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*The 16th Neolithic Studies anthology comprises seventeen selected papers presented at the fifteenth Neolithic Seminar '*Climate Anomalies, Population and Culture Dynamics in Prehistory*' that took place at the Department of Archaeology, University of Ljubljana in November 2008. We also present complementary studies focused on: (i) Palaeolithic 'art' objects in Slovenia, which were described as 'art' by their excavators, who undertook no further examination or authentication; (ii) the ^{14}C gradient of Early Neolithic pottery dispersal and the gradients of Y-chromosome subhaplogroups J2b and E3b1 distribution that were hypothesised to mark the Early Neolithic demic event in Southeastern Europe; (iii) the diverse iconographic landscapes of the southern Balkans, especially those populated by human figurines; (iv) the comparative study of wild boar and domestic pig skulls, which suggests that a change in feeding habits as a result of domestication may have been a factor which influenced the action of the masticatory and neck muscles in reshaping the cranial region; (v) the study of the formation of layers of burnt herbivore dung in Neolithic, Eneolithic and Bronze Age Mediterranean caves that suggests that instead of seeing dung as a culturally neutral refuse which has to be disposed of, we might see its burning and deposition as the cultural manipulation of a potent substance.*

'The Gaban Venus'
(see Cristiani et al., this volume).

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The relationship between Early Holocene climate change and Neolithic settlement in Central Anatolia, Turkey: current issues and prospects for future research

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ABSTRACT – *Episodes of global climate change have traditionally been invoked as explanations for settlement re-organisation and socio-economic transformation in the prehistory of the Middle East (*e.g.*, the Neolithic period). By focusing on the 8.2K event, this paper presents a theoretical and methodological argument against the assumption of unilinear, passive responses by prehistoric societies to global climate change, using as a case study datasets recently obtained from the Konya Plain in Central Anatolia, Turkey.*

IZVLEČEK – *Pri pojasnjevanju epizod velikih preoblikovanj naselij in družbeno-ekonomskega prehoda v prazgodovini Srednjega Vzhoda (*e.g.*, neolitika), se običajno sklicujemo na epizode globalnih klimatskih sprememb. Z osredotočenjem na klimatski dogodek pred 8.2K, v tem članku podajamo teoretični in metodološki dokaz zoper domnevo o premočrtnih, pasivnih odgovorih prazgodovinskih družb na globalno klimatsko spremembo. Kot študijski primer smo uporabili nedavno pridobljeno serijo podatkov s planote Konya v centralni Anatoliji, Turčija.*

KEY WORDS – *climate change; 8.2k event; Central Anatolia; Konya Plain*

Introduction

The impact of environmental change on human societies has been a traditional concern of palaeo-ecological and archaeological research (*Rosen 2007*). Processes as diverse as human migrations, plant and animal domestication, the restructuring of settlement patterns (*e.g.* site abandonment) and socio-economic transformations have often been attributed to the impact of climate change and/or human impact on the landscape and its resources (*Redman 1999*). With regard to the archaeological investigation of such inter-relationships, the issues of the scale and resolution of the archaeological and the palaeo-ecological record are of paramount importance. First, it is necessary to verify independently the magnitude, scale and specific ecological impact of episodes of climate change on landscape resources. Second, one must evaluate and assess within a defined spatial and chronological framework the aspects of the archaeological record (*e.g.*, landscape exploitation, settlement patterns) that might hold evidence of those human choices and decision-making that took shape as a response to climate (and resulting landscape) change.

In the Middle East, the end of the Early Neolithic period has been variously associated by a number of scholars with climatic deterioration (characterized by cold conditions bringing about increasing aridity) occurring at about 8200 years calBP and lasting for <400 years (see *Alley et al. 1997; Wiersma et al. 2006*). The 8.2k event is believed to have forced the widespread abandonment of settlements, with consequent population diffusion and the spread of settlement westwards into Southeast Europe (see contributions in this volume; also *Weninger et al. 2006*). Such assumptions have often been based on constructing generalized radiocarbon sequences, spanning both local and regional chronologies, which are

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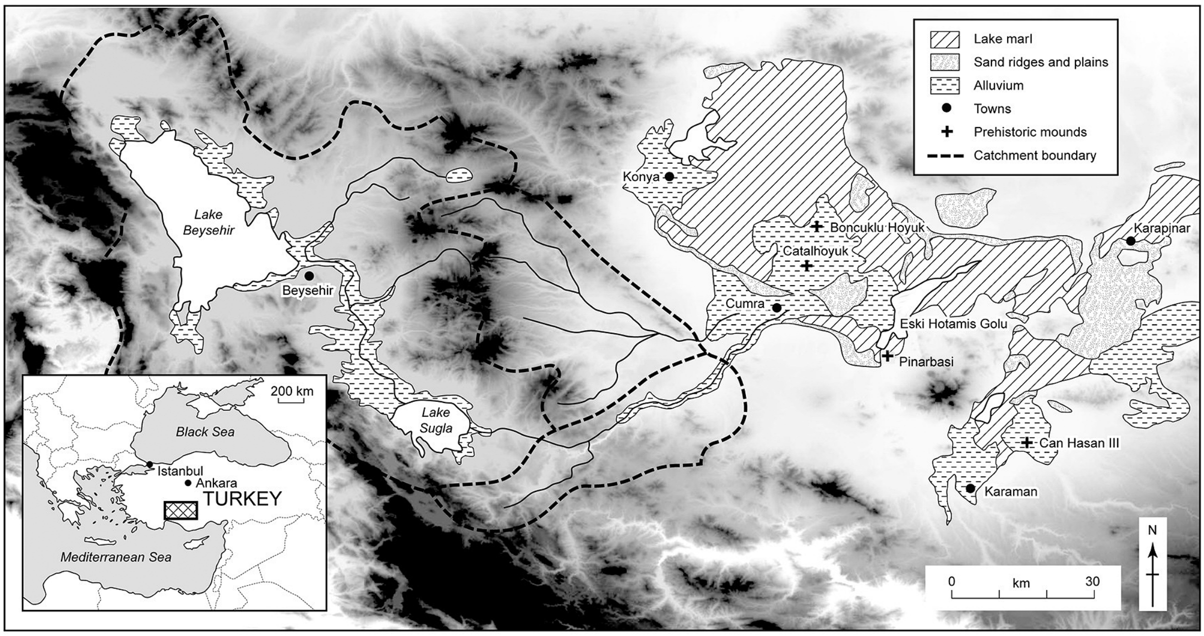

Fig. 1. Map of the Konya plain in central Anatolia, showing the excavated Neolithic sites, and the main topographic features and landscape units.

then 'correlated' in order to build chronological sequences aimed at demonstrating cultural genealogies (whereby the chronologically 'older' represents the source, and the 'younger' its derivative). However, such arguments tend to ignore the fact that, in order to establish causality between climate and cultural change, it is not enough to demonstrate broad chronological contemporaneity between the two. Proof consists of correlating records of climate change with evidence for its specific impact on the landscape resources exploited by past societies (*e.g.* vegetation, water sources), and the subsequent impact of such landscape transformations upon human choices as reflected in prehistoric habitation practices and settlement patterns. However, most scholarly arguments in favor of climate-driven explanations tend to ignore evidence pertaining to local variations in patterns of landscape and (associated?) socio-cultural change (often treating it as 'noise') by subsuming it under grand narratives of regional 'trends'. They may thus overlook critical evidence for diversity in both the configuration of the local landscapes and the living strategies of prehistoric communities. The aim of this paper is to question the assumption (sometimes uncritically promoted by palaeo-ecologists) of passive responses by prehistoric societies to climate change.

Case study: the Konya Plain, Central Anatolia

The Konya Plain of Central Anatolia (Fig. 1) was chosen as a case study due to its unusual concentration of archaeological and palaeo-ecological research designed and carried out by research teams aiming at the integration of on-site (geo-archaeological, subsistence) and off-site (palaeo-ecological) evidence, in addition to intensive survey and excavation work (overviews available in *Boyer et al. 2006; Baird 2002; 2007; Eastwood et al. 2007; Hodder 2007; Roberts et al. 1999; 2001; 2007*). Here, I will present a brief summary of the findings of these different projects, in order to demonstrate the rationale behind integrating diverse lines of evidence for reconstructing the complexity of human-environment interactions in the Neolithic (for detailed presentations of the evidence discussed here, the reader is referred to the original publications).

The available pollen sequences from Central Anatolia (*Eastwood et al. 2007; Roberts et al. 2001*) have shown that by the time of the first known Neolithic settlement in Cappadocia (*c.* 10 000 calBP) the regional vegetation was oak-terebinth-juniper grass parkland. Two millennia later (*c.* 8000 calBP, the beginning of the main Ceramic Neolithic occupation at Çatalhöyük) the regional landscape had been transformed into a mosaic of woodland (including some mesic species such as hazel) and more open grassland. Although by 6000 calBP mesic taxa had regressed, the available evidence indicates that deciduous oak continued to expand until the mid-Holocene, when there was a permanent decline in oak woodland, which was replaced by a more open landscape. The widespread occurrence of other tree species such as pine has invariably been interpreted as the result of long-distance transport. High-resolution isotope, diatom, mineralogical and lithological data also demonstrate deep, dilute lake conditions from the beginning of the Holocene until *c.* 6500 calBP. After this time there was a permanent fall in lake levels, with maximum salinity levels probably being achieved around 3000–2000 calBP. Pollen and limnological records are in agreement in demonstrating a sequence indicating a rapid climate improvement at the start of the Holocene, followed by a sustained period of moisture availability significantly above modern values until *c.* 6500 calBP, with much drier conditions prevailing during the second half of the Holocene. Anthropogenic impacts on vegetation did not become major features of the local landscape before *c.* 4500–4000 calBP, which is in agreement with comparable evidence for low Neolithic impact on woodland vegetation in SE Europe (*Willis and Bennet 1994*). However, the response of tree taxa in Anatolia to increasing moisture availability during the Early Holocene has also indicated significant time lags in their expansion, which might be attributable to the combined effects of poor pollen preservation and Neolithic landscape practices (*e.g.*, vegetation burning, coppicing during pollination periods, etc., which might be difficult to detect by the classic indicators of anthropogenic impact deployed in pollen analysis; *Roberts 2002*). The analysis of charcoal macro-remains has also demonstrated the regular exploitation of numerous tree and shrub taxa which are not preserved at all (*e.g.* Rosaceae) in the local pollen diagrams (*Asouti and Hather 2001; Asouti 2005*).

With regard to geo-archaeological investigations in the Konya Plain, an intensive coring program was undertaken by the KOPAL team (*Boyer et al. 2006*) to investigate the depositional history of the Çarşamba alluvial fan, in order to reconstruct the configuration of the local landscape and its hydrological regime. These data have indicated that the so-called 'Lower Alluvium' (backswamp clay, interpreted as an indicator of extensive flooding occurring at regular intervals) was actively deposited during the greater part of the Neolithic. Its deposition in the periphery of the Çarşamba fan continued after the onset of the Chalcolithic period (*c.* 6000 calBC), when the so-called 'Upper Alluvium' (indicative of a change to drier conditions) had begun to accumulate. This sedimentary sequence indicates that a complex topography (comprising both wet and well-drained surfaces) was available to the inhabitants of the area throughout the prehistoric period (*Boyer et al. 2006*).

The same complexity is evident for the Neolithic period (9^{th}–7^{th} millennia calBC). Recent systematic work on mud bricks and a pilot coring project undertaken by a joint Oxford-Sheffield team around Çatalhöyük (*Doherty et al. 2008*) plus a landscape project undertaken by a Liverpool team led by the author in the vicinity of the aceramic site of Boncuklu (*work in progress*) have conclusively demonstrated that there is significant micro-topographic variability around both sites, which is not necessarily picked up by the general Lower-Upper alluvium succession model proposed by the KOPAL project. This topographic variability seems to be a persistent feature of the Neolithic (and later) local landscape and, as such, is not generally conducive to climate-driven inferences with regard to its causes at any particular period.

Turning briefly to settlement patterns in relation to landscape configuration: plotting the results of sediment coring investigations against settlement distribution (*Boyer et al. 2006.Fig. 5*) shows that settlement expansion and contraction occurred independently of major shifts in topography and the hydrological balance of the Çarşamba alluvial floodplain and fan. Prior to the mid-8^{th} millennium calBC (*i.e.* in the early Aceramic Neolithic), settlement appears to have been dispersed, taking advantage of different landscape units, including both marshes and better drained areas. In the late Aceramic Neolithic (to which dates the first archaeologically known habitation at Çatalhöyük) this picture of diversity does not alter. During the Ceramic Neolithic (7^{th} millennium calBC), one can observe a process of settlement nucleation with the end of these Aceramic communities which resulted in the growth of the community of Çatalhöyük. This process again appears to be unrelated to any major episodes of environmental and/or climate change (*Baird 2002*).

Discussion

Prospects for future research on the Neolithic landscapes of the Konya Plain focus on the diversity of local micro-topographies in relation to landscape practices (*e.g.* cultivation, herding, woodland exploitation, raw materials extraction), and are aimed at reconstructing the various pathways leading to the creation of anthropogenic landscapes. A core concern of this research is to address how Neolithic landscape practices and decision-making might have differed from traditional assumptions and expectations of catastrophic human impact on the 'natural' landscape (*e.g.* through overgrazing, deforestation and consequent land degradation). Such effects are habitually predicted by conceptual models of 'environmental collapse' (the latter often perceived as being accentuated and/or triggered by negative climate change). With specific reference to the Neolithic period, evidence for catastrophic human impact on the landscape at a scale sufficient to have caused settlement fragmentation and dislocation remains poorly documented across the region (*Campbell 2009*).

As regards the 8.2k event, there is also very limited evidence to suggest that it had a significant impact on settlement patterns and the resource base of Neolithic communities in central Anatolia. In effect, evidence unearthed during the most recent excavations at Çatalhöyük would suggest continuity rather than discontinuity in habitation patterns and practices between the Neolithic East Mound and the Chalcolithic West Mound (see *Çatalhöyük Archive Report 2008.13–15* and references therein). Overall, it seems that the proximate causes for the prevailing pattern of settlement nucleation observed during the *c.* 1000 year long habitation of the East Mound and the return to the fragmentation observed towards the end of the 7th millennium must be sought in economic and societal developments, rather than being considered as the ultimate result of environmental pressures exerted on prehistoric populations and communities (*Baird 2002*).

In addition to inferences drawn from the archaeological and palaeo-environmental record, the evidence pertaining to the magnitude and impact of the 8.2k event as an episode of global climate change has indicated that it was short in duration (*c.* 300 yrs). Recent simulations (*Wiersma and Renssen 2006*) have indicated that its effects as regards key parameters such as temperature and precipitation varied globally, regionally and even within individual geographical areas. This research suggests that vegetation and hydrological responses to such short-term events might have been extremely variable, and displayed significant time lags. Such evidence, together with the archaeological record, indicates that the 8.2k event is unlikely to form a sufficient explanation per se for the role of climate change as the primary or even a significant contributing factor to the 'collapse' of Early Neolithic settlement, and the subsequent spread of populations from the Middle East to continental Europe (*contra Weninger et al. 2006*).

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The Impact of Rapid Climate Change on prehistoric societies during the Holocene in the Eastern Mediterranean

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ABSTRACT – *In this paper we explore the impact of Rapid Climate Change (RCC) on prehistoric communities in the Eastern Mediterranean during the Early and Middle Holocene. Our focus is on the social implications of the four major climate cold anomalies that have recently been identified as key time-windows for global RCC (*Mayewski et al. 2004*). These cooling anomalies are well-dated, with Greenland ice-core resolution, due to synchronicity between warm/cold foraminifera ratios in Mediterranean core LC21 as a proxy for surface water temperature, and Greenland GISP2 non sea-salt (nss) [K^+] ions as a proxy for the intensification of the Siberian High and for polar air outbreaks in the northeast Mediterranean (*Rohling et al. 2002*). Building on these synchronisms, the GISP2 age-model supplies the following precise time-intervals for archaeological RCC research: (i) 8.6–8.0 ka, (ii) 6.0–5.2 ka, (iii) 4.2–4.0 ka and (iv) 3.1–2.9 ka calBP. For each of these RCC time intervals, based on detailed ^{14}C-based chronological studies, we investigate contemporaneous cultural developments. From our studies it follows that RCC-related climatic deterioration is a major factor underlying social change, although always at work within a wide spectrum of social, cultural, economic and religious factors.*

IZVLEČEK – *V članku obravnavamo vpliv hitre klimatske spremembe (HKS) na prazgodovinske skupnosti v vzhodnem Sredozemlju v zgodnjem in srednjem holocenu. Naš fokus je usmerjen v socialne posledice, ki so jih povzročile štiri glavne klimatske anomalije. Ohladitve so bile identificirane nedavno in označene kot ključne časovne niše za globalne HKS (*Mayewski et al. 2004*). Ohladitve so dobro datirane z ledeno vrtino na Grenlandiji, s sinhronostjo razmerij toplo/hladno med foraminiferami kot indikatorji temperature morja na površini v globokomorski vrtini LC21 vzhodnem Sredozemlju in z ne-morskimi solnimi (nms) [K^+] ioni kot indikatorji intenzivnosti Sibirskega anticiklona in prodora polarnega zraka v severovzhodno Sredozemlje. GISP2 časovni model gradi na teh sinhronizmih in zagotavlja precizne časovne intervale za arheoološke raziskave HKS: (i) 8.6–8.0 ka, (ii) 6.0–5.2 ka, (iii) 4.2–4.0 ka in (iv) 3.1–2.9 ka calBP. S pomočjo ^{14}C kronoloških analiz kulturnih sekvenc smo vzpostavili kronološke korelacije z vsakim intervalom HKS in opazovali kulturne dinamike. Ugotovili smo, da so klimatske spremembe in poslabšanja povzročitelji socialnih sprememb, seveda v povezavi z drugimi kulturnimi, ekonomskimi in religijskimi dejavniki.*

KEY WORDS – *Rapid Climate Change; Holocene; GISP2; Dead Sea Level; Levantine Moist Period; Neolithic; Chalcolithic; Bronze Age; domestication*

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INTRODUCTION

Definition of Rapid Climate Change (RCC)

Our understanding of natural climatic variability in the Holocene has increased considerably during recent years. One of the most remarkable discoveries is the existence of a distinctly repetitive pattern of global cooling anomalies, with major (among other cycles) 1450-year periodicity during the Glacial periods, extending through the Holocene up to modern times, *i.e.* the most recent 'Little Ice Age' (*Mayewski et al. 1994; 1997*). These Holocene cold anomalies, the focus of the present paper, are known as Rapid Climate Change (RCC) events (*Mayewski et al. 1997; 2004*).

Mayewski *et al.* (*2004*) have identified as many as six RCC periods for the Holocene, that are given as 9000–8000, 6000–5000, 4200–3800, 3500–2500, 1200–1000, and 600–150 calBP. These periods were documented by a comparison of ~50 globally distributed palaeoclimate records, carefully selected according to length (with preference given to full Holocene coverage), sampling resolution (dating resolution better than 500 yr), interpretation quality, and geographic distribution. For the purposes of the present paper, we reduce the study area to the Eastern Mediterranean, and focus on three (shortened) RCC periods (8600–8000, 6000–5200, and 3000–2930 calBP).

Previous studies

The 4200–4000 RCC period (also known as '4.2 ka calBP event') is not studied further here. Detailed studies are provided by Weiss *et al.* (*1993*) and Staubwasser and Weiss (*2006*, both with further references) on the effects of drought in northern Mesopotamia. First considerations towards the possibility of a climatic background for the collapse of Anatolian and Aegean Early Bronze Age trade networks are supplied by Şahoğlu (*2005.passim 354*). Much further work is necessary on this topic, but if confirmed this would significantly extend the already large region (northern Mesopotamia, parts of the Indian subcontinent, East Africa) for which there appear to be observable social effects of the 4.2 ka calBP event (*Weiss 2000; Staubwasser and Weiss 2006*). A useful general introduction to the topic of '*Collapse as Adaptation to Rapid Climate Change*' is provided by Weiss (*2000*).

