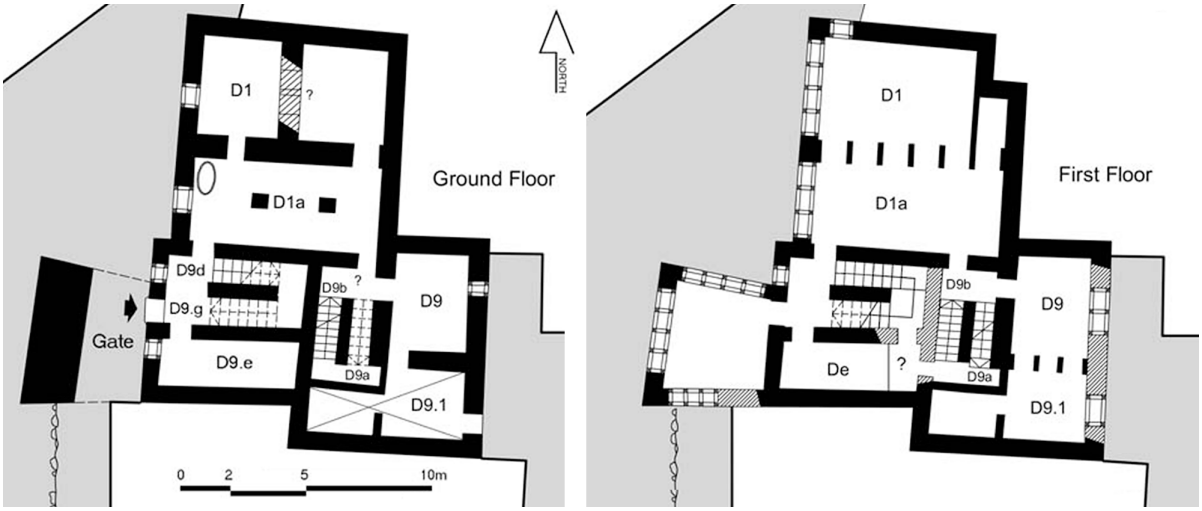


Fig.5 Sector Delta (D), Akrotiri: the western house of the complex, ground and first floor (after* Palyvou 2016*).

long elongated leaves, just like *Alliaceae*, and this could, perhaps, indicate onion or garlic plants. The bulbous looking flower on the edge of a stalk is very characteristic of this family. They grow in a line which has been identified as depicting/symbolizing a terrace (*Sarpaki 2000.665*), near a well, a water source, which indicates they were bulbous plants which needed watering, and thus this is a garden plot. At the time of publication, garlic had not been identified, therefore there was no tentative identification of the plant. In view, though, of the archaeobotanical finds and the knowledge that garlic was present at Akrotiri in the Late Bronze Age (*c.* 1600 BCE), it would not be far-fetched if we tentatively suggested it to be garlic/onion.[7]

Garlic plants grow *c.* 60cm tall. The spherical flower cluster is initially enclosed in a pair of papery tapered bracts. These bracts split open when the green-white or pinkish flowers bloom. They can be schematically depicted as a ball, as is shown in the plants in the wall painting.

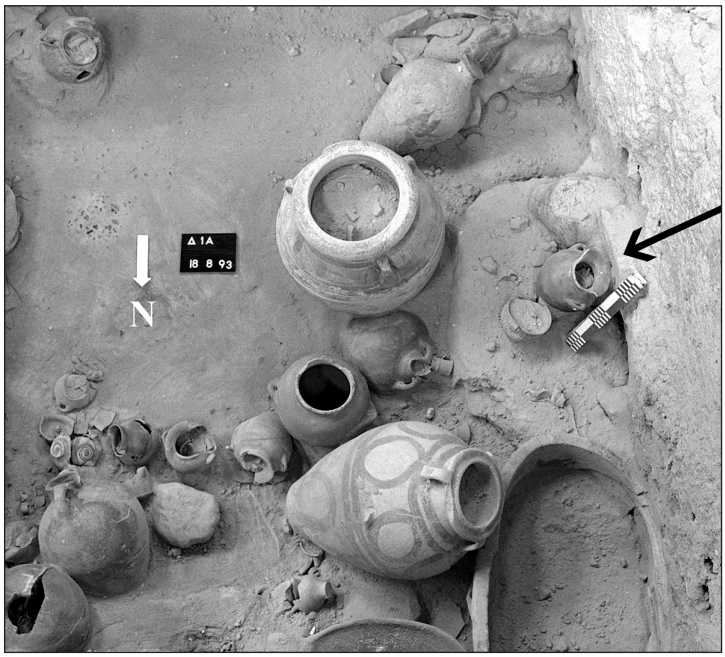


Fig.6 Sector D1a, photo of the northwest corner of the room, where the pot was found on the hearth (arrow) (Akrotiri archives, photo 93/474–475).