Welcome methodological guidance on how to approach these questions is also provided by recent studies towards understanding the collapse of rainfed agricultural cultures in the western part of the Chinese Loess Plateau (*An et al. 2005*). Here, a conspicuous transition from long-established farming communities to more mobile (pastoralist) societies is observable. However, in this case, the archaeology is poorly dated.

A continuous 9000 year high-resolution (U/Th-dated; $\Delta^{14}C$-tuned) record of the Holocene Asian Monsoon is available from Dongge Cave in Southwest China (*Wang et al. 2005*). This record provides interesting structural details for the 4.2 ka calBP event, which may be of interest in archaeological studies. In this respect, it is also worth noting that the 4.2 ka calBP event is the biggest anomaly for chloride in the GISP2 Holocene record. The chloride series is interpreted as a proxy for North Atlantic sea ice extent. During the 4200–4000 calBP time interval, the GISP2 chloride values are the lowest in the entire Holocene, indicative of a Holocene sea ice minimum in the North Atlantic. During this period, it is to be expected that summer-like conditions prevailed in the North Atlantic, thus parallel to drought in the Levant (*Mayewski and White 2002*).

Archaeological RCC-catchment

In our studies, the RCC periods as defined by Mayewski *et al.* (*2004*) are first shortened according to a combination of archaeological and geographic criteria to age intervals 8600–8000, 6000–5200 calBP, and 3100–2900 calBP. These shortened RCC time windows correspond to the maximum density of high GISP2 non-sea salt (nss) [K^+] values. When approaching the site level, the RCC time windows are further shortened, with a focus on individual (annual) peak values of the GISP2 nss [K^+] proxy. This window-technique and the ^{14}C-methods used for archaeological RCC-catchment in this paper are described in more detail below.

In essence, the approach is to use the Gaussian (200 yr) smoothed GISP2 nss [K^+] data for explorative (regional) cultural studies, and the higher-resolution GISP2 nss [K^+] raw-data for fine tuning on specific sites.

Organisation of study

This study is organised as follows. Firstly, those climate records to feature in this study are introduced, after which we provide a brief recapitulation of the combined Rapid Climate Change (RCC) scenario.

In the second section, archaeological case studies are presented; these are organised in chronological order, beginning with the oldest, and are taken from our study area, which encompasses the Eastern Mediterranean (Levant, Turkey, Greece, Bulgaria, and Romania). For each of the time-intervals in which there is strong evidence for RCC impact during the Early and Middle Holocene, we have chosen a specific region for more detailed archaeological RCC research. Using this approach we hope to optimise the potential of this study.

Be this as it may, many results remain complicated due to the wide diversity in cultural, climatic and environmental phenomena involved. The diversity of research topics is itself mirrored, to some extent, in the number of participating researchers.

CLIMATE RECORDS

Overview of RCC-records

To begin, Figure 1 supplies an overview of selected records showing Holocene Rapid Climate Change (RCC) events in the Mediterranean, southern Europe, and the North Atlantic (Fig. 1, from top to bottom): the Greenland GISP2 ice-core ($\delta^{18}O$ record), the Western Mediterranean (marine core MD95–2043), the Eastern Mediterranean (marine core LC21), the North Atlantic (Bond-Events), Romania (Steregoiu), and the Greenland GISP2 ice-core (nss [K^+] Gaussian smoothed (200 yr) and nss [K^+] high-resolution record. Site-locations are shown in Figure 2, together with a schematic representation of the main climatic players, the atmospheric and oceanic circulation mechanisms during RCC periods.

Individual RCC-records

Little Ice Age

Perhaps the most prominent of the RCC events/periods is the recent Little Ice Age (LIA) when mountain glaciers expanded in both hemispheres (*Mayewski et al. 2004.Fig.4*) and there occurred a strengthening of westerlies over the North Atlantic and in Siberia (*Mayewski et al. 2004.250*). However, as emphasised by Maasch *et al.* (*2005*), a reduction in global temperature is not necessarily the best indicator of climatic deterioration. Simultaneous with the LIA, some of the most severe droughts of the entire Holocene are observed in tropical regions (*Haug et al. 2001*).

This strong regional component of Holocene RCC makes studies in climate-archaeology complicated, since observations made in one region are not necessarily valid for the next. However, as shown below, in view of recent advances in palaeoclimatology, and especially in terms of regional climatic forecasting (and the use of modern analogues), it is now possible to reduce significantly uncertainty in regional forecasting. Consequently, by combining modern regional and supra-regional modelling predictions with empirical evidence from recent marine, terrestrial and ice-core records for the Holocene, we are now well-equipped to study for the first time, and that means explore, the impact of Rapid Climate Change (RCC) on prehistoric communities in the Eastern Mediterranean.

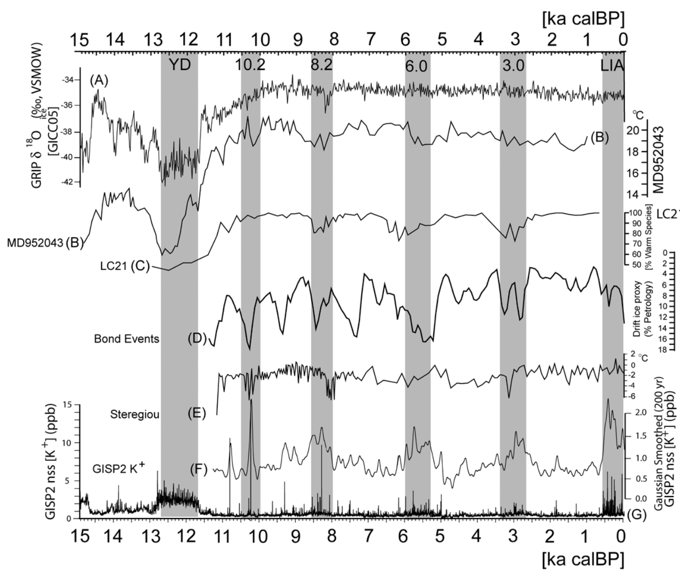


Fig. 1. Northern Hemisphere Palaeoclimate Records showing Holocene Rapid Climate Change (RCC) (site map* cf. *Fig. 2), (A) Greenland GISP2 ice-core $\delta^{18}O$ (*Grootes et al. 1993*), (B) Western Mediterranean (Iberian Margin) core MD95–2043, sea surface temperature (SST) C37 alkenones (*Cacho et al. 2001; Fletcher et al. 2008*), (C) Eastern Mediterranean core LC21 (SST) fauna (*Rohling et al. 2002*), (D) North Atlantic Bond-Events, stacked petrologic tracers of drift ice from cores MC52–V29191+MC21–GGC22 (*Bond et al. 2001*), (E) Romania (Steregoiu), Mean Annual Temperature of the Coldest Month (MTC, °C) (*Feurdean et al. 2008*), (F) Gaussian smoothed (200 yr) GISP2 potassium (non-sea salt [K+]; ppb) ion proxy for the Siberian High (*Mayewski et al. 1997; Meeker and Mayewski 2002*), (G) High-Resolution GISP2 potassium (non-sea salt [K+]; ppb) ion proxy for the Siberian High (*Mayewski et al. 1997; Meeker and Mayewski 2002*).

Marine Core LC21 (35.66° N, 26.48° W, –1522 m water depth)

Due to its central position in the southeast Aegean to the east of Crete (Fig. 2), marine core LC21 (35.66° N, 26.48° W, –1522 m water depth) is of prime importance to this study. At this location, selected marine fauna have been used as a proxy for sea-surface temperature (SST), thus providing an insight into expansions and contractions of cooler Aegean waters in relation to warmer Levantine waters (*Rohling et al. 2002*). Accordingly, it has been established that the ratio of warm/cold surface living foraminifera can be used to describe a series of rapid SST variations during the Holocene. The LC21 record reveals a pattern of (presently) three major temperature drops in the SE Aegean, which can be dated to 8.6–8.0 ka calBP, 6.5–5.8 ka calBP, and 3.5–2.8 ka calBP (*Rohling et al. 2002*). Modern calibration of fauna-derived sea-surface temperature (SST) variations shows that these temperature drops have a strong seasonal component in winter and early spring (*Rohling et al. 2002*).

Although the decline in warm species in core LC21 from 90% to 80% just after 8.6 ka calBP (Fig. 1) might appear slight, this decrease nevertheless corresponds to a significant change in surface temperature (SST) of between 2 and 3° Celsius. Consequently, the wind-chill (see below) underlying such apparently small changes in water temperature fluctuation should not be underestimated. First, the temperature change (from warm to cold) is rapid; it is observed in marine core LC21 from one sample to the next, hence corresponding to a maximum interval of approximately one century. Second, the change in temperature is observed in a *c.* 300 metre deep water column, *i.e.* the habitat of the marine fauna under study. Therefore, the seemingly small temperature change corresponds to the transfer of huge amounts of energy. Similar temperature drops have also been recorded in many other marine records in the Mediterranean basin, although these can of course have resulted from various factors, *e.g.* cold water circulation from one basin to another. As mentioned above, the focus of this paper is on the SST fluctuations observed in core LC21 during RCC periods, since these are primarily caused by wind induced cooling of the water surface.

The RCC-mechanism

Perhaps the most remarkable result of LC21 studies was the recognition that the rapid SST variations observed in this core resulted from the rapid movement of extremely cold air masses over the surface of the Aegean Sea. The location of core LC21 close to Crete makes it particularly sensitive to the expansion and contraction of cooler northern Aegean waters, *i.e.* it lies at the southern point of these water masses, in a position that is especially sensitive to the cooling effects of winds sweeping down from the Balkans. Before reaching the LC21 core location, north-easterly (RCC) winds would have already traversed the sea surface over a distance of some 700km. Since the RCC winds are predominantly winter/early spring phenomena and typically only occur for a few days at a time, the energy transfer between surface water and wind must proceed quite rapidly. Therefore, there are strong indications that in certain (RCC) periods during the Holocene, large amounts of cold air must have been available in the northern Aegean, but typically only for a short time during winter and early spring. The ability of the cold north-easterly winds to induce so much energy transfer from the LC21 water column (~300m) in such a short time (max ~100 yrs) during RCC periods, at-

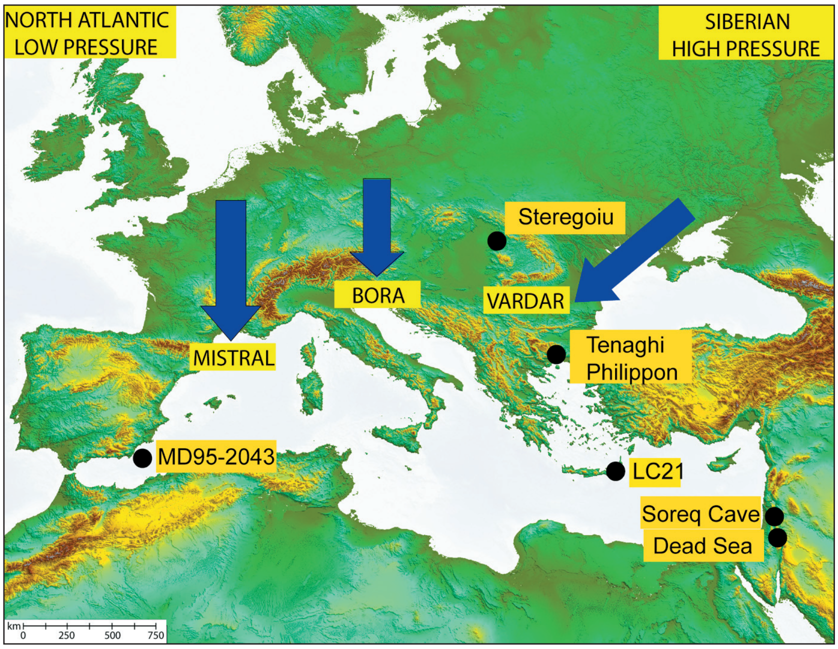


Fig. 2. Map showing locations of RCC-study sites and important RCC-winds. SRTM Global Bathymetry and Elevation Data: courtesy of **Becker et al. 2009.** *Mapped using Lambert Equal-Area Projection by Globalmapper.*

tests to the remarkable intensity of the cold polar/ continental airflows.

Correlation of Aegean sea surface temperature and Siberian high pressure

Now that the basics of the water cooling mechanism are understood (water evaporation caused by extremely cold and dry air flowing rapidly over a warm ocean surface), the question arises as to the source of this cold air. General meteorological considerations and modern observations indeed suggest Siberia as a likely source region. This atmospheric path (Siberia–>Aegean) has been proposed for cold air masses during the Holocene on the basis of an unusually high correlation between the LC21 SST record and the non-sea-salt (nss) [K^+] chemical ion concentration measured in the Greenland GISP2 ice-core (72.6° N, 38.4° W, +3200 m height). High [K^+] values are coincident with an intensification of the semi-permanent Siberian high pressure zone (*Mayewski et al. 1997*).

The correlation between Aegean SST and Greenland GISP2 nss [K^+] is of major importance for our studies. It provides not only a meteorological mechanism for RCC, and therefore an explanation for RCC, but also a long and continuous (~60 ka; *cf.* Fig. 4), and very precise (GISP2 ice-core based) time-scale that can be applied to all fields of RCC-research. This being the case, the next question is whether it is possible to identify the effects of RCC at terrestrial sites.

Steregoiu (Romania)

Recently published high-resolution pollen records from Steregoiu (47° 48' 48" N; 23° 22' 41" E; 790 m.a.s.l) and Preluca Tiganului, two fen-peat sites in northwest Romania, have provided the first evidence that movements of extremely cold air associated with the RCC-mechanism had a massive ecological impact in Southeastern Europe in the past (*Feurdean et al. 2008*). At these locations there are indications for rapid air temperature drops (> 4°C), at least during the 8.2 ka and the 3.0 ka calBP RCCs. Intriguingly, in the Steregoiu record there is additional evidence for the existence of a further RCC at 10.2 ka calBP that is not visible in LC21. The temperature reconstruction for Steregoiu is based on calculations performed for eight modern analogues. Figure 1 shows the estimated [°C] temperature of the coldest month (MTC). In this record, even the 3.0 ka calBP RCC is represented (if only with one data point). The 8.2 ka calBP event is unequivocal (but see below for critical discussion of what we are actually seeing here), and as previously mentioned, there is good evidence for a strong RCC period around 10.2 ka calBP.

Certainly, one might now ask why the clearly discernable GISP2 nss [K^+] peak at 10.2 ka calBP (Fig. 4) was not already defined as an RCC event by Mayewski *et al.* (*2004*). The reason for this lies in the fact that this research deliberately avoided the Early Holocene section of the GISP2 nss [K^+] record so as to minimise the risk of confusing RCC with post-Younger Dryas North Atlantic melt-water events. The mechanism underlying the GISP2 K^+ peak at 10.2 ka calBP remains unknown, and it is for precisely this reason that it is interesting to see the environmental impact of an Early Holocene cold event dating to 10.2 ka calBP in northwest Romania. The sites at Steregoiu and Preluca Tiganului are located at a considerable distance (~700km) from the North Atlantic, but equally distant (~700km) from both the Aegean coast and the Black Sea. Strictly speaking, just as for the 8.2 ka calBP cold signal at Tenaghi Philippon (*Pross et al. 2009*), the cause of the 10.2 ka calBP event in Romania remains to be established, although it has been suggested it was caused by perturbation of the North Atlantic circulation (*Feurdean et al. 2008*). According to the pollen-based temperature reconstructions, whereas a significant drop in (average) at both sites during RCC intervals a significant drop in (average) winter temperatures in the order of 4°C has been estimated for both sites during RCC intervals, summer temperatures during RCC intervals appear to have been comparable to those currently prevailing. Cold episodes around 10.2 and 7.8 ka calBP have also been recorded in $\delta^{18}O$ values in speleothems from northwest Romania (*Tamas et al. 2005*). Calculated annual (average) RCC precipitation rates are significantly higher than at present. It remains to be mentioned that from no other region of Southeastern Europe do we presently have evidence for the impact of the (expected) RCC at 3000–2930 calBP.

Hudson Bay outflow (classical 8.2 ka calBP event)

As is well-known from Greenland ice-core stable oxygen records (Fig. 1), temperatures in the North Atlantic region dropped abruptly around 8200 years ago, only to recover over the course of the subsequent *c.* 160 years (*Thomas et al. 2007*). It is now widely accepted that the observed cooling was caused by the catastrophic collapse of a remnant Laurentide ice-dome and subsequent drainage of large amounts of melt-water from the Hudson Bay (alias proglacial Lake Agassiz) into the North Atlantic (*Barber et al.*

1999). Theoretical studies (*e.g. Renssen et al. 2001; 2002; Bauer et al. 2004*) confirm that the amount of fresh water stored in Lake Agassiz would have been sufficient to lower the surface water density in the North Atlantic below the threshold value for salinity-driven (contrasting wind-driven) deep-water formation (*cf. Rahmstorf 2003*). Further, these studies demonstrate that the Hudson-Bay outflow could indeed have triggered, and upheld, a reduction of the thermohaline circulation (THC) for many hundreds of years, depending on the amount of freshwater released and the duration of the freshwater pulse. Naturally, there are still questions concerning, for example, the THC slowdown mechanism and the spatial extent of the associated supra-regional air temperature reduction.

Most importantly, however, and as pointed out by Rohling and Pälike (*2005*), the sharp peak so prominent in the Greenland $\delta^{18}O$ records is, in fact, only one specific component (dating *c.* 8.2–8.0 ka calBP) within the much broader climatic anomaly identified in many proxies on a global scale (typically dating *c.* 8.6–8.0 ka calBP). The compounded nature of these signals, and specifically the temporal overlap of the (oceanic) Hudson Bay outflow event with the (atmospheric) 8.6–8.0 ka calBP GISP2 RCC period, implies that we should be cautious with far-reaching interpretations of the Hudson Bay event until the underlying mechanisms and potential combined effects are better understood.

Tenaghi Philippon (Northern Greece)

Further terrestrial evidence for the expected massive ecological impact of the movement of extremely cold RCC air in the Northeastern Aegean during RCC periods is provided by pollen data from Tenaghi Philippon, North Greece (*Pross et al. 2009*). Here, during the 8.2 ka calBP RCC event a significant reduction in tree-pollen is observed that is representative of a decline in winter temperatures of more than 4°C. The shape of the pollen decline record has close similarities to the classical 8.2 ka calBP 'Hudson Bay' event. Although this suggests a direct southern European atmospheric response to changes in North Atlantic thermohaline circulation, here we must note the occurrence of exactly that scenario referred to above, *i.e.* that at Tenaghi Philippon the effects of the Hudson Bay outflow and of RCC may be compounded (*Rohling and Pälike 2005; Pross et al. 2009*).

MD95–2043 (west Mediterranean)

Since the Mediterranean basin is practically isolated from North Atlantic oceanic circulation, the transmission of climate signals from the North Atlantic to the Eastern Mediterranean must proceed via the atmosphere. For this reason, we expect differences between climate development in the Holocene in the east and west of the Mediterranean. Although our present focus is on the Eastern Mediterranean, a high-resolution climate record (core MD95–2043) from the Western Mediterranean is included in Figure 1 for comparison (record B). Due to the existence of anticyclonic gyres in the Alborán Sea at this location (Fig. 2), it is possible to register low-salinity surface waters that derive from the North Atlantic. Palynological studies on core MD95–2043 (*cf. Fletcher et al. 2008*) have shown the high sensitivity of this location to rapid climate variability during the last glacial period. For example, during interstadial conditions, rapid forest expansion is observed on the Iberian Peninsula, whilst forest contraction is observed during stadials. It is therefore interesting to explore whether this high-resolution also provides evidence for Holocene RCC events. As can be seen in Figure 1 (record B), there are indications in core MD95–2043 of SST decline (in the order of 2 °C) during some of the RCC time intervals (*cf.* shaded RCC events ~10.2 ka; ~8.6–8.0 ka calBP; ~6.0–4.2 ka calBP). Regarding the 3.1–2.9 ka calBP RCC in the Western Mediterranean, pollen records indicate the occurrence of short-term arid phases in the southern Iberian Peninsula (*Carrión 2002; Fletcher et al. 2007*). These correspond chronologically with enhanced flood frequencies in the Lower Moulouya Basin of northeast Morocco (*Zielhofer et al. 2009; in press*).

Bond events (north Atlantic)

Further conspicuous evidence that the generally warm and supposedly stable Holocene climate was repeatedly punctuated by a sequence of abrupt cooling events comes from the North Atlantic. First identified some 12 years ago (*Bond et al. 1997*), the existence of periods of intensified ice drifting across the North Atlantic is now well-established for the Glacial. Detailed source and material analysis of lithic grains has shown that these materials were transported on icebergs ('ice-rafting') and deposited on the ocean floor when the icebergs melted ('Heinrich events'). The icebergs originated from glaciers on the western side of the North Atlantic. Unfortunately, the corresponding Holocene drift-ice record, which uses stacked petrologic tracers from cores MC52–V29191+MC21–GGC22 (Fig. 1; *Bond et al. 2001*), is not sufficiently well-dated for application per se in archaeological high-resolution climate studies. Nevertheless, it does provide additional evidence for the existence of cooling anomalies in the Holocene, most notably around 9.5 ka calBP (perhaps the 9.4 ka calBP GISP2 nss [K^+] peak) and again around 7.5 ka calBP, (without convincing GISP2 nss [K^+] peak). In the Bond event sequence, the 3.1–2.9 ka calBP GISP2 nss [K^+] -defined RCC has the curious appearance of a double peak; this requires further study.

Frozen Bosporus (northwest Turkey)

A modern climate analogue record for our study area is supplied by the historical eye-witness documentation of winter-freezing events in the Bosporus region (*Yavuz et al. 2007*). The Frozen Bosporus record builds on the observed freezing over of the narrow Bosporus/Marmara waterway caused by ice masses pushed into the Bosporus from the Black Sea by strong, cold and dry winds blowing from the northeast. Since it is no easy matter to freeze salt water, we have here a vivid illustration of the intensity of the cold winds needed to produce the observed masses of floating icebergs, and transport them downwind (although supported by strong surface currents) from the Black Sea through the Bosporus and the Marmara Sea, and even as far as the Dardanelles (the location of Troy).

What we observe in the historical Bosporus record is a strong clustering of freezing events between 1600 and 1929 AD, quite in line with the GISP2 nss [K^+] peak cluster during the Little Ice Age (LIA). Due to the likely bias in the historical documentation towards younger events, this record cannot be applied directly to instrumental calibration. A further disadvantage is the non-linearity of this record, since salt water freezing has a threshold value depending on salinity, *i.e.* around −2 °C lower than freshwater. Nevertheless, the Bosporus record does supply a useful illustration of climatic effects to be expected in this region during RRC times.

During the LIA, it appears that the most severe winters were regularly accompanied by the often complete freezing over of the Bosporus, the Golden Horn, and parts of the Black Sea. Such freezing events were observed in the years 1621, 1669, 1755, 1779, 1823, 1849, 1857, 1862, 1878, 1893, 1928, 1929, and – most recently – in 1954. The 1954 freezing originated not directly from local RCC winds, but from the dynamiting of the ice-blocked Danube, with icebergs subsequently drifting into the Bosporus (*pers comm, Mehmet Özdoğan 2008*). Interestingly, again early in 1954, the Prehistoric Department at Istanbul University was difficult to access for many weeks due to metre-deep snow (*pers comm, Mehmet Özdoğan 2009*). Regardless of whether or not we count 1954 as a RCC-year, these observations provide a glimpse of the widespread effects of extreme cooling to be expected in the Eastern Mediterranean during RCC periods.

Transferred to prehistoric RCC periods, the Bosporus event sequence suggests an average of at least one catastrophically cold winter per generation (~25 yrs). Interestingly, the intensity of the cold spells appears to have gradually diminished during the last three centuries (*Yavuz et al. 2007.646*). These observations are of immediate interest for our understanding of the abandonment of Troy (northwest Anatolia) during the 3.0 ka calBP RCC, as well as for the general timing of the Aegean Dark Ages, should this indeed be the result of RCC (*cf.* discussion below). For the sake of completeness, we finally note that the frequency analysis of historical eye-witness accounts of the freezing of the River Thames during the last 1000 years (*Currie 1996*) shows a similar density maximum during the LIA period 1600–1928 AD (Fig. 3). Again, we cannot exclude a bias towards younger observations.

The Glacial GISP non-sea salt (nss) potassium [K^+] concentration record

It is informative to extend discussion of the GISP2 nss [K^+] record further back in time into the glacial periods. Over its entire extent, the GISP2 record shows a clear anti-correlation between the stadial-interstadial sequence defined by stable $\delta^{18}O$ oxygen isotopes and the nss [K^+] series. Detailed examination of the GISP2 chemical ion series (*Mayewski et al. 1997*) has shown that not only [K^+], but the ma-

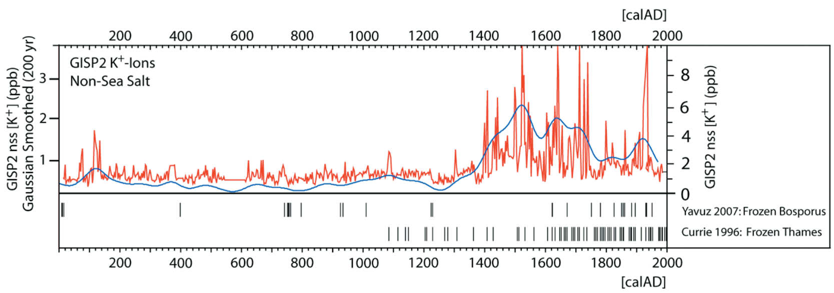


Fig. 3. Freezing Events during the last 2000 years in the Bosporus, the southern Black Sea and Marmara region, derived from historical documents (**Yavuz et al. 2007*****), compared to the GISP2 nss [K^+] ion record (*****Mayewski et al. 1997; 2004*****). Also shown is the historical record (1000–2000 AD) of the Thames freezing (*****Currie et al. 1996*****).***

jority of measured chemical species (Ca_2^+, Mg_2^+, Na^+, Cl^-) rise and fall in concert with the Greenland stadials and interstadials, respectively, with the exception of NH_4 and NO_3. Each species has its own environmental signature, but in combination they map an intensification of the atmospheric dust flux (*i.e.* polar circulation) during Greenland Stadials, and a reduction in polar circulation during Interstadials (*Mayewski et al. 2004*). Prior to the Holocene, the coldest and windiest periods in high-latitudes (including North America, Europe, and the Northeastern Mediterranean) are those with high [K^+] values.

One of most conspicuous and most often studied time-intervals covered by the GISP2 record is the cold and dry Younger Dryas (YD). It is characterised, like other stadial periods, by high GISP2 nss [K^+] values (Fig. 4). However, due to the dominant role of North Atlantic Ocean circulation in its formation, the YD is not rated by Mayewski *et al.* (*2004*) as an RCC event *sensu strictu*. Instead, the RCC designation is reserved solely for atmospheric circulation patterns. For the pre-Holocene periods this is most notably the case for Greenland stadials, although continuously high GISP2 nss [K^+] values are also observable during the Late Glacial Maximum (LGM) (Fig. 4). Due to the RCC definition (*Mayewski et al. 2004*), with its clear focus on atmospheric circulation (contrasting oceanic circulation), the GISP2 nss [K^+] record (Fig. 4 lower) is probably even more useful for archaeological applications than the presently most frequently referenced GISP2 stable oxygen isotope record.

For example, during the LGM the landscapes of much of Central Europe comprised inhospitable steppe and were open-forested. Not unexpectedly, therefore, during this period a major population decline is observed in Central Europe. In terms of human tolerance towards extreme cold, the climate modelling studies by the Cambridge Stage 3 Project have identified wind-chill, along with snow cover, as the two most important hominid-related climatic variables underlying Palaeolithic landscape use and migration patterns (*van Andel et al. 2004*).

Modelling studies: glacial rapid climate change

Evidence that the RCC mechanism is at work – not only during the Holocene (as is presently best shown by LC21) – but also during Glacial periods, is obtained from reconstructions of glacier ablation line displacements. These show that atmospheric configurations similar to the LIA were manifest in intensified form during the Last Glacial Maximum (LGM), some 19–23 000 years ago (*Kuhlemann et al. 2008*). In this work, which is of immediate relevance to archaeological studies, it is shown for the LGM that the cooling associated with enhanced GISP2 nss [K^+] values was accompanied by a lowering of the equilibrium line altitude (ELA) for glacier formation by up to 1500m in the circum-Mediterranean mountain chains.

Furthermore, during glacial RCC periods, due to funnelling effects between the Alps and the Pyrenees, an invasion of polar air masses into the Western Mediterranean is to be expected, particularly down the Rhône valley into the Gulf of Lyons, just as for the Eastern Mediterranean (*Kuhlemann et al. 2008*). Although derived for glacial conditions, which would have been more extreme than today due to the more southerly position of the LGM polar front, similar conditions can be expected for the Holocene RCC time intervals.

The 10.2 ka calBP RCC event

What can also be deduced from Figure 4 is the exceptional amplitude of the GISP2 nss [K^+] record at ~10 277 calBP (GISP2). We associate this peak with a new RCC not previously defined by Mayewski *et al.* (*2004, cf. above*). The 10.2 ka calBP nss [K^+] peak is sufficiently removed from the nearest SO_4-peak in terms of GISP2 ages, as well as in GISP2 core depth, to exclude influence from neighbouring strong volcanic SO_4 activity dating to ~10 325 calBP (GISP2). Hence we can state with some confidence that the 10.2 ka calBP [K^+] peak is unlikely to have resul-

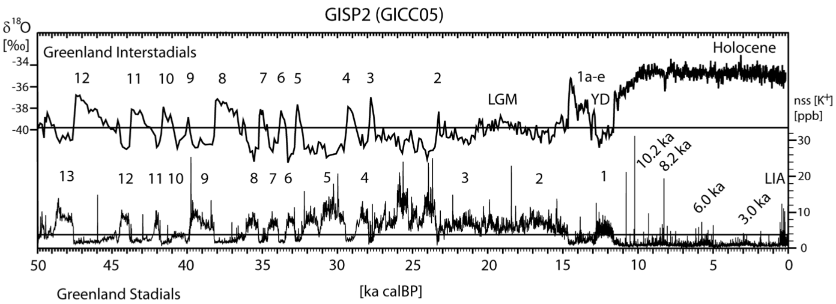


Fig. 4. Glacial GISP2 nss [K⁺] chemical ion record in the time-window 0–50 ka calBP (**Mayewski et al. 1997; 2004*****). GI – Greenland Interstadial (GI numbers*** **cf. Johnsen et al. 1992*****); LGM – Last Glacial Maximum, YD– Younger Dryas. Holocene RCC-periods are indicated at ~10.2 ka, ~8.2 ka, ~6.0 ka, ~3.0 ka and Little Ice Age (LIA). Age. GISP2 records are presented on U/Th-Hulu age-model (*****Weninger and Jöris 2008*****). Greenland stadials are defined by δ¹⁸O minima (*****cf. Johnsen et al. 1992*****).***

ted from volcanic activity. The possibility that this peak is related to biomass burning is also unlikely, since there are no unusual amounts of NH_4 in the corresponding GISP2 ice-sample. It is important to note that all GISP2 ion measurements stem from the same ice sample. For this reason, we infer that the source of the 10.2 ka calBP GISP2 nss [K^+] deposit – as is the case with all other RCC events – must lie in atmospheric crustal dust transported from Asia to Greenland. This is the dominant atmospheric path underlying [K^+] in all sections of the GISP2 record. Further, judging from its intensity (Fig. 4), the 10.2 ka calBP [K^+] represents one of the most intense cold events to have occurred during the last 50 kyr. Indeed, this deposit appears even stronger than the GISP2 nss [K^+] event dating to 40 ka calBP (GISP2). Interestingly, the 40 ka calBP GISP2 nss [K^+] peak is distinct in time (by ~50 years) from the Campagnian Ignimbrite Eruption. The time difference of 50 ice-yrs corresponds to 2–4 samples at given GISP2 depths.

Sapropel S1 (Eastern Mediterranean)

Sapropel S1 is yet another important RCC record that stems from the marine domain in the Eastern Mediterranean, but which has strong supra-regional climate connections to the lower latitude Monsoon regime. Sapropels are dark, organic-rich sedimentary deposits that can be found throughout the Mediterranean basin. The formation of sapropels occurs when the ventilation of the ocean floor is interrupted, *i.e.* when the ocean surface is diluted with buoyant fresh water. Accordingly, fresh water inhibits the formation of deep-water, thus starving the benthic fauna (ocean-bottom species) of oxygen. Beyond their formal identification as thick black layers in sediment cores, sapropels are characterised by a reduced salinity (salt concentration) of surface water at the time of deposition, and by their stable oxygen isotope composition. The latter can be measured in the varying frequency of selected planktonic (surface-living) foraminifera. Sapropels are common throughout the Mediterranean basin, and are among the most important marine indicators for enhanced precipitation/runoff.

The formation of sapropels in the Eastern Mediterranean during the Early Holocene is related to a strong increase in summer rainfall (*e.g. Rohling and Hilgen 1991; Rohling 1994; Ariztegui et al. 2000*). Since any change from dry to humid conditions can be expected to have a considerable influence on the development of vegetation, thereby affecting practically all kinds of human food resources, they may be used in archaeological studies as important general indicators for (terrestrial) rainfall variation. However, prior to the consultation of sapropels for the purpose of archaeological RCC studies in the Holocene, it is essential that three specific requirements are met: (i) there must be an accurate and precise chronology of Eastern Mediterranean Sapropel S1 formation; (ii) the predicted precipitation changes must be substantiated by terrestrial climate data; and (iii) the combined precipitation record must be placed alongside the precise GISP2 nss [K^+] chronology and in relation to the archaeological events under study. Only then can we confidently forecast climatically-induced social responses and processes.

The LC21 core record has recently been integrated into a supra-regional multiproxy chronostratigraphic framework (*Casford et al. 2007*). Within this framework special attention has been placed on the derivation of reliable (statistically robust) ages for the beginning and end of Sapropel S1. Accordingly, the most reliable age for the onset of Sapropel S1 is 9920±240 calBP; the end of Sapropel S1 is dated to 6806±240 calBP. Both ages are noted here at the 2σ level (95% variance) and have been derived using standardised depths of 174.5 cm (for the base) and of 131.0 cm (for the top) of the Sapropel S1 dark layer in core LC21 (*Casford et al. 2007; ebda., Tab. 4*, Number 1 & equation in Fig. 5).

Complementary climate records: precipitation (Dead Sea levels)

The Holocene Dead Sea lake level record (Fig. 5) recently published by Migowski *et al.* (*2006*) provides a rain gauge with tremendous predictive capabilities for Near Eastern archaeology, and especially for the Jordan valley, with its rich cultural heritage. In combination with other lower latitude climate proxies, the Dead Sea record is given a central position in the present study. Notwithstanding, there are several points that need to be made regarding this proxy. Firstly, the Dead Sea level responds primarily to precipitation changes in the northern Jordan Valley which are channelled down-valley from the Lake Kinneret basin. Secondly, due to its high salinity, the Dead Sea itself does not provide the fresh-water necessary to support farming communities.

Thirdly, there is a pronounced non-linearity in the relation between (hypothetical) Levantine precipitation and (measured) Dead Sea lake level. This non-linearity is due the fact that the Dead Sea comprises two closely connected sub-basins separated by a sill at ~402–403m bmsl (*Migowski et al. 2006.422*).

The deep northern basin is fed mainly by the Jordan and to a lesser extent by local runoff. When the waters of the northern basin rise to levels above the sill, overflowing waters flood the shallower southern basin. In this case the combined lake area, and therefore total evaporation, rises significantly. Therefore, very high precipitation is required to simultaneously raise the water level of the northern basin above the sill and to maintain this high level against enhanced evaporation. Conversely, when the northern basin drops significantly below the sill during extreme arid periods, salt is deposited in the centre of the lake. This important process is not evident in the level graph (Fig. 5).

To support the interpretation of the Dead Sea record, particularly with respect to this non-linearity, we have drawn a dashed horizontal line in Figure 5 at the sill height of ~402.5m. Allowing for such scaling complications, the Dead Sea level represents an invaluable document for climate-archaeological research in the Levant. It remains to be mentioned that the Dead Sea record is derived from multiple cores with an age model based on a large set (N = 38) of precise AMS ^{14}C-ages measured on 'organic relics' (*Migowski et al. 2006. 428*, Appendix A) at the Kiel laboratory.

Of outstanding interest for RCC studies is the very abrupt rise in lake level at approximately 10.1 ka calBP, which sees water rise from a level below *c.* 430 bmsl to a height of ~380 bmsl (Fig. 5). This level is maintained for about 500 years before it drops by approximately 10m to around 370 mbsl at ~9.4 ka calBP. Migowski *et al.* (*2006*) attach a number of question marks to the (oscillating?) heights measured between 9.4 ka and 8.6 ka calBP; however, water levels are still clearly higher than the sill. At around 8.6 ka calBP, the water level drops significantly to a level some 10m below the sill, followed at *c.* 8.1 ka calBP by a further drastic decrease, when the level plummets by a further 15m to approx. 428 bmsl, the lowest ever recorded value in the Holocene. After recovering slightly to ~405 mbsl at around 7.5 ka calBP, relatively low level conditions continue until 5.6 ka calBP. Thereafter, several fluctuations are observed until a second conspicuous maximum at 370 mbsl is reached. This maximum is maintained for ~400 yrs, between 4.0 ka and 3.6 ka calBP. Then, once again, at around 3.2 ka calBP there occurs a significant drop, by 60m, to a lake level well below the sill (Fig. 5, *Migowski et al. 2006*).

Regional predictions using combined RCC-precipitation data (Near East)

Comparisons with other climate records (Fig. 5) show that the abrupt rise in Dead Sea level at 10.0 ka calBP corresponds well (within error limits of ± 100 yrs) with the onset of Sapropel S1. The extremely large Dead Sea level drop to ~428 mbsl, dating between 8.1 ka and 7.5 ka calBP, is to some large extent synchronous with the Sapropel S1a-b interruption. This is indicative of a major arid period in the Jordan Valley, and appears to run parallel to supra-regional aridity as indicated by the synchronicity with the Sapropel S1a-b interruption. Most im-

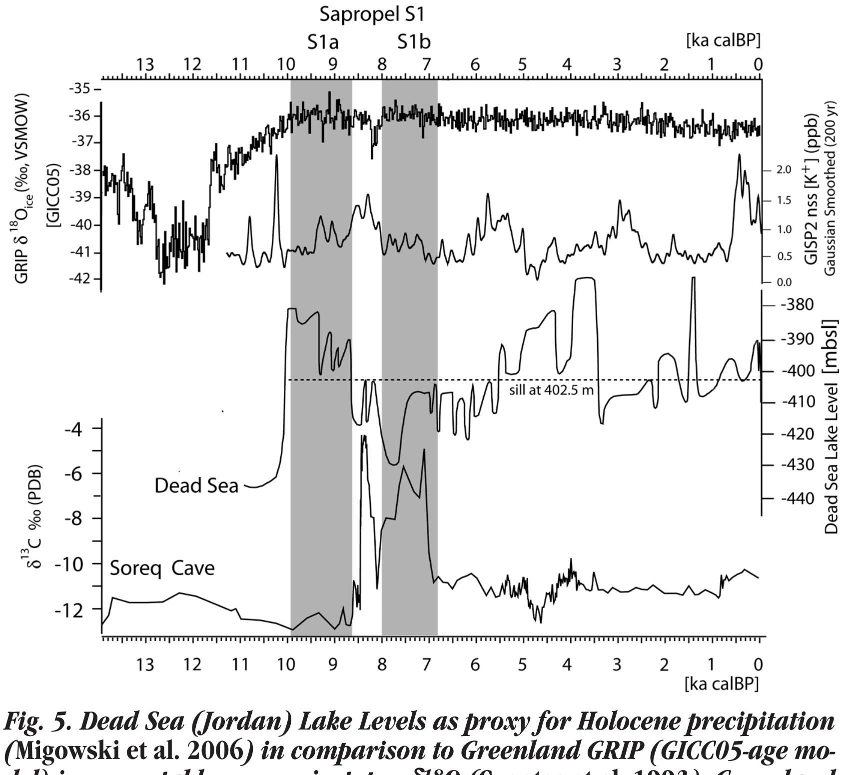


Fig. 5. Dead Sea (Jordan) Lake Levels as proxy for Holocene precipitation (**Migowski et al. 2006*****) in comparison to Greenland GRIP (GICC05-age model) ice-core stable oxygen isotopes $\delta^{18}O$ (*****Grootes et al. 1993*****), Greenland GISP2 ice-core nss [K$^+$] chemical ions as proxy for Rapid Climate Change, (*****Mayewski et al. 1997*****), and Soreq Cave (Israel) $\delta^{13}C$ record as proxy for flash-flood intensity (*****Bar-Matthews et al. 2003*****). Shaded area indicates Sapropel S1 with onset ~9.9 ka calBP and end ~6.8 ka calBP) according to Casford et al. (*****2007*****), and interruption between S1a and S1b assumed c. 8.6–8.0 ka calBP (see text).***

portantly, the drought conditions in the Levant coincide with the 8.6–8.0 ka calBP RCC (Fig. 5).

Together, these records provide tantalising evidence for an extended period (10.1–8.6 ka calBP) with enhanced rainfall in southern Jordan and, by implication, perhaps even in the entire Levant. This wet period started abruptly, shortly after the 10.2 ka calBP cold-event, and came to an abrupt end at the onset of the next younger RCC at 8.6 ka calBP. A further GISP2 nss [K^+] peak at 9.5 ka calBP might also be related to Dead Sea low stands, and North Atlantic impact is suggested by its age-correlation with a Bond event of similar age (Fig. 1). However, caution is advised in the interpretation of all such correlations, particularly as the Monsoon-related Q5 cave record from Oman (*Fleitmann et al. 2003*) also shows a marked signal at around 9.5 ka calBP.

Early Holocene climate in the Near East

At this point, we recapitulate our general understanding of the climate system in the wider Near East, and provide a set of regional predictions for Early Holocene Rapid Climate Change in the Levant. By comparative study of climate records from the Jordan Valley (Dead Sea Lake Levels), the Aegean Sea (marine core LC21), the Red Sea (core GeoB 5844-2) and Greenland GISP2 ice-core records (Fig. 1) the following key messages can be formulated:

● The Jordan Valley was extremely wet from *c.* 10.0–8.6 ka calBP. We use the term 'Levantine Moist Period' (LMP) to characterise the high levels of precipitation in this time-interval. The LMP is presently best-documented in Dead Sea lake levels (*Migowski et al. 2006*) and low Red Sea salinity (*Arz et al. 2003*). In the Dead Sea record the LMP is recognised as an approx. 1400-year period, with high lake levels that resided continuously above the sill separating the northern and southern basins. During the LMP, it appears that both basins were filled.

● Following a brief (~200 yrs), but extremely cold RCC event at 10.2 ka calBP, the LMP commences abruptly at 10.0 ka calBP, and wet conditions are maintained for the following 1400 yrs.

● The LMP ends abruptly and immediately prior to the onset of the next RCC (8.6–8.0 ka calBP) interval. During both RCC events (10.2 ka and 8.6–8.0 ka calBP) the Eastern Mediterranean was punctuated by regular winter/spring outbreaks of extremely cold polar air masses. During these RCC periods the region would have been regularly 'bathed' – perhaps for days on end and maybe even for weeks in winter and early spring – with air masses directly from Siberia.

● Consistent with meteorological expectations, and independently confirmed by the major drop observed in Dead Sea Lake Levels (*Migowski et al. 2006*), during the entire 8.6–8.0 ka calBP GISP2 RCC event the Jordan Valley experienced an extended drought. On the basis of the Soreq Cave record (*Bar-Matthews et al. 2003*) it is likely that this drought period may have been interrupted by major episodic torrential rainfall events.

ARCHAEOBIOLOGICAL RECORDS

Early domestication of cereals in the Near East

The cultivation of wild cereals began during the very late Younger Dryas (YD), continuing during the Pre-Pottery Neolithic A (PPNA) period (*Willcox et al. 2009*). In correlation to the slow increase of precipitation following the end of YD, annual harvesting would have become increasingly successful, and, as known from experimental studies, the process of steady cultivation ended with the appearance of the cultigens. Therefore, it is not surprising that the rapid onset of the Dead Sea moist period at ~10.1 ka calBP displays a highly positive temporal correlation to an almost simultaneous appearance at many sites in the Near East of domesticated cereals (see below). These sites could represent budding-off communities, in line with a related demographic increase due to the success in this early phase of farming (*cf.* Neolithic Demographic Transition: *Bouquet-Appel and Bar-Yosef 2008*).

This trend is clearly visible in Figure 6 where archaeobotanical findings from Near Eastern sites are arranged according to age (calibrated ^{14}C-ages) and cultural period; sites are classified into three different categories: (i) use of wild cereals (green); (ii) use of domesticated cereals (blue); and (iii) unclear crop status (black). The archaeobotanical data are taken from Nesbitt (*2002.Tab. 1*), with conventional ^{14}C-ages replaced here (Fig. 6) by calibrated ^{14}C-ages. The crop status-coded sites are shown in context with the Dead Sea level record of Migowski *et al.* (*2006*). Featured sites are located in Southeastern Turkey, Syria, Israel, and Jordan. Within dating errors, the earliest use of genetically changed cereals coincides everywhere in these regions (within *c.* ± 100 yrs, 68%) with the abrupt increase in precipitation as documented in Dead Sea levels. As discussed in the next section of this paper, further correlations should follow from this, and indeed do; for example, the contemporaneous onset of large villages that marks the beginning of the Middle Pre-Pottery Neolithic B (MPPNB) tradition.

Early domestication of goats in the Near East

Following Zeder and Hesse (*2000*), the earliest (culturally) domesticated goats in the Near East are presently known from the site of Ganj Dareh in the Zagros Mountains. This claim is based on a set of twelve AMS ^{14}C-ages on goat bones (Capra hircus aegagrus). As already pointed out by the authors, these ages fall within a remarkably narrow time-window, especially considering that the dated bone samples were collected from five different stratigraphic levels (A to E) of the 7-metre-deep tell settlement.

According to the accumulative ^{14}C-age calibration diagram (Fig. 7), the Ganj Dareh ^{14}C-ages lie in such temporal proximity that it is difficult to further differentiate between the different bone ages on the basis of the given ^{14}C-values. There is good agreement of these ^{14}C-ages with previous AMS-measurements on seeds (hordeum) from the same layers (B, C, D, and E) (Tab. 1). We therefore support the proposal of Zeder and Hesse (*2000*) that site occupation at Danj Dareh must have been brief, probably no more than one or two centuries. As can be deduced from Figure 7, ^{14}C-ages correspond closely with the onset of moist conditions around 10.1 ka calBP, *i.e.* the beginning of the Levantine Moist Period. However, we realise that the existence of a close correlation between any two variables does not prove the existence of a causal relation between them.

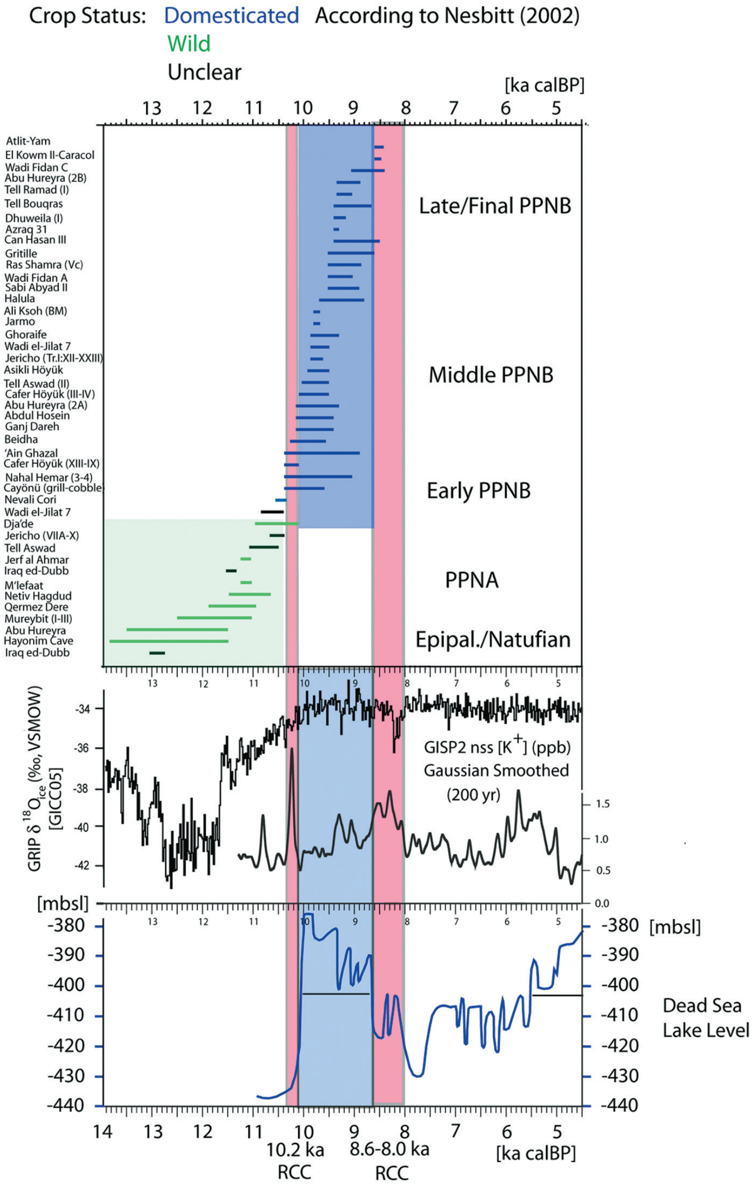


Fig. 6. Archaeobotanical records for cereals (crop status: wild, domesticated, or unclear) arranged according to site age and cultural periods after Nesbitt (*2002*) compared with Greenland GRIP stable oxygen isotopes (*Grootes et al. 1993*), Greenland GISP2 nss [K^+] values (*Mayewski et al. 1997; 2004*) and Dead Sea Lake Levels (*Migowski et al. 2006*). Note: the archaeobotanical data shown here are from Nesbitt (*2002: ebda. Tab. 1*), with the replacement of conventional ^{14}C age values by tree-ring calibrated ^{14}C dates.

SOCIAL RESPONSES TO RAPID CLIMATE CHANGE

There are good (ethnographically documented) reasons to link (archaeologists seldom say: correlate) the beginning of farming and herding in the Early Holocene in the Near East with major changes in social organisation (*Cauvin 2000; Bar-Yosef 1998; 2001; Kuijt and Goring Morris 2002; Nesbitt 2002*). To date, however, researchers have been reluctant to add the next link, *i.e.* that between social organisation, based on domesticated animals and plants, and the supporting climate conditions. According to contemporary archaeobiological modelling, significant social changes are to be expected when mobile and semi-sedentary lifestyles based on hunting and gathering are replaced by farming and herding in permanent settlements. Since plant domesticates have nutritional advantages, and these advantages can be optimised in combination with animal husbandry, it is further to be expected that the transition from gathering to cultivating will be accompanied by local population growth.

It is significant that once domesticated cereals and animals have become available, farming communities can literally take these resources (plants, animals) and carry them into regions far beyond those parts in which their wild forms occur. In theory, all of these factors acting together, *i.e.* the adaptation of agriculture and active animal management, *should* lead to major demographic growth on a supra-regional scale. There are, of course, questions that remain unanswered. Did this envisaged population growth really occur, and – if so – where and under which cultural, economic and religious circumstances; and how can we best measure prehistoric population size?

A review of contemporary studies on these major issues of prehistoric research in the Near East confirms the above expectations to some extent, but only to first-order and with varying degrees of uncertainty and ambiguity. For example, according to recent studies on animal domestication in SE Turkey (*Ilgezdi 2008*), there is evidence from Çayönü, as well as from Nevali Çori and Göbekli Tepe, that the establishment of these early permanent villages did not depend on animal domestication, nor on crop cultivation. For an extended time period the economies of these sites were based on hunting wild animals and gathering wild crops. We may also expect major site-specific differences, depending on site function. For example, at religious centres an extended use of hunted game would be understandable, given that people tend to keep to old traditions. There are presently only a few sites which have supplied sufficient ^{14}C-data to study such questions. We take a closer look at the site chronology of Çayönü below.

Strongly effecting our present RCC-forecasting is the fact that it is impossible to separate the 10.2 ka calBP GISP2 nss [K^+] RCC peak from the onset of LMP. In addition to the statistical (^{14}C-measurement) as well as ^{14}C-age calibration errors for the LMP-onset, we must allow for errors in the GISP2-age model. To simplify the discussion, in the following we define the RCC/LMP time slot as an error-prone (±100 years, 68%) combined age marker of ~10.1±0.1 ka calBP. This does not imply that both processes are synchronous. It is simply not yet possible to separate them in time. Strictly speaking, we do not even know their order.

NEAR EASTERN EARLY HOLOCENE CULTURAL DEVELOPMENT

Having completed the presentation and discussion of the RCC proxies, in the second section of this paper we turn to archaeological case studies, in chronological order, from old to young. The case studies are further assembled geographically and cover selected study areas; we begin in the Levant (Jordan, Syria, SE-Turkey, Cyprus) where our first focus is the 10.2 ka calBP RCC event. Subsequently, for the younger RCC-events we move ever westwards, through Turkey, Greece, Bulgaria, and finally to Romania.

Near Eastern Early Holocene chronology

All the studies in this paper are based on a large archaeological radiocarbon database for the Epipalaeo-

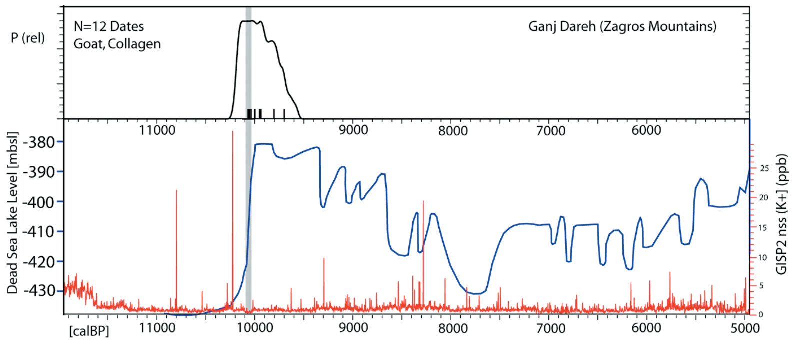


Fig. 7. Radiocarbon Data from Ganj Dareh (Zagros Mountains, NW-Iran) for the earliest (known) domesticated goats (*Zeder and Hesse 2000*), shown in comparison to Dead Sea (Jordan) Lake Level record (*Migowski et al. 2006*) and Greenland GISP2 ice-core nss [K^+] chemical ions (*Mayewski et al. 1997*). The shaded area indicates good temporal agreement between the first appearance of domesticated goats in NW-Iran and the onset of the Levantine Moist Period (see text). Additional ^{14}C-ages on charcoal and short-lived seed samples from Ganj Dareh (not shown in this figure) are given in Tab. 1. Note the extreme depth (more than 7m) of the Ganj Dareh stratigraphy in comparison to the small spread of ^{14}C-ages.

lithic and Neolithic in the Near East and SE-Europe that currently includes 14 627 ^{14}C-ages of which 65% are georeferenced (*cf.* Appendix). The ^{14}C-database contains N = 1856 different (usually multi-period) georeferenced sites. Databases of this kind are never complete. However, due to large-scale collection by a number of researchers working independently (*Housley 1994; Görsdorf and Bojadžiev 1996; Gérard 2001; Bischoff 2004; Bischoff et al. 2004; 2005; Rollefson pers comm 2002; Reingruber et al. 2004; 2005; Thissen 2004; Thissen et al. 2004; Weninger et al. 2006; Böhner and Schyle 2009*) we may now, for all practical purposes, uphold a claim of relative completeness.

Figure 8 provides a chronological overview of the contents of this database with respect to the Early Holocene in the Levant. The ^{14}C-ages are arranged according to country (Jordan, Israel and Palestine), with further grouping after currently defined cultural periods (Natufian, PPNA, EPPNB, MPPNB, LPPNB, and PPNC/Yarmoukian).

Since the Natufian is always found below PPNA accumulations in archaeological stratigraphies, the apparent temporal overlap of Natufian and PPNA is caused by dating errors.

Figure 9 provides a set of maps showing the geographical distribution of major sites assigned to these various cultural units. The majority of these sites have supplied either large or (mainly) small sets of ^{14}C-ages. For historical reasons (*i.e.* early excavation), however, many of these archaeological ^{14}C-data sets are characterised by unsatisfactory properties, *e.g.* in terms of limited dating precision, frequent selection of long-lived (charcoal) samples, inadequate chemical pre-treatment of bone, and the often incomplete – and in some cases even entirely absent – archaeological and archaeobiological sample documentation. Nevertheless, as is indicated by Figure 8, it is possible to construct a reasonably well- constrained regional and temporal-cultural periodisation for the early Holocene in the Near East via larger-scale archaeological, cartographic, and statistical processing of ^{14}C-dating probability (Methods: Appendix). In archaeology, as in palaeoclimatological research, questions of dating are inevitably often the most crucial. Some of the more specific dating problems will be discussed in the course of the following RCC case studies.

Lab Code	^{14}C-Age (BP)	Material	Species	Level	Depth (cm)+	Reference
Beta–108238	8780 ± 50	bone collagen	goat	A	180–200	Zander and Hesse (2000.*Tab. 1*)
Beta–108239	8930 ± 60	bone collagen	goat	B	165–180	Zander and Hesse (2000.*Tab. 1*)
Beta–108240	8780 ± 50	bone collagen	goat	B	220–240	Zander and Hesse (2000.*Tab. 1*)
Beta–108241	8720 ± 50	bone collagen	goat	B	240–260	Zander and Hesse (2000.*Tab. 1*)
Beta–108242	8940 ± 50	bone collagen	goat	B	280–300	Zander and Hesse (2000.*Tab. 1*)
Beta–108243	8920 ± 50	bone collagen	goat	C	460–480	Zander and Hesse (2000.*Tab. 1*)
Beta–108244	8840 ± 50	bone collagen	goat	D	430–460	Zander and Hesse (2000.*Tab. 1*)
Beta–108245	8940 ± 50	bone collagen	goat	D	580–600	Zander and Hesse (2000.*Tab. 1*)
Beta–108246	8870 ± 50	bone collagen	goat	E	580–585	Zander and Hesse (2000.*Tab. 1*)
Beta–108247	8830 ± 50	bone collagen	goat	E	665–675	Zander and Hesse (2000.*Tab. 1*)
Beta–108248	8900 ± 50	bone collagen	goat	E	700–710	Zander and Hesse (2000.*Tab. 1*)
Beta–108249	8840 ± 50	bone collagen	goat	E	765–770	Zander and Hesse (2000.*Tab. 1*)
OxA–2102	8690 ± 110	charred seeds	hordeum	E	GD.F1.136	*Housley 1994*
OxA–2099	8840 ± 110	charred seeds	hordeum	B	GD.F1.70	*Housley 1994*
OxA–2101	8850 ± 100	charred seeds	hordeum	D	GD.F1.70	*Housley 1994*
P–1488	8888 ± 98	Charcoal	n.d.	B	–2,10 to –2,40 m	*Lawn 1970*
P–1484	8968 ± 100	Charcoal	n.d.	D	–6,20 m	*Lawn 1970*
OxA–2100	9010 ± 110	charred seeds	hordeum	C–D	GD.F1.110	*Housley 1994*
P–1485	9239 ± 196	Charcoal	n.d.	C	–4,50 m	*Lawn 1970*

* This list does not include the (clearly aberrant) measurements of the SI- and GaK-laboratories. The complete set of Ganj Dareh ^{14}C-ages is given in Böhner and Schyle (2009).

+ In Zander and Hesse (2000.*Tab. 1*) the depth scale is erroneously given as 'mm'.

Tab. 1. Radiocarbon Dates on animal bones from Ganj Dareh, NW-Iran (34°27' N, 48°07' E), shown by metrical analysis to be from domesticated goat (*Capra Hircus Aegagrus*), (*Zander and Hesse 2000*). This list includes complementary* ^{14}C-data from Ganj Dareh, (not shown in Figure 7). Note the good agreement between ^{14}C-ages on short-lived seed samples and on short-lived animal bones for all phases (B, C, D, E).

Natufian

In the Near East, the transition from a Palaeolithic mobile hunter-gatherer to more sedentary forms of settlement with horticulture can be traced back to the late Pleistocene and the pre-agricultural villages of the Early Natufian. This is a pan-Levantine cultural and economic complex that is generally characterised by the occurrence of well-established sedentary communities in the moister zones of modern-day Israel, with seasonal camps in the Negev, in the Jordan Valley and the Damascus basin. Natufian sites are also known from Syria. Important Late Natufian deposits, rich in plant remains, have been excavated at Abu Hureyra and Mureybet in the Middle Euphrates region. Otherwise, the preservation in most Natufian sites, and in spite of the practice of floatation, did not provide botanical remains, but a considerable amount of fauna. The great paucity of plant remains from these sites explains why we have so few ^{14}C-AMS dates for the Natufian. The dependence of present dating on bulk charcoal (that may contain clay with a certain amount of old carbon), as well as on bone samples (that are often contaminated by carbonates) may explain the apparent overlap between the Natufian and the PPNA (Fig. 8). Quite remarkably, the Natufian is unknown in Southeastern Turkey.

Researchers have often noted that the Early Natufian evolved under the favourable (warm, moist) conditions of the Last Interstadial (Bölling-Alleröd, *c.* 14 500–12 900 calBP). In comparison, the Late Natufian is very much contemporaneous with the colder and drier conditions of the *Younger Dryas* (*e.g. Bar-Yosef 1998*). Regarding these questions, however, caution is advised, particularly as the periods known as Bölling, Alleröd, and *Younger Dryas* are primarily defined with reference to Northern European vegetation patterns. Given the lack of high-resolution palynological proxies in the Near East, it remains questionable whether similar definitions can be applied. Notwithstanding, palynological studies do suggest a significant decrease of rainfall over the entire region during the (Levantine) *Younger Dryas* (*Bar-Yosef 1998.161*, with references; *Willcox et al. 2009*).

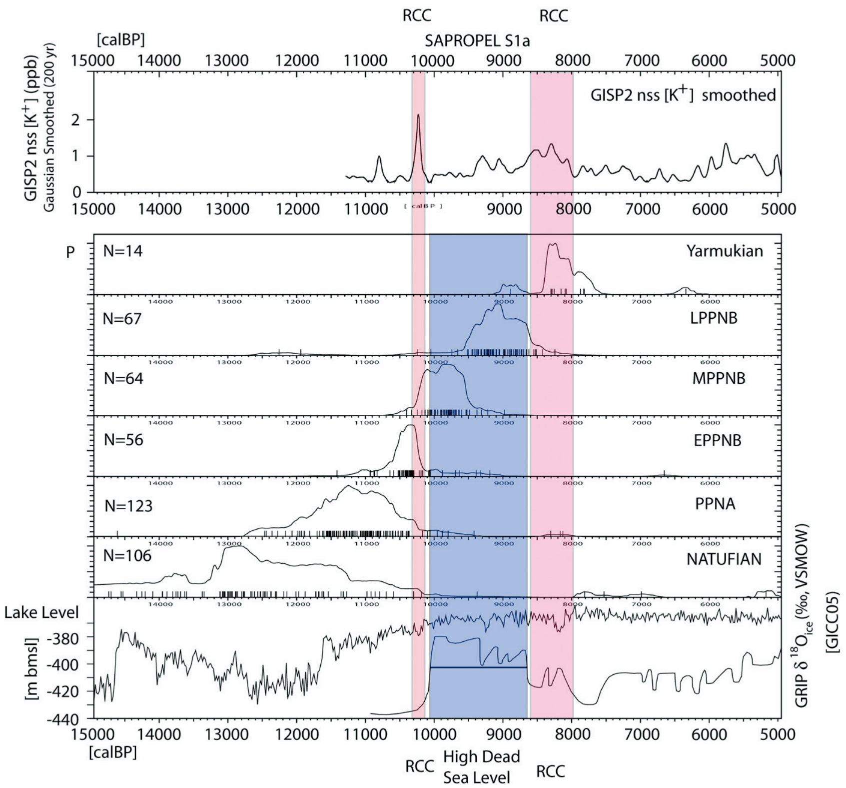


Fig. 8. Upper: Greenland GISP2 nss [K+] values (**Mayewski et al. 1997; 2004*****). Middle: Schematic Early Holocene Cultural Chronology in West Asia based on grouped calibrated ^{14}C-ages (*****cf.*** ***Appendix I, Radiocarbon Database). Abbreviations: (PPNA): Pre-Pottery Neolithic A, (E-M-L PPNB): Early-Middle-Late Pre-Pottery Neolithic B. Lower: NGRIP stable oxygen isotopes with GICC05 age model (*****Rasmussen et al. 2006*****); Dead Sea Levels (*****Migowski et al. 2006*****). Blue shading shows high Dead Sea Levels (called Levantine Moist Period, LMP,*** **cf.** ***text); red shading shows 10.2 ka and 8.6–8.0 ka calBP RCC.***

During this period, many of the observed changes in subsistence patterns do appear to be under climatic control, albeit with strong regional components. For example, towards the end of the Natufian, there is a generally downward trend in settlement density, but which (i) in the Levantine corridor is associated with a notable increase in gazelle hunting; and (ii) in the Negev is accompanied by evidence for newly emerging foraging groups, known as the Harifian culture (*Goring-Morris 1991*), specialising in plant collection in combination with a broad spectrum of hunting activities.

Pre-pottery Neolithic A (PPNA)

Following the Natufian, and prior to the onset of the Pre-Pottery-Neolithic (PPN) *sensu strictu*, the existence of a transitional phase linking these

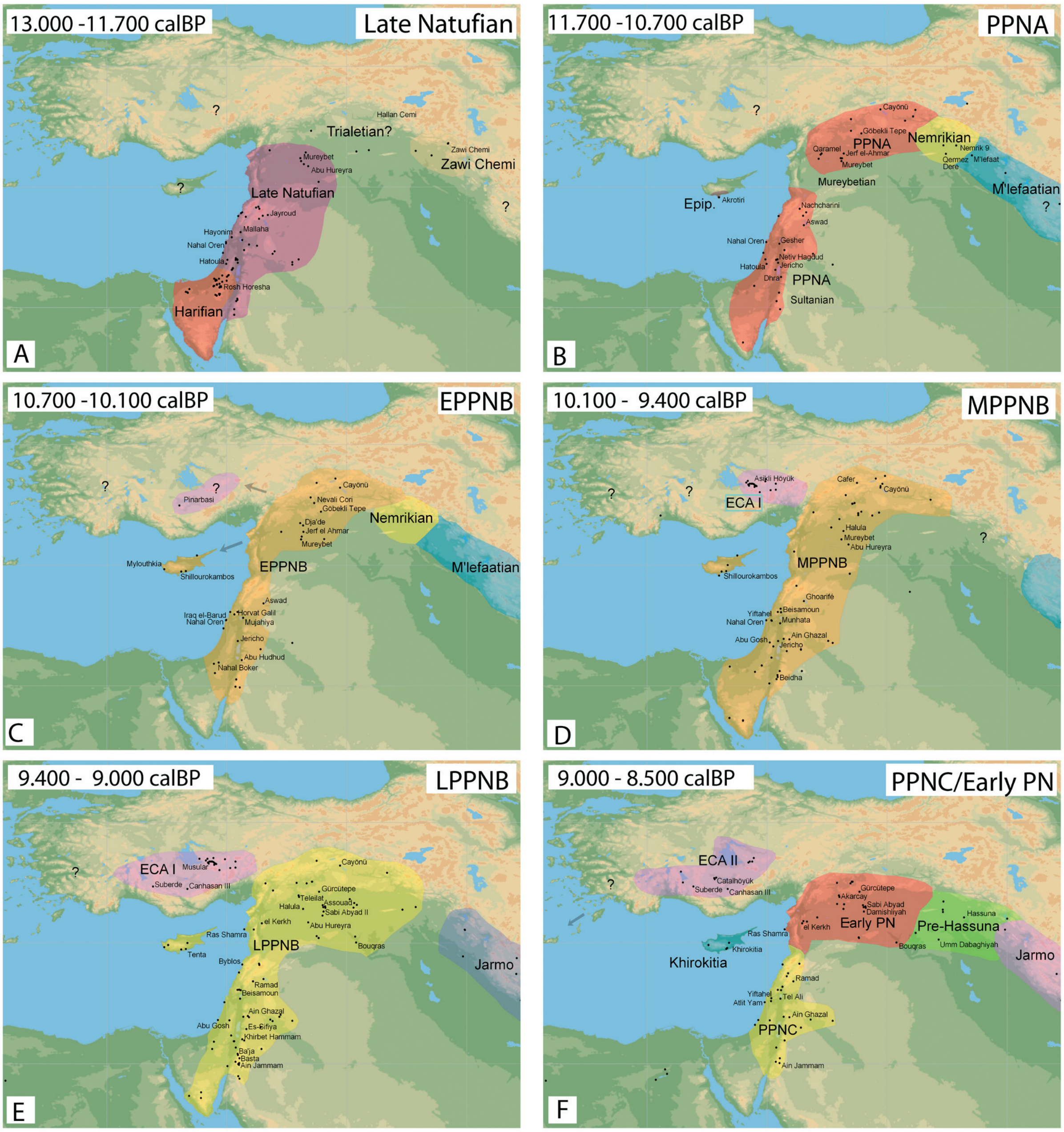


Fig. 9. Geographic distribution of cultural units and archaeological sites referenced in the text: (A): Late Natufian, (B): PPNA = Pre-Pottery Neolithic A, (C): EPPNB = Early Pre-Pottery Neolithic B, (D): MPPNB = Middle Pre-Pottery Neolithic B, (E): LPPNB = Late Pre-Pottery Neolithic B, (F): PPNC = Pre-Pottery Neolithic C, Early PN = Early Pottery Neolithic. Further acrynms: Epip = Epipalaeolithic, ECA = Early Central Anatolian.

two cultural entities has been postulated, the so-called Khiamian. It is considered a short term phenomenon that, together with the ensuing Sultanien, is incorporated under the term PPNA. In the northern Levant the two are more clearly separated in the Mureybet excavations, and are therefore not included under the general term of PPNA (*Ibanez 2008*). As recommended twenty years ago (*Bar-Yosef 1989*), the underlying problems are even today best resolved by subsuming both entities under the term PPNA. When applied to the ^{14}C-database (Appendix), this approach culminates in a prolonged PPNA period with a rather diffuse inception around 12 ka calBP, although with an extended overlap with available Natufian ^{14}C-ages. However, any requested precise dating of the Natufian and Natufian/PPNA transition is immediately confronted with the high standard deviations of available ^{14}C-ages, prevailing doubts as to the chemical integrity of the samples dated, and poor archaeological sampling strategies. Clearly, there is still room for more precise cultural and regional differentiation of the Natufian and PPNA data.

This will be achieved when Natufian sites with good preservation of charred botanical remains are found and excavated.

The long PPNA, as defined here, is found in two distinct regions: in the northern Levant (as 'Khiamian' and Mureybetian) and in the southern Levant (as 'Khiamian' and 'Sultanien'). Major sites in the Middle Euphrates region are Mureybet (with basal layers IB and II), Jericho and Salabiyah IX in the Jordan Valley, and Hatoula in the Judean Hills.

In both regions the PPNA is associated with a decline in Natufian-type microlithic assemblages and the pan-Levantine introduction of new projectile types, so called 'el-Khiam points'. Although they upheld earlier building traditions (*i.e.* round or oval structures) from the Natufian and Khiamian, PPNA communities certainly invested more energy and materials than their forefathers in house building. Circular and oval stone foundations continued to be the standard shape of the domestic unit, but quarrying clay and hand moulding plano-convex bricks for the walls, as well as mounting flat roofs that required supporting posts, represent increased investment in creating a human space (*Bar-Yosef 1989*). Some settlements show a clear subdivision of settlement space, including storage facilities. In addition to these staples of PPNA architecture, there occur some very significant developments: for example, the appearance of rectangular shaped buildings at Mureybetian sites, the development of monumental religious architecture in SE Anatolia (*Schmidt 2006*), and the construction of the massive encircling wall and tower at Jericho.

In contrast to its ill-defined beginnings, the PPNA has a distinctly defined termination at *c.* 10.3 ka calBP (Fig. 8). This is conspicuous, since it correlates with the 10.2 ka calBP RCC cold event. Now, with this preliminary result, as is typical of our explorative approach, we must immediately switch from the given level of cultural study to a more detailed site analysis. The next step would be to identify, for as many sites as possible with given cultural identification, the exact site-position (layer, stratum, phase, architecture) for which further archaeo-climatic studies would appear rewarding. This approach is applied, immediately below, at the sites of Jericho and Çayönü.

Site study: Jericho (Israel)

The tower at Jericho provides our first archaeological RCC study. Measuring 10m in diameter at its base, constructed of unshaped stones to a (preserved) height of *c.* 8.5m, and with an internal staircase, already from the technical aspect this structure was a major feat of Neolithic architectural expertise (Fig. 11). Nevertheless, debate continues concerning its exact function. Whereas its excavator Kathleen Kenyon (*Kenyon 1981.6–8*) believed it to have been part of a defence system, following Bar-Yosef (*1986. 158*) this is unlikely; it was erected against the interior of Jericho's perimeter wall and would have projected inwards, thus resulting in the partial loss of any defensive advantage. Instead, Bar-Yosef proposes that the perimeter wall protected the domestic infrastructure of Jericho against mud flows and flash floods emanating from the cliffs to the west of the site (*Bar-Yosef 1986.161*).

A new look at the available ^{14}C-data (Tab. 2) shows that the transition from PPNA to PPNB at Jericho falls close to the 10.2 ka calBP RCC (Fig. 10). Building on this result, we have applied a more detailed analysis of the ^{14}C-series to identify the exact position of the 10.2 ka calBP RCC within the Jericho site stratigraphy. A subset (Tab. 3) of the Jericho data supplies a stratified series of ^{14}C-ages, as is necessary for the application of the wiggle matching technique. As shown in Figure 12, using a simple linear growth (equidistant 50-year phase length) model to describe the architectural sequence, the seriated ^{14}C-ages are seen to fit well to the ^{14}C-age calibration curve for PPNA Levels IV–IX. Immediately following (*i.e.* prior to PPNB Levels XI–XIV), there appears to be a hiatus in the stratigraphy. At this time – during Level X and dating to ~10.2 ka calBP – the tower finally becomes embedded within the growing settlement debris. Level X, which directly covers the tower, is described by Kenyon (*1981*) as consisting of soft, grey powdery soil. The position of this layer, which is the first layer to completely cover the tower, is indicated in Figure 12.

We conclude that there may be a climatic background to the Level X mud flows that, according to Bar-Yosef (*1986*) gave reason for the construction of a protection wall. Specifically, the mud flows may result from flash-floods in causal connection with the 10.2 ka calBP RCC (*cf.* below; discussion of rubble slides in S Jordan during 8.2 ka calBP RCC). Furthermore, according to the ^{14}C-ages, following Level IX there appears to be a hiatus in the order of ~300 yrs between the PPNA and the PNNB. This is indicated by the fact that the ^{14}C-ages of layers XI–XIV disagree with the above (continuous) linear growth model. They fit the calibration curve better, and then also agree with the 50-year Level model if a ~300 gap is assumed between Levels IX and XI (Fig. 12). Although it is clearly not advisable to over-interpret the precision of these dates from early excavations, the PPNA-PPNB transition at Jericho is an interesting candidate for future geo-archaeological RCC studies.

Pre-Pottery Neolithic B (PPNB)

In general terms, the EPPNB is believed to have evolved in a continuous line of development from the final Mureybetian in parts of northern Syria, whence it dispersed, spreading into southeastern parts of Anatolia (*e.g.* Boytepe, Cafer Höyük, Çayönü, Nevalı Çori, and Göbeli Tepe) in a first expansion phase. At present, Dja'de in northern Syria, and Çayönü in the foothills of the Eastern Taurus feature some of the best investigated EPPNB settlement deposits. Architecture now encompasses rectangular plan buildings, first seen in late PPNA (late Mureybetian) contexts, and which at Çayönü are eponymous for the so-called 'grill plan' phase of the settlement (*Özdoğan 2007*). At Çayönü the stone foundations of these N–S oriented structures are indicative of a clear internal organisation of the buildings in three sections. In their northern part they are characterised workshop for leather working and the production of jewellery. The central part of this area features a room with a hearth which is thought to have been domestic. At their southern end are found three smaller adjacent rooms, possibly used for storage. Stone assemblages are now characterised by the appearance of what are to become typical PPNB tool types. Among the projectiles to appear in this phase are, for example, archaic forms of so-called Byblos points, which in the course of the PPNB take on supra-regional significance; leaf-shaped points; and points with a truncated base. Generally speaking, these projectiles are now larger than earlier pieces, their bases and points thinned by long, flat, parallel removals known as 'lamellar retouch' (*cf. Cauvin 2007.Fig. 25*).

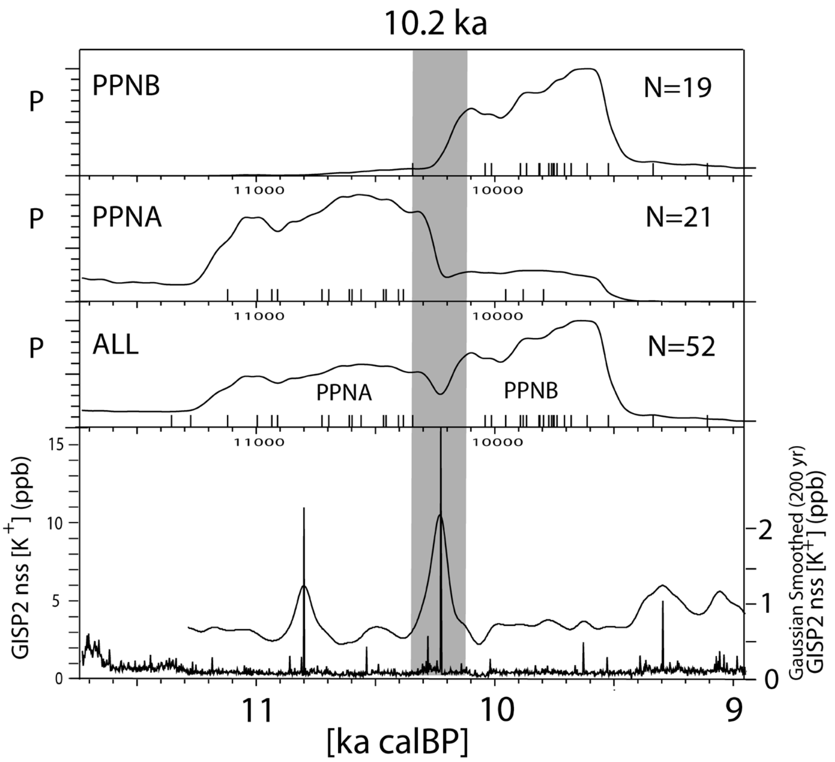


Fig. 10. Radiocarbon Data from Jericho (Tab. 2) arranged according to cultural period (Top: PPNB; Middle: PPNA; Lower: Combined PPNA and PPNB), in comparison to (lower graph): Gaussian smoothed (200 yr) and high-resolution GISP2 potassium (non-sea salt [K+]; ppb) ion proxy for the Siberian High (*Mayewski et al. 1997; Meeker and Mayewski 2002*). The GISP2 nss [K+] RCC event at 10.2 ka calBP falls exactly between the PPNA and PPNB layers. The calibrated ¹⁴C-age distribution gives reason to assume a hiatus between PPNA and PPNB. Radiocarbon periodisation according to Böhner and Schyle (*2009*), with references for individual ¹⁴C-ages given in Tab. 2.

Site study: Çayönü (PPNA-PPNB, southeast Turkey)

As mentioned above, according to recent research in the Near East, the establishment of permanent villages did not necessarily depend on animal domestication nor on crop cultivation. Since at Çayönü there is a long series of ^{14}C-ages available, which not only covers the PPNA-B transition but also the transition from hunting to herd management, it is interesting to take a closer look at the chronology of this site in terms of potential RCC or LMP influence.

For comparison purposes, in Figure 13 we have arranged the radiocarbon data from Çayönü. The data are grouped according to architectural period, and are shown against the GISP2 nss [K^+] RCC proxy and the Dead Sea Lake Levels. For each period the status of animal management (wild, domesticated) and animal species (sheep, goat, pig, cattle) identified by faunal analysis is indicated. From a chronological perspective it is disappointing that no clear separation of the different architectural periods appears. Neither do the radiocarbon ages for the earlier architecture (Basal Pits, Round -, Grill-, Channelled Building) respond to the assigned cultural units (PPNA, EPPNB). These architectural changes follow each other so rapidly, within a span of some 400 years, that the available ^{14}C-data do not support their separation. The settlement at Çayönü begins at ~10.6 ka calBP, with no evident connection to given climate data. Following the drop in dating probability around 10.2 ka calBP, the sequence continues with a group of MPPNB ^{14}C-ages centred on the rising Dead Sea Lake Levels at ~10.0 ka calBP. For the younger

Lab Code	^{14}C-Age (BP)	Material	Period	Level-Locus	Reference
BM–105	10 250 ± 200	Charcoal	PPNA	Level IV. iiib	(1),(2),(4),(5)
BM–106	10 300 ± 200	Charcoal	PPNA	Level VI A. x–xi	(1),(2),(4),(5)
BM–110	10 180 ± 200	Charcoal	PPNA	Level IX. xxii–xxiii	(1),(2),(4),(5)
BM–115	9170 ± 200	Charcoal	PPNB	level XII.xlviia	(2),(4)
BM–1320	8539 ± 64	Charcoal	PPNB	level XI. lv	(2),(4)
BM–1321	9226 ± 76	Charcoal	PPNA	level VIII A. xvib	(2),(4),(5)
BM–1322	9376 ± 85	Charcoal	PPNA	level IV A iiib	(2),(4),(5)
BM–1323	9382 ± 83	Charcoal	PPNA	level VI A x–xi	(2),(4),(5)
BM–1324	9427 ± 83	Charcoal	PPNA	level VI xxvii	(2),(4),(5)
BM–1326	9225 ± 217	Charcoal	PPNA	level VIII A. xvib	(2),(4),(5)
BM–1327	9551 ± 63	Charcoal	PPNA	level IV A. iiib	(2),(4),(5)
BM–1401	11 086 ± 90	Charcoal	Late Natufian	level I. ii	(2),(5),(11)
BM–1769	8700 ± 110	Charcoal	PPNB	level XI. lvia	(2),(3),(4)
BM–1770	8680 ± 70	Charcoal	PPNB	level XI. lxa	(2),(3),(4)
BM–1771	8660 ± 260	Charcoal	PPNB	level XIII. lxxxa	(2),(3),(4)
BM–1772	8810 ± 100	Charcoal	PPNB	level XIII. xiv	(2),(3),(4)
BM–1773	8730 ± 80	charcoal	PPNB	level XIV. lxxxvi	(2),(3),(4)
BM–1787	9280 ± 100	charcoal	PPNA	level VIII A. xv	(2),(3),(4),(5),(13)
BM–1789	9200 ± 70	charcoal	PPNA	level IX. xx–xxia	(2),(3),(4),(5),(13)
BM–1793	8660 ± 130	charcoal	PPNB	level XIV. xxxvii	(2),(3),(4)
BM–250	10 300 ± 500	charcoal	PPNA	area D I	–
BM–251	9390 ± 150	charcoal	PPNA	area D II	(6)
BM–252	9320 ± 150	charcoal	PPNA	area D I	(6)
BM–253	8710 ± 150	charcoal	PPNB	area E I, II, V	(6)
GrN–	8900 ± 70	charcoal	PPNB	area F I	(14)
GrN–	8785 ± 100	charcoal	PPNB	area F I	(14)
P–376	11 166 ± 107	charcoal	Late Natufian	level I. ii	(2),(5),(10),(11)
P–377	9582 ± 89	charcoal	PPNA	area E I, II, V	(10)
P–378	9775 ± 110	charcoal	PPNA	area F I	(10)
P–379	9655 ± 84	charcoal	PPNA	area D I	(10)
P–380	8610 ± 85	charcoal	PPNB	area D I	(10)
P–381	8658 ± 101	charcoal	PPNB	area E I, II, V	(10)
P–382	8956 ± 103	charcoal	PPNB	area E I, II, V	(10)

References:

(1) *Barker and Makkey 1963*
(2) *Burleigh 1981*
(3) *Burleigh 1982*
(4) *Burleigh 1983*
(5) *Schyle 1996*
(6) *Barker &al 1969*
(7) *Vogel and Waterbolk 1972*
(8) *Kenyon 1959*
(9) *Deevey 1967*
(10) *Stuckenrath 1963*
(11) *Weinstein 1984*
(12) *Zeuner 1956*
(13) *Bar-Yosef 1981*
(14) *Science 128, 1958, 1555*
(15) *BASOR 225, 1977, 1–16*

* This list does not include the (clearly aberrant) measurements of the GL-laboratory.

Tab. 2. Radiocarbon Dates from Jericho, Jordan (31°52'16" N, 35°26'38" E). Data source: Böhner and Schyle (2009).

MPPNB cell building period, only one ^{14}C-age is available. Naturally this value appears isolated. The ^{14}C-sequence ends with another limited number for ^{14}C-ages for the LPPNB Cell/Large Room period.

As mentioned, we must be cautious in our analysis of the Çayönü dates. The stratigraphy at Çayönü is only 2–3m deep. The stratigraphic sequence of (superimposed) building phases is well-established. However, due to the thin deposits the finds taken from the buildings (including ^{14}C-samples) may not in all cases be correctly associated with the building phases. We must allow for this in the radiocarbon analysis. The method is to construct a summed probability distribution for all phases. As shown in Figure 13, by adding the ^{14}C-ages for all phases the effect of any potentially wrong assignments between dated samples and architectural periods is neutralised. The corresponding calibrated ^{14}C-age graph for total (N = 32) samples is named 'Çayönü All Dates'. Similar to Jericho (Fig. 12), the accumulated sequence of ^{14}C-ages from Çayönü shows signs of a short break between the EPPNB (Channelled Building) and initial MPPNB phases (Cobble Paved Building).

What is more interesting, however, is that a consistent set of N = 7 ^{14}C-ages from the EPPNB-channelled building period offers strong indications of the introduction of (culturally) domesticated animals around 200 years before the 10.2 ka calBP RCC event. This is also prior to the onset of moist conditions during the LMP. The distance of channelled building ^{14}C-ages to the onset of the LMP at 10.0 ka calBP is even larger. We therefore conclude from the data arranged in Figure 13 that at Çayönü the earliest appearance of (culturally) domesticated animals (sheep, goat pig, cattle) occurs some 200 years prior to the RCC/LMP marker. As a reminder, since the sharp 10.2 ka calBP RCC-peak and the onset of LMP around 10.0 ka calBP are difficult to separate with any confidence, we have assigned a date of ~10.1 ka calBP to the combined RCC/LPM marker (see above). As shown in the following, similar results are obtained on Cyprus.

Site study: Mylouthkia (Cyprus)

Although the presence of Epipalaeolithic hunters on Cyprus is clearly attested at Akrotiri Aetokremnos (*Simmons 1991*), this first colonisation of the island has proven extremely difficult to date by the radiocarbon method. As shown by detailed statistical analysis (*Manning 1991*), the large majority of ^{14}C-dated bone samples from this site are contaminated to such an extent that it is impossible to provide more than an educated guess as to the correct age of the samples (*Simmons 1991*). Nevertheless, the excavations at Aetokremnos are important, even without secure site chronology, since the faunal assemblage at this site includes dwarf hippopotamus and pygmy elephant. These animals are not found at later Neolithic sites. Conversely, Aetokremnos contains none of the animal species (cattle, goats, sheep, pig) later attested for the Neolithic occupation *e.g.* at Shillourokambos and Mylouthkia. This lends support to the notion that all domesticates were brought to the island on boats from the mainland.

It is of immediate interest for RCC-research to establish whether the earliest communities on Cyprus reached the island before or after the onset of RCC/

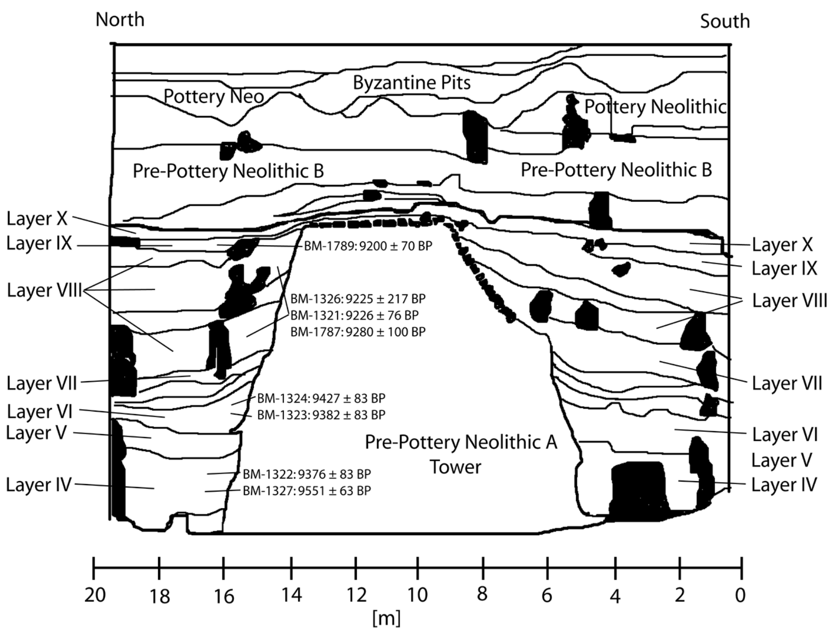


Fig. 11. Schematic Representation of Pre-Pottery Neolithic B Tower at Jericho, redrawn and simplified from Kenyon (*1981.Pl. 238*), with projection of ^{14}C-ages by stratigraphic layer, as provided in Table 2. This diagram is used as the basis for applying a simple linear growth (equidistant 50-yr phase length) model to the stratified ^{14}C-ages, with wiggle matching results shown in Figure 12. In Layer X, the PPNA tower is covered by soft, grey powdery soil (*Kenyon 1981.Pl. 238*), which may have been deposited by mudflows (*Bar-Yosef 1986*) during the 10.2 ka calBP RCC (see text).

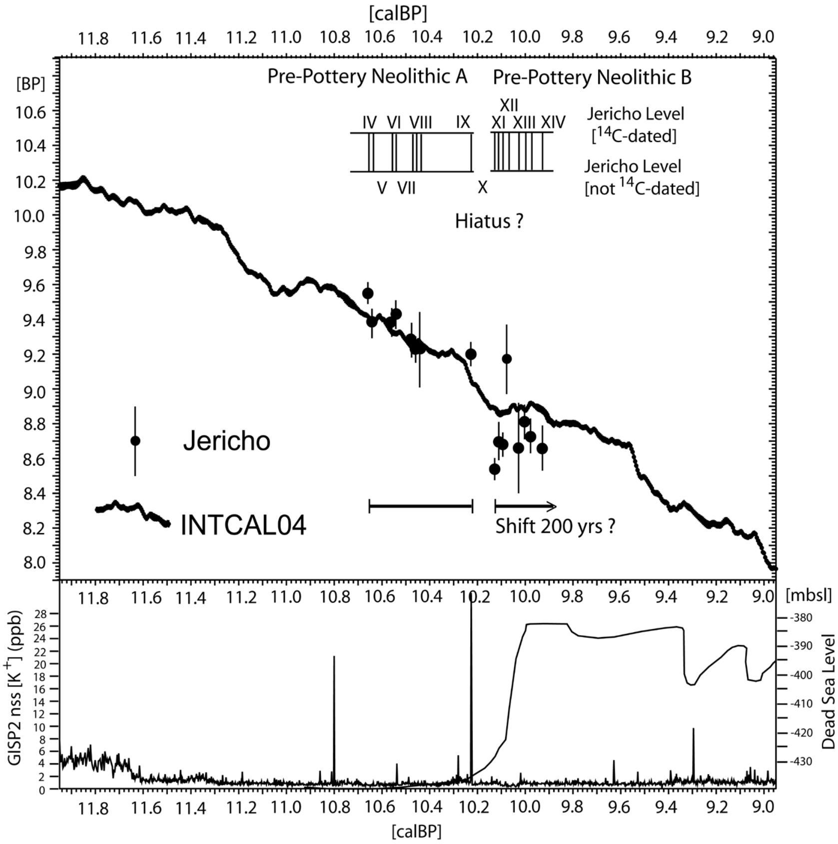


Fig. 12. Upper: Stratigraphic Wiggle Matching Radiocarbon Data from Jericho based on linear continuous growth model with Phase length of 50 yrs. This model is confirmed in terms of group for older Levels IV–IX (PPNA), and for younger Levels XI– XIV (PPNB), but with stratigraphic hiatus at Level X. The younger data group for Levels XI–XIV (PPNB) fits better to the calibration curve, when shifted en bloc younger by ~300 yrs. Lower: Greenland GISP2 nss [K+] values (*Mayewski et al. 1997; 2004*) and Dead Sea Lake Levels (*Migowski et al. 2006*). Note that the hiatus in Level X is synchronous, within error limits of ~ ± 100 yrs (95%), with the 10.2 ka calBP RCC event. The PPNB site re-occupation following the hiatus is synchronous with the onset (or early part) of the Levantine Moist Period.

LMP. Archaeological data relevant to this question are provided by excavations at Kissonerga-Mylouthkia and Parekklisha-Shillourokambos (*Peltenburg et al. 2000; Peltenburg 2004*). Both sites show features that are typical of sedentary (farmer-herding) communities (*e.g.* post hole alignments, palisade trenches), and – at Mylouthkia – the construction of two wells. According to the available ^{14}C-ages (Fig. 14; Tabs. 5, 6) processed on short-lived plant remains, the two wells at Mylouthkia (well Nr. 116 and well Nr. 133) are of very different age. Interestingly, well Nr. 116 appears to have been in use prior to the 10.2 ka calBP RCC event, whilst well Nr. 133 post-dates this RCC. Whether the emerging gap (>200 yrs?) between the two wells has any relation to the 10.2 ka calBP RCC event remains to be established. According to Peltenburg *et al.* (*2000*), the well Nr. 116 at Mylouthkia is contemporary with the Early A phase at Shillourokambos. Well Nr. 133 is expected to be contemporary with the Shillourokambos Late Phase.

The establishment of sedentary Neolithic communities on Cyprus at such an early time has aroused considerable interest in the archaeological community. We conclude that the appearance of (culturally) domesticated animals and cereals at Mylouthkia and Parekklisha occurred at least 100 years prior to the combined ~10.1 ka calBP RCC/LMP marker, and are therefore probably not intrinsically related to RCC-conditions.

Site study: 'Ain Ghazal (Jordan)

'Ain Ghazal ('Spring of the Gazelles') lies on the northeastern outskirts of Amman, Jordan. It is one of the largest prehistoric sites in the Near East and was excavated extensively between 1982 and 1989, and again from 1993 to 1998 (*Rollefson et al. 1992; Rollefson and Kafafi 2000*). The settlement lies at the intersection of several major ecological zones, including galleria forests of the Zarqa River valley, open woodland and forest, steppe, and desert; the modern isohyet at the site is *c.* 250mm, which places it at the limit of rain-fed agriculture, although in the early Neolithic, annual rainfall was probably significantly higher. The main settlement is located on a weakly inclined Pleistocene slope on the west bank of the river. This terrace-like position marks a geomorphologic exception to the generally steep slopes of the Zarqa River valley; it would have been favourable to an agrarian/pastoralist economy, especially due to the strong eponymous spring provided a year-round water supply for the residents.

The sequence of ^{14}C-ages from 'Ain Ghazal (Fig. 15) indicates that the settlement was founded around 10 200 years ago, at the beginning of the MPPNB (*cf.*

Fig. 8). Based on full-fledged cereal and pulse agriculture and goat herding (*von den Driesch und Wodtke 1997; von den Driesch 1999*), the site grew in terms of size and population during the MPPNB by up to around five hectares by the end of the period. But at around 9500 calBP the settlement size suddenly doubled (within a few generations), and the succeeding LPPNB population grew to around 3000 people or more, and covered between 14–15 hectares on both banks of the river. The LPPNB subsistence economy expanded to include domesticated sheep (*von den Driesch und Wodtke 1997; von den Driesch 1999; Wasse 1997*). At some time around 9000 calBP the site decreased in size as dramatically as it had grown only 400–500 years earlier, reduced to around 5 hectares during the PPNC period. During the following Yarmoukian culture of the Pottery Neolithic period the village continued to decrease in size and population, and eventually the site no longer supported a permanent farming population of any size, replaced instead by periodic visits to the spring by Yarmoukian pastoralists.

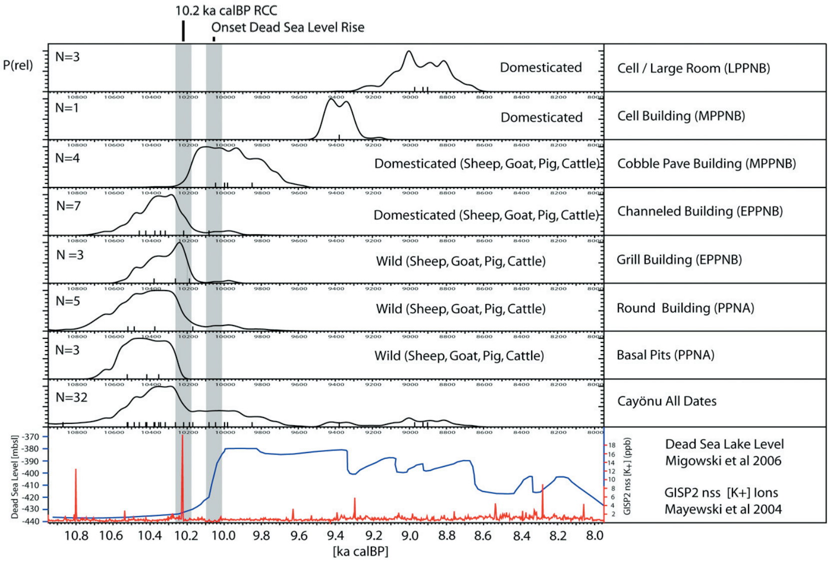


Fig. 13. Upper: Radiocarbon Data from Çayönü, arranged according to architectural periods, from old to young: Basal Pits, Round Building, Grill Building, Channelled Building, Cobble Paved Building, Cell Building, Cell/Large Room, with indication of animal management status (wild or domesticated) according to Ilgezdi (2008). Lower: Greenland GISP2 nss [K⁺] values (**Mayewski et al. 1997; 2004*****) and Dead Sea Lake Levels (*****Migowski et al. 2006*****).***

After the Yarmoukian, the site was completely deserted until the Byzantine period, when a field house was built on the slope of the west bank.

From Figure 15 it becomes apparent that permanent settlement at 'Ain Ghazal became established immediately following the onset of high Dead Sea Water Levels (~10.0 ka calBP). Following some 1700 years of continuous occupation, the site was deserted; it

Lab Code	¹⁴C-Age (BP)	Material	Level	Distance (yrs)	Results: Age (calBP}
BM–1793	8660 ± 130	charcoal	XIV	0	9978
BM–1773	8730 ± 100	charcoal	XIV	50	10 028
BM–1772	8810 ± 100	charcoal	XIII	25	10 053
BM–1771	8660 ± 260	charcoal	XIII	25	10 078
BM–115	9170 ± 200	charcoal	XII	50	10 128
BM–1770	8680 ± 70	charcoal	XI	16	10 144
BM–1769	8700 ± 110	charcoal	XI	17	10 161
BM–1320–	8539 ± 64	charcoal	XI	17	10 178
not dated		**Hiatus**	**Level X**	**300 yr gap**	**continuous –> 300 yr gap**
BM–1789	9200 ± 70	charcoal	IX	100	10 278 –> 9978
BM–1326	9225 ± 217	charcoal	VIII	16	10 492 –> 10 192
BM–1321	9226 ± 76	charcoal	VIII	17	10 509 –> 10 209
BM–1787	9280 ±100	charcoal	VIII	17	10 526 –> 10 226
BM–1324	9427 ± 83	charcoal	VI	66	10 592 –> 10 292
BM–1323	9382 ± 83	charcoal	VI	17	13 609 –> 10 309
BM–1322	9376 ± 85	charcoal	IV	83	10 692 –> 10 392
BM–1327	9551 ± 63	charcoal	IV	17	10 709 –> 10 409

Tab. 3. Jericho. Stratigraphic Age Model used for ¹⁴C Wiggle Matching (Fig. 12). Linear 50 yr Levels. Outliers BM-206-205-210 (Tab. 2) excluded. A hiatus may exist between Levels IX and XI. Levels XI–XIV is likely to date ~300 yrs younger than calculated for a continuous occupation model.

Lab Code	^{14}C-Age	Material	Period	Cöyönü Phase	Locus	Ref.
GrN–10358	9180± 80	charcoal	PPNA	Round Building Phase	building RB, KE 6–1	(1)
GrN–10359	9050 ± 140	charcoal	PPNA	Round Building Phase	building RB, KE 6–5	(1)
GrN–10360	9300 ± 140	charcoal	PPNA	Round Building Phase	level r?, KW 8–1	(1)
GrN–10361	9290 ± 110	charcoal	PPNA	Round Building Phase	building RA, floor KW 6–5	(1)
GrN–13947	9240 ± 90	charcoal	EPPNB	Channelled Building Phase	ch1–4	(2)
GrN–13948	8910 ± 50	charcoal	MPPNB	Cobble-Paved Building Phase:	square 19M, hearth	(2)
GrN–13949	9205 ± 45	charcoal	EPPNB	Channelled Building Phase	ch1–4	(2)
GrN–14857	9155 ± 35	charcoal	EPPNB	Channelled Building Phase	square 27L, fire pit	(2)
GrN–14859	9170 ± 50	charcoal	EPPNB	Channelled Building Phase	building DG	(2)
GrN–14860	9040 ± 35	charcoal	EPPNB	Channelled Building Phase	square 20N, fire pit	(2)
GrN–14861	9090 ± 50	charcoal	EPPBN	Grill Building Phase	building GH, outdoor area	(2)
GrN–14862	8920 ± 130	charcoal	MPPNB	Cobble-Paved Building Phase	building BM	(3)
GrN–16462	9040 ± 65	charcoal	EPPNB	Grill Building Phase	building GTc	(3)
GrN–16463	8040 ± 60	charcoal	LPPNB	Cell/Large Room Building Phase:	building EA floor	(2)
GrN–19481	10020 ± 240	charcoal	PPNA	Round Building Phase	square 30M	(2)
GrN–19482	10230 ± 200	charcoal	PPNA	Round Building Phase	square 29M	(2)
GrN–4458	9520 ± 100	charcoal	PPN	–	K–12. unit 12	(4)
GrN–4459	9200 ± 60	charcoal	EPPNB	Grill Building Phase	K 6–9	(4)
GrN–5827	5815 ± 65	charcoal	Chalc.	Dark-Faced Burnished Ware	trench BN (NS)	(5)
GrN–5952	6100 ± 80	charcoal	Chalc.	Dark-Faced Burnished Ware	trench BN (NS)	(5)
GrN–5953	9795 ± 260	soil	PPNA	Round Building Phase	SB 1–3	(5)
GrN–5954	8055 ± 75	charcoal	LPPNB	Cell/Large Room Building Phase:	QC 5,4, fill	(5)
GrN–6241	9275 ± 95	charcoal	EPPNB	Channelled Building Phase	R, 14–0	(5)
GrN–6242	8795 ± 50	charcoal	MPPNB	Cobble-Paved Building Phase	R, 8–2.	(5)
GrN–6243	9320 ± 55	charcoal	EPPNB	Basal Pits	R, 18–1., pit	(7)
GrN–6244	8980 ± 80	charcoal	EPPNB	Channeled Building Phase	EF, 2/1	(5)
GrN–8078	8355 ± 50	charcoal	LPPNB	Cell Building Phase	Hearth, SA 14–17	(5)
GrN–8079	9250 ± 60	charcoal	EPPNB	Basal Pits	Hearth, HA, 24–1	(5)
GrN–8103	10430 ± 80	charcoal	PPNA	Round Building Phase	S, 3–1.	(5)
GrN–8819	8080 ± 90	charcoal	LPPNB	Cell/Large Room Building Phase	Hearth, SE, 12–2	(5)
GrN–8820	8865 ± 45	charcoal	MPPNB	Cobble-Paved Building Phase	BG, hearth, HG, 14–0	(5)
GrN–8821	9175 ± 55	charcoal	EPPNB	Basal Pits	hearth, HA, 25/–1/1	(5)
M–1609 *	8790 ± 250	charcoal	EPPNB	Grill Building Phase	unit K9	(8)
M–1610 *	8570 ± 250	charcoal	EPPNB	Grill Building Phase	K 6–9.	(8)
METU–10 *	9510 ± 100	soil	PPN	–	R–3/4–0.51	(6)
METU–11 *	10480 ± 100	soil	PPN	–	R–5/11/1.10	(6)
METU–13 *	5940 ± 150	soil	–	–	R–3/4–0.51	(6)
UCLA–1703B*	8340 ± 250	human	LPPNB	Large Room Phase	–	(7)
UCLA–1703C*	7620 ± 250	bone	LPPNB	Large Room Building Phase	Ir1–6	(7)

References

(1) *Braidwood 1982*
(2) *Bıçakçı 1998*
(3) *Özdoğan 1999*
(4) *Vogel and Waterbolk 1967*
(5) *Çambel 1981*
(6) *Özbakan 1988*
(7) *Çambel and Braidwood 1980*
(8) *Barker and Mackey 1968*

* Dates not used due to lack of quality control

Tab. 4. Radiocarbon Dates from Çayönü, SE-Turkey (38°13'N, 39°43'E) (*Böhner and Schyle 2009*) with site-phases related to cultural periods as follows: Basal Pits: PPNA, Round Building Subphase: PPNA; Grill Building Subphase: EPPNB; Channeled Building Subphase: EPPNB; Cobble-Paved Building Subphase: MPPNB; Cell Building Subphase: MPPNB; Cell/Large Room Building Subphase: LPPNB; Large Room Subphase: LPPNB; Dark-Faced Burnished Ware horizon: PN.

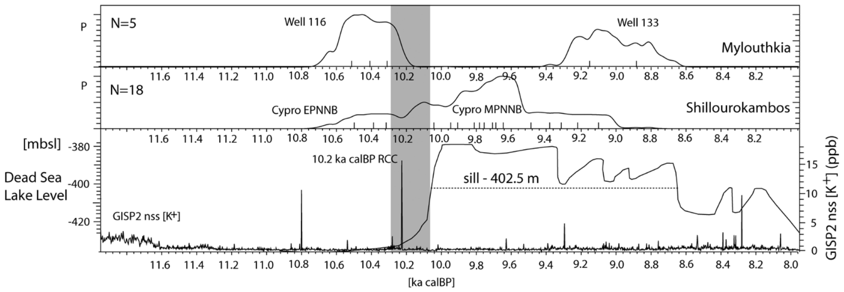


*Fig. 14. Upper: Radiocarbon Dates from Mylouthkia (Tab. 4) and Shillourokambos (Tab. 5), Cyprus. Lower: Greenland GISP2 nss [K^+] values (*Mayewski et al. 1997; 2004*) and Dead Sea Lake Levels (*Migowski et al. 2006*). The shaded area covers 10.2 ka calBP RCC and the initial rise in Dead Sea Levels around ~10.1 ka calBP, which are difficult to separate (*cf. *text).*

appears again in direct causal connection with the fall in Dead Sea Levels (~8.6 ka calBP).

In the following, we address the question of whether the abandonment of 'Ain Ghazal at the end of its long settlement may be explained by variability in LMP-levels, or perhaps by the dramatic environmental deterioration that can be recognised in this very period.

ENVIRONMENTAL IMPACT OF RAPID CLIMATE CHANGE ON THE NEAR EAST

Rubble slides in Jordan

In Jordan, a large number of archaeological sites are covered by massive rubble and gravel slides, often to extreme depths (several metres). Although the existence of these slides is well known to Jordanian researchers (see site description, below), their true extent and widespread occurrence in Jordan has only really become clear with the recently published review by Rollefson (*2009*). The list of Neolithic sites with rubble slides known from Jordan is impressive: 'Ain Ghazal, Abu Suwwan, es-Sifiya, Ba'ja, Basta, Wadi Shu'eib and 'Ain Jammam. The complex nature and chronology of Jordanian rubble slides will prove to be an excellent field for the study of the various interacting causes for the formation of rubble slide deposits. Current evidence already warns to concentrate exclusively on RCC explanations and to focus on certain event periods. The formation of rubble slide deposits is co-influenced by local parameters such as drainage catchments and topography, earthquakes, agricultural field clearing activity, intra-site architectural barriers (*e.g.* building terraces), *etc*., indicating the need for geo-morphological investigations accompanying rubble slide research. However, all these parameters may themselves interact with RCC-conditions (*Gebel 2009*).

List of Rubble Slides in Jordan

For reference purposes, there follows a list of sites in Jordan with Rubble Slides according to Rollefson (*2009*, with further details).

● At Wadi Shu'eib, a Yarmoukian site, some 25km to the west of 'Ain Ghazal, Simmons *et al.* (*2001.7*) reported "*a massive sorted layer of cobbles ... that roughly separates portions of the Pre-Pottery and Pottery Neolithic layers*". A photo published by Rollefson (*2009*) shows that two rubble events can be discerned.

● The nearby site at Jebel Abu Thawwab also produced a substantial Late Neolithic Rubble Layer. According to Kafafi (*1988.453; cf. Kafafi 2001.17, 32, Pl. 8B*), the Early Bronze and Yarmoukian layers "*were separated by a fill containing large quantities of small stone debris*".

● At the site of 'Ain Rahub, a thick (1.0–1.5m) layer of limestone rubble contains Yarmoukian pottery, and the Yarmoukian occupation may continue below the layer (*Muheisen et al. 1988.493*). 'Ain Rahub is a good example of Yarmoukian rubble slides resulting from interacting wadi terrace formation and col-

Lab Code	^{14}C-Age [BP]	Material	Period	Feature/Locus	Reference
AA–33130	8025 ± 65	n.d.	Cypro-LPPNB	Well 133, loc. 264	*Peltenburg 2000; 2001*
OxA–7561	8185 ± 55	n.d.	Cypro-LPPNB	Well 133, loc. 264	*Peltenburg 2000; 2001*
AA–33129	9110 ± 70	n.d.	Cypro-EPPNB	Well 116 loc. 124	*Peltenburg 2000; 2001*
AA–33128	9235 ± 70	n.d.	Cypro-EPPNB	Well 116 loc. 114	*Peltenburg 2000; 2001*
OxA–7460	9315 ± 60	n.d.	Cypro-EPPNB	Well 116 loc. 124	*Peltenburg 2000; 2001*

Tab. 5. Radiocarbon Ages from Kissonerga-Mylouthkia (Cyprus).

luvial processes by an increased fluvial activity in a V-shaped valley (*Gebel 2009*).

● A further massive layer of rubble (~1m in thickness) is known from the excavations at Tell Abu Suwwan on the southern outskirts of Jerash. This layer contains Yarmoukian pottery (*an-Nahar, pers. comm. to Rollefson 2007*) and overlies some extensive PPN architecture.

● During a survey described by Cropper *et al.* (*2003.18*) in the region south of Madaba, two sites known as Umm Meshrat I and II were located. Both show a broad distribution of Yarmoukian pottery and typical stone tools. These sites are on a terrace which includes deposits of "*fieldstones and greyish sediment, suggestive of the Yarmoukian 'debris fields' that may be associated with the 8th millennium BP climate shift … identified by Rossignol-Strick*".

● At Basta, a sediment unit up to 2m thick in places is comprised of "*tremendous amounts of detritus and mud flows*" that "*passed through and above the LPPNB layers*" (*Gebel 2003.100, cf. Tab. 1 and Pls. 2B and 2C*). Whilst awaiting further studies on these events, we must note that the excavators have not as yet ascribed the pottery finds either to the Yarmoukian or Jericho IX cultural spheres. At Basta, the slides have been responsible for the excellent architectural preservation at the site, at least in some areas (*Gebel 2003.104*).

● The situation at Ba'ja shows that we are best advised to remain cautious in all interpretations, since here the rubble slide phenomenon shows different facets. At Ba'ja, the rubble layers probably represent earthquake related debris. Earthquake damage might even stem from two separate events that occurred towards the end of occupation at the site. At a later stage, the site then experienced a thick flow (up to 1.5m in thickness) of coarse rubble and gravel with interdigitated fine gravels, all transported by water. It appears that these water-borne sediments did not result from slope collapse, but were caused by flash flooding down the narrow gorge (*Gebel and Kinzel 2007.32*). The temporal sequence of these events remains to be established and represents a major challenge due to the lack of organic materials suitable for radiometric dating.

● To complete the list, we note that evidence for the occurrence of a rubble slide is also available from the settlement at Abu Gosh, at the north-western periphery of Jerusalem. This site has produced evidence for both Pre-Pottery and Pottery Neolithic occupations. The existence of a post-PPN 'stony layer' is mentioned by Ronen (*1971*), and recent geomorphologic analysis suggests that the stony layer is confined to the habitation area itself and is not present in the nearby areas; this would suggest an anthropogenic origin for the material (*Barzilay 2003.7*).

Lab Code	^{14}C-Age [BP]	Material	Period	Feature/Locus	Reference
Ly–292	8125 ± 70	n.d	Cypro-LPPNB	Area 4, Maison 1	*Peltenburg 2000; 2001*
GifA–95032	8230 ± 90	n.d.	Cypro-MPPNB	Area 2, Level 3d	*Peltenburg 2000; 2001*
GifA–95033	8340 ±100	n.d.	Cypro-MPPNB	Area 2, Level 4a	*Peltenburg 2000; 2001*
GifA–95034	8390 ± 90	n.d.	Cypro-MPPNB	Area 2, Level 5	*Peltenburg 2000; 2001*
Ly–928	8495 ± 80	n.d.	Cypro-MPPNB	Area 1, Pit 23	*Peltenburg 2000; 2001*
Ly–1262	8670 ± 80	n.d.	Cypro-MPPNB	Area 1, Pit 23–Level D	*Peltenburg 2000; 2001*
Ly–1261	8735 ± 75	n.d.	Cypro-MPPNB	Area 1, Pit 23–Level C	*Peltenburg 2000; 2001*
Ly–291	8655 ± 65	n.d.	Cypro-MPPNB	Area 1, Level 1ž2	*Peltenburg 2000; 2001*
Ly–929	8700 ± 70	n.d.	Cypro-MPPNB	Area 1, Str. 117	*Peltenburg 2000; 2001*
Ly–6	8725 ±100	n.d.	Cypro-MPPNB	Area 1, Level 1/2	*Peltenburg 2000; 2001*
Ly–289	8760 ± 80	n.d.	Cypro-MPPNB	Sondage 2, Level 5	*Peltenburg 2000; 2001*
Ly–5	8825 ±100	n.d.	Cypro-MPPNB	Area 1, Level 1	*Peltenburg 2000; 2001*
Ly–574	8930 ± 75	n.d.	Cypro-MPPNB	Area 1, Str. 117	*Peltenburg 2000; 2001*
Ly–930	8670 ± 80	n.d.	Cypro-EPPNB	Area 1, Str. 114	*Peltenburg 2000; 2001*
Ly–931	8860 ± 90	n.d.	Cypro-EPPNB	Area 1, Str. 2	*Peltenburg 2000; 2001*
Ly–573	9110 ± 90	n.d.	Cypro-EPPNB	Area 1, F 23–Level B	*Peltenburg 2000; 2001*
Ly–572	9205 ± 75	n.d.	Cypro-EPPNB	Area 1, Str. 66	*Peltenburg 2000; 2001*
Ly–290	9310 ± 80	n.d.	Cypro-EPPNB	Area 1, Level 2, St. 45	*Peltenburg 2000; 2001*

Tab. 6. Radiocarbon Ages from Parekklisha-Shillourokambos (Cyprus).

Dating of the Yarmoukian Rubble Slides

The majority of these slides are dated by embedded Yarmoukian pottery to ~8.6–7.8 ka calBP (available ^{14}C-ages: Tab. 7). Alternatively, expressed in cultural terms, the Yarmoukian slides are dated to the transition from late Pre-Pottery Neolithic B/C (late PPNB/C) to early Pottery Neolithic (early PN). Accepting for the moment that many of these slides occurred 'simultaneously', in principle they could all have been caused by a single large earthquake. This is not even unlikely, since all the listed sites lie in close proximity (*e.g.* 'Ain Ghazal: 40km) to the active Dead Sea Fault, the seismic boundary between the African and Arabian plates. Geological observations show slip rates between these plates in the Jordan Valley in the range of 1 to 20mm per year (*Klinger et al. 2000*). Modern instrumental observations supply mean recurrence intervals for major destructive earthquakes in this region between 400 (Richter Scale Magnitude MR > 6) and 3000 years (MR > 7) (*Begin 2005*). Such earthquake magnitudes and rates of recurrence appear quite sufficient to trigger the observed slope failures, perhaps not everywhere, but surely at those sites for which Rollefson (*2009*) has documented slope declinations larger than 12 degrees. The physical character of the rubble slide at 'Ain Ghazal is illustrated in Figure 17.

Apart from earthquakes, there are other plausible explanations for the rubble slides, none of which we would like to exclude a priori. Acceptable explanations (and combinations of such) include regional environmental degradation due to over-grazing by large herds of goats/sheep, and deforestation due to factors such as Neolithic housing requirements, fuel consumption for domestic purposes, as well as lime-plaster production. Our preferred explanation is that the majority of slides were caused by slope failure due to torrential rainfall and corresponding large-scale water-lifting of slope material (*Weninger 2009*), or as Rollefson (*2009*) puts it, by "*slippery slopes*". Whether this proposal is correct or not, remains to be established, but what makes this specific hypothesis more interesting than many others is the possibility that the Yarmoukian rubble slides represent the local manifestation of broader 8.6–8.0 ka calBP RCC conditions.

Table 7 shows all available ^{14}C-ages for the Yarmoukian period, with the exception of a small number of outliers (AA-25424, AA-5204; GrN-15192). The remaining samples provide us with a small but consistent set of tree-ring calibrated ^{14}C-ages for the Yarmoukian Period, and by inference for the Yarmoukian Rubble Slides. Certainly, not all sites with Yarmoukian settlement feature a Rubble Slide (*e.g.* Sha'ar Hagolan), although it is encouraging that all Yarmoukian sites share ^{14}C-readings within the same time interval: 6300–5900 calBC (8300–7800 calBP).

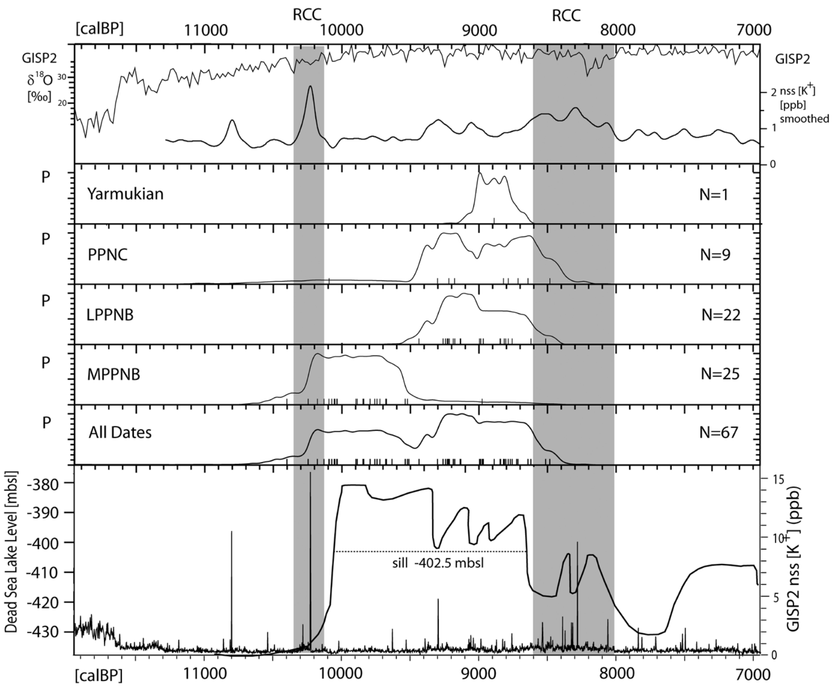


Fig. 15. Radiocarbon Dates from 'Ain Ghazal (Jordan) in comparison to selected climate records. Upper: Greenland GISP2 ice-core $\delta^{18}O$ (**Grootes et al. 1993*****), Gaussian smoothed (200 yr) GISP2 potassium (non-sea salt [K$^+$]; ppb) ion proxy for the Siberian High (*****Mayewski et al. 1997; Meeker and Mayewski 2002*****); Middle: Early Holocene Cultural Chronology of 'Ain Ghazal based on grouped calibrated ^{14}C-ages (*****cf. Appendix I, Radiocarbon Database*****). Abbreviations: (MPPNB): Middle Pre-Pottery Neolithic B, (LPPNB): Late Pre-Pottery Neolithic B, (PPNC): Pre-Pottery Neolithic C. Note: The overlapping of LPPNB, PPNC and Yarmoukian ^{14}C-dates from 'Ain Ghazal does not correspond to stratigraphic observations at the site. Lower: Greenland GISP2 nss [K$^+$] values (*****Mayewski et al. 1997; 2004*****) and Dead Sea Lake Levels (*****Migowski et al. 2006*****).***

Explanation for the Yarmoukian Rubble Slides

We propose the following climatic, geographical and meteorological scenarios to explain the Jordanian Rubble Slides. RCC intervals, especially times with exceptionally high GISP2 nss [K^+] values, are characterised by the high occurrence of circumpolar air pressure anomalies similar to those which prevailed in the more recent Little Ice Age. These atmospheric pressure anomalies (record: GISP2 nss [K^+]) are capable of transporting large amounts of cold and dry air from Asia into both the Balkans and adjacent parts on the northern edge of the Aegean. From here, they are channelled southwards across the Aegean Sea, where they are registered as rapid sea surface temperature (SST) variations in the LC21 marine core to the east of Crete. It follows that during this RCC interval (8.6–8.0 ka calBP), extremely cold and arid conditions, together with strong winds in the Aegean, would have prevailed in the Eastern Mediterranean. This scenario is substantiated by the period of extreme drought as documented for this period in the water level data from the Dead Sea. On the other hand, and due to the still very northerly position of the moisture-bearing Intertropical Convergence Zone, at stochastically distributed time intervals in winter or early spring (unforeseeable for the early farming communities) the cold Siberian winds interacted with the moist Mediterranean air masses to produce flashy and intensive precipitation. This is perhaps most clearly recognised in the 'flash-flood' record from the Soreq cave (*Bar-Matthews et al. 2003*). The dried out landscape in the southern Levant, perhaps in combination with widespread human-induced environmental degradation, had little to set against these flash-flood events.

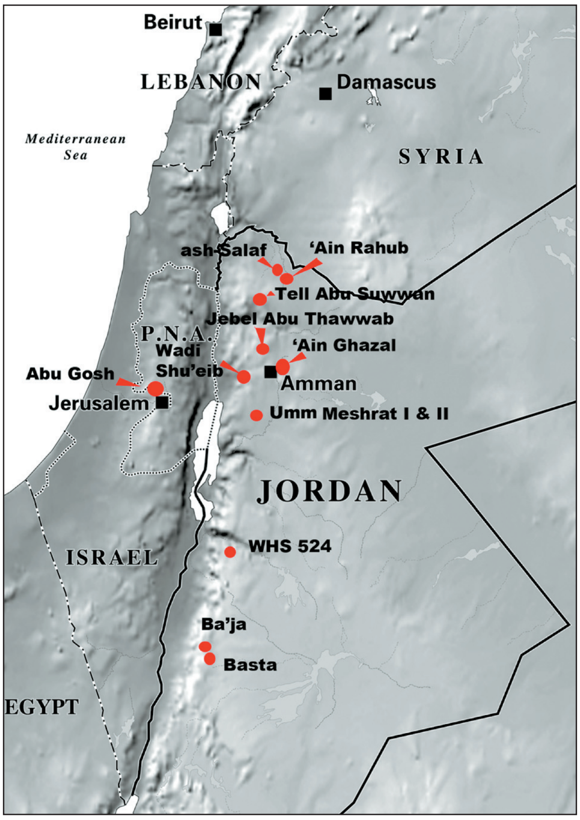


Fig. 16. Distribution of Archaeological Sites with Rubble Slides dating to the Yarmoukian Period in the Southern Levant (*Rollefson 2009*).

RAPID CLIMATE CHANGE IN THE KONYA PLAIN (8600–8000 calBP, CENTRAL ANATOLIA)

Site study: Çatal Höyük

In a continuation of previous studies (*Weninger et al. 2006; Clare et al. 2008*), let us now turn again to Central Anatolia to study the impact of the 8.6–8.0 ka calBP RCC at Çatalhöyük. The combined (and quite probably predisposed) extreme social and environmental sensitivity of Çatalhöyük make this site an ideal object for archaeological RCC-research. The settlement is located in a climatically quite sensitive position – in the Konya plain, on the margins of rain-fed horticulture, where even the slightest climate fluctuation could have spelled disaster for subsistence farming (*Christiansen-Weniger 1964*). Çatalhöyük looks back on a long history of research, from the first excavations by James

Lab code	^{14}C Age BP	Material	Site	Age (calBP)
Ly–4927	7330 ± 70	charcoal	Munhata	8150 ± 100
M–1792	7370 ± 400	charcoal	Munhata	8260 ± 420
RT–1544	7050 ± 78	charcoal	Qanah	7870 ± 80
RT–861D	6980 ± 180	charcoal	Qanah	7820 ± 160
OxA–7884	6980 ± 100	charcoal	Sha'ar Hagolan	7820 ± 100
OxA–7885	7270 ± 80	charcoal	Sha'ar Hagolan	8090 ± 80
OxA–7917	7410 ± 50	charcoal	Sha'ar Hagolan	8250 ± 60
OxA–7918	7465 ± 50	charcoal	Sha'ar Hagolan	8290 ± 60
OxA–7919	7495 ± 50	charcoal	Sha'ar Hagolan	8300 ± 70
OxA–7920	7245 ± 50	charcoal	Sha'ar Hagolan	8080 ± 70
OxA–9417	7285 ± 45	Seed	Sha'ar Hagolan	8100 ± 53
AA–25424	8030 ± 65	charcoal	'Ain Ghazal	8890 ± 110
AA–5204	2880 ± 95	charcoal	'Ain Ghazal	3040 ± 130
GrN–14539	7480 ± 90	charcoal	'Ain Rahub	8290 ± 80
GrN–15192	5540 ± 110	charcoal	Abu Thawwab	6340 ± 110

Tab. 7. Radiocarbon Ages for the Yarmoukian Period. Data Source:* Böhner and Schyle 2009*. Possible outliers in italics.

Mellaart in the early 1960s to the new multidisciplinary project directed by Ian Hodder initiated in the 1990s. The site comprises two settlement mounds – an eastern and a western 'höyük'. Çatalhöyük East was originally settled in the late-10th millennium calBP, and following a long (~1000 yr) period of continuous occupation, was abruptly abandoned at ~8.2 ka calBP. Based on the well-constrained ^{14}C-chronology at Çatalhöyük by dendro-architectural analysis (*Newton and Kuniholm 1999*), we previously argued that the east mound abandonment was likely to have been linked to the onset of cold and dry conditions associated with climate deterioration associated with a major weakening of the North Atlantic ocean circulation (*Weninger et al. 2006*). This explanation was supported by the observation that the adjacent site of Çatalhöyük West was apparently founded ~200 yrs later, at around 8.0 ka calBP. In terms of dating, the transition from the east to the west mound corresponds very precisely to the age and duration of the classical 8.2 ka calBP Hudson Bay event.

Fig. 17. Rubble Slide at the South Field of 'Ain Ghazal (Photo by Curt Blair).

This interpretation is substantiated by a large set of ^{14}C-ages from the two Çatalhöyük mounds. Due to the realisation that the 8.2 ka calBP North Atlantic cooling episode is actually superimposed on a globally more extended cooling period – the 8.6–8.0 ka calBP RCC interval (*Rohling and Pälike 2005*) – a re-evaluation of previous conclusions has become necessary (*Clare et al. 2008*). Even so, our findings remain unaltered. Meanwhile, new radiocarbon measurements have been put forward as evidence for continuity between the two settlements (*Higham et al. 2007; Marciniak and Czerniak 2007*). In our view, these new measurements provide yet more supporting evidence for the existence of a glaring 200-year gap that separates the two settlements (Fig. 18).

Let us return to the observation that the classical (Hudson Bay) 8.2 ka calBP event is superimposed on a wider period of climatic deterioration. The GISP2 nss [K^+] RCC record shows an abrupt switch to cooler conditions, the first time at 8.6 ka calBP. The question is whether this switch can be identified in the archaeological data from Çatalhöyük. Interestingly, the RCC-switch at 8.6 ka calBP occurs some four centuries prior to the abandonment of Çatalhöyük East. In terms of the internal architectural sequence, which is still today the best dated due to the dedicated tree-ring studies of Newton (*1993*), it occurs between settlement levels VI and V. Consequently, the evident changes in material culture at Çatalhöyük East for these levels are treated in our previous studies (*Clare et al. 2008*) as characteristic signs of the social, religious and economic impact of the 8.6–8.0 ka calBP RCC. Elsewhere, the same changes are presented as chance social markers for the transition from 'Early Pottery Neolithic' to 'Late Pottery Neolithic' in Central Anatolia (*e.g. During 2002*). Such interpretational differences are certainly not unexpected; changes in complex spheres, such as subsistence, socioeconomic systems and worldview, represent markers of climatic stress just as they do other causes of social variability.

RAPID CLIMATE CHANGE IN SOUTHEASTERN EUROPE (6000–5200 calBP)

General overview

As stated in the introduction, archaeological case studies in this paper are aimed at identifying potential settlement regions, cultural periods and archaeological sites in the Eastern Mediterranean and Southern Europe that show the possible cultural (or environmental) effects of RCC. Having studied the 8600–8000 calBP RCC in the Near East and Anatolia, we now turn to the next younger RCC period. Its time range is 6000–5200 calBP. In southern Europe, this period is associated with the transition from the Final Neolithic (FN) (or Late Copper Age/Late Eneolithic, according to region) to the Early Bronze Age (EBA).

The three main reasons we have chosen Southeastern Europe for archaeological studies on this RCC are: (i) the widely acknowledged and manifest evidence in the regional study areas (Greece, Bulgaria, Romania) for an abrupt collapse of long-standing cultural systems; (ii) this collapse dates to some time around 6 ka calBP; and (iii) this corresponds to the onset of the RCC under study (*cf.* below). We credit this evidence as manifest due to the unusually large number of breaks in the regional cultural sequences, and the quite atypical (extreme) lack of immediately (?) subsequent settlements.

In the following chapters, we analyse the above mentioned system collapse in southeast Europe from within a climatic perspective that (i) utilises high-resolution ice-core data, and (ii) provides a plausible meteorological mechanism for societal change.

6000–5200 calBP RCC-climate history

First, to the RCC-climate history. This can be deduced from a combined view of the courser-scale (200 year Gaussian smoothed nss (K^+] values) and the finer scale GISP2 nss [K^+] raw data (Fig. 1). On the courser scale the 6000–5200 calBP RCC shows a stepwise increase in [K^+] density from 6200 to 5400 calBP, a dip in density at around 5200 calBP, and an abrupt end of high density at 5000 calBP (Fig. 1). On a finer scale (Figs. 23, 24), therefore, this RCC conveys the appearance of a ramp rising continuously from 6200–5400, with a significant dip round 5150 calBP, followed by a second shorter ramp from 5200 to 5000 calBP. Sitting on the long ramp are large free-standing peaks at 6162, 5971, and 5764 calBP. The RCC finishes abruptly with its second largest peak at 4992 calBP. There are other structures in these curves (*e.g.* isolated peaks, grouped oscillations, local bumps). We refrain from further classifying these structures. They support alternative historical RCC descriptions. For example, the 6000–5200 calBP RCC may already have ended at 5200 calBP, and then had a brief renaissance at 4992 calBP. As mentioned in the introduction, the existence of such sub-structures in the GISP2 nss [K^+] record gives reason to approach the social RCC-impact on different levels of the archaeological catchment (*i.e.* regional and site-specific).

Cultural terminology

What first complicates the study of this RCC (and other studies) – and this is generally evident in Southeastern Europe – are regional differences in cultural terminology. In Greece the 6000–5200 calBP RCC interval corresponds to the transition from the Final Neolithic to the Early Bronze Age (Fig. 19). In Bulgaria the same period corresponds to the transition from the Late Eneolithic to Early Bronze Age (Fig. 22). In Romania the multilayer tell sites of the KGK VI Cultural Complex (Karanavo VI–Gumelniţa-Kodjaderman) come to an abrupt end and are replaced by single layer Cernavodã I sites (Fig. 25 a, b). What all chosen study regions have in common is that there appears to be an abrupt finale to an extended (millennial scale) period of cultural continuity and stability. This finale is most evident in widespread site abandonment. But the reasons for any such assumed settlement discontinuity are seldom clear. At many sites the crucial occupation phases are near to the modern surface, where finds are disturbed due to ploughing, and all that remains is a wide scatter of largely non-identifiable sherds.

Problems of site visibility

The poor visibility of surface pottery sherds is well-known from Thessaly, and especially for sites dating to the FN/EBA transition. In other regions, such pure visibility of pottery sherds may simply be due to lack of surveys. In Thessaly, however, thanks to the detailed analyses of settlement patterns and pottery taphonomy by Perlès (*2001*) and Johnson and Perlès (*2004*), it has recently become clear that the lack of surface finds is indeed caused by a drastic decline in population during the FN period. Further, the population decline correlates with a major move away

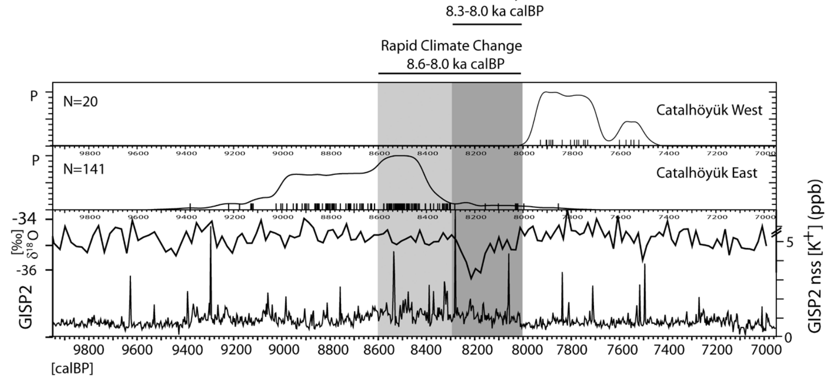


Fig. 18. Radiocarbon Dates from Çatalhöyük (Central Anatolia) in comparison to selected climate records. Upper: ^{14}C-Data from Çatalhöyük West (N = 20), ^{14}C-Data from Çatalhöyük East (N = 141) (*cf. Appendix I, Radiocarbon Database*). Lower: Greenland GISP2 ice-core δ^{18}O (*Grootes et al. 1993*); GISP2 potassium (non-sea salt [K^+]; ppb) ion proxy for the Siberian High (*Mayewski et al. 1997; Meeker and Mayewski 2002*).

from the large tell settlements. Below, we review the data in support of these statements. We find that, whereas during the EN, MN, LN–1 and LN–2 periods (Fig. 19) the large Thessalian magoules were often continuously occupied by farming communities, with the onset of the FN the majority of magoules was abandoned in favour of a distinct shift towards small upland sites. These sites are occupied mainly by pastoralists (*Perlès 2001; Johnson and Perlès 2004*). Hence, it appears that the 6000–5200 ka calBP time interval was characterised by important social change. This may be due to RCC.

Problems of site mapping

As a first test of such notions, we have reworked the Thessalian settlement maps, mainly by adding EBA site distribution data (*Hanschmann 1976.Abb. 2 with site list; van Andel, unpublished data, pers. comm.*). From the new maps (Fig. 20) it becomes even clearer how dramatic the socio-demographic shift (from Neolithic agrarian to Copper Age pastoralist economy) actually was. Quite notably, with the onset of the Early Bronze Age (EBA), there is a switch back to floodplain-based agriculture. This is followed by the next extended period of cultural flourishing – the Greek Bronze Age. Such changes become all the more evident after the application of necessary corrections to the established archaeo-radiometric age models (*cf.* below). Very similar cultural trajectories are apparent, as in Thessaly, for the same period in Bulgaria (*cf.* below) but, to some extent different, in Romania (Fig. 25 a, b).

Problems in radiocarbon dating

Before reaching further conclusions, we first identify the more precise chrono-stratigraphic position (absolute age, cultural period, site phasing) of the postulated cultural break. In terms of method, we do this by looking more closely at the ^{14}C-dating of selected archaeological sites. The criterion for site selection is the availability of larger amounts of ^{14}C-data. Clearly, the more data there are, the more precise the dating. But there are dangers in this ^{14}C-dating approach. As mentioned, over the last few decades researchers in southeast Europe have naturally been drawn into exploring the larger (multi-layer) tell-sites. Of course, this is due to a legitimate interest in their rich cultural heritage. This research interest leaves the smaller (single layer) sites often unexplored. Importantly, an amplification of given bias towards selective dating of the larger (agrarian) sites is also due to the requirements of the conventional (beta-decay counting) ^{14}C-technique. For precise measurements, in the past (prior to AMS) a typical request of conventional laboratories was that submitters provide large (5–20g) charcoal or grain samples. These came either from burnt (long-lived) wooden beams or from charred (large) grain depots. In both cases the focus is on dating *destruction events*. This focus is further amplified by the methodological necessities underlying the application of Bayesian ^{14}C-analysis (*e.g.* wiggle matching). This method works best for dates on (again: burnt) architectural sequences. In consequence, over the last decades, research on Neolithic and Bronze Age ^{14}C-chronology in SE-Europe has been systematically *overtuned* towards the omnipresent, large, multilayer (agrarian) tell settlements, and especially by those destroyed in conflagrations; on the other hand it has been *undertuned* with regard to the smaller sites with their (assumed) different economy. This bias is omnipresent in the CalPal ^{14}C-database (Appendix), despite its large size and scope, and indeed, all the more due to these very factors.

We must account for this bias. The method taken here is to produce cartographic pictures of site distributions based on pottery dating. This substantially expands the scope of the ^{14}C-database by pulling into analysis the many sites with a shortage of ^{14}C-data. But this produces new dangers that are well-known to archaeologists, and are often subsumed under headings such as *selective visibility*. Whatever limitations exist, the method is clearly most effective when the mapping is performed on a tripartite level, *i.e.* for cultural periods dating to *before, during, and