Conclusion on the finds of garlic in Greece

Based on the above evidence, we can assert that garlic has been used in Greece since at least about 1600 BCE, if not earlier, and was important enough to have been mentioned in Linear B. The rarity of this crop in the archaeological record could be due to several reasons, one of which may be its low preservation, *i.e.* deformation, that occurs due to its processing (inclusion in food) and its composition, which includes ethereal oil. Another reason might have been due to its rarity of use, storage needs and/or the way it was processed (*i.e.* sliced, mashed). Most probably, even if not imported, would have been a high-status crop, pertaining to rather well-

7 Onion skins (*Marinatos 1999.43, Pl. 108 b*) are believed to have been found in Sector Delta, in a vase. These came from a different building, of the same complex (Fig. 4), in Δ2, room of the lilies, (ground floor) named after the wall painting of lilies that was found there.

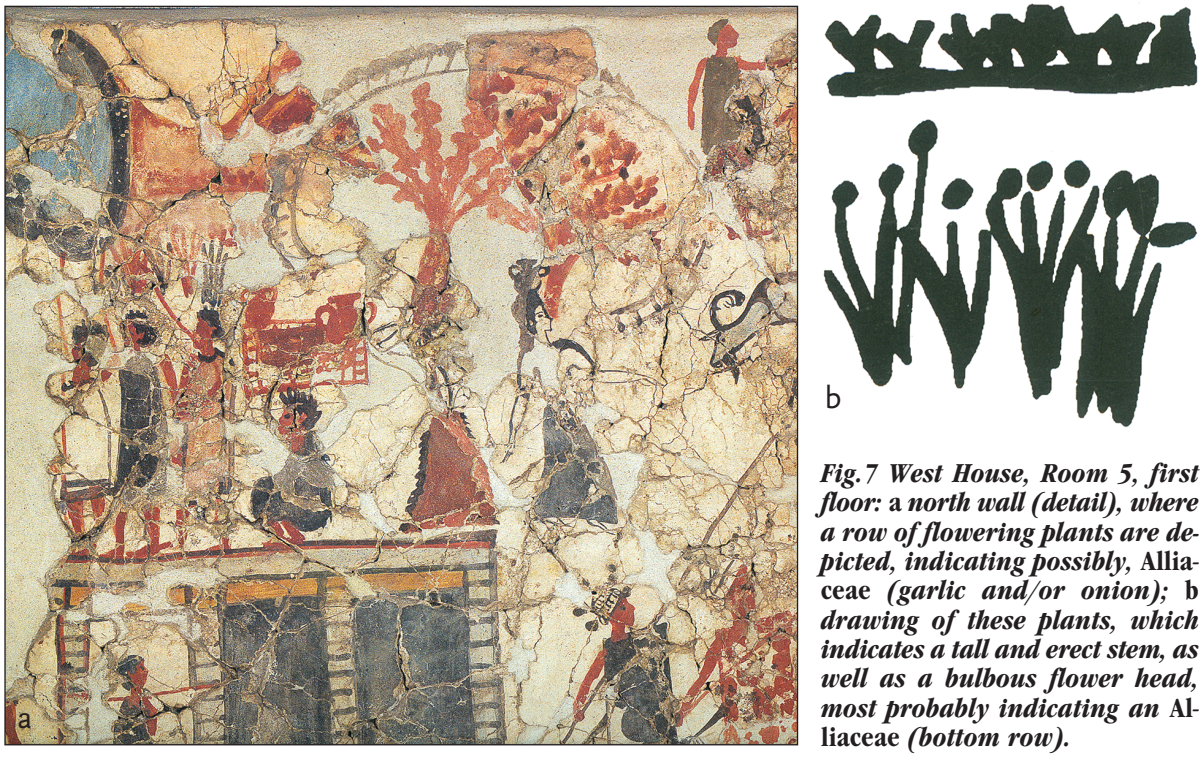


Fig. 7 West House, Room 5, first floor:* a *north wall (detail), where a row of flowering plants are depicted, indicating possibly,* Alliaceae *(garlic and/or onion);* b *drawing of these plants, which indicates a tall and erect stem, as well as a bulbous flower head, most probably indicating an* Alliaceae *(bottom row).

to-do individuals and their high cuisine, and thus rare and never wasted. The rarity of this crop in Prehistory, as it has only been found at Akrotiri, perhaps at Palaikastro and, recently, at Tsoungiza, so far, together with its appearance in Linear B (*c.* 1200 BCE), might indicate that it was a 'luxury' crop, or at least, a crop somewhat controlled by the exchange/trade/bureaucratic networks of the Bronze Age, even later than *c.* 1600 BCE, when Linear B was used. The interest of the palatial bureaucracy in garlic is indicative of its retaining its high status, even after several centuries, at first as an import, but even later when it might have been cultivated locally. Perhaps the use of wild 'garlics', as in Turkey, Greece and probably in other cultures of the Near and Middle East, reflects further evidence of 'indigenization' and 'popularization' of this new flavour, together with its eventual local cultivation. Its multiple uses, beyond cuisine, would have rendered this crop to be highly in demand for medicinal, ritual and preservative reasons, especially for storage of food, and specifically of animal products (*Kumar, Berwal 2002*).[8]

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8 It is known to repel bacteria. For example, fresh cheese gets a prolonged shelf life when garlic is added to it.

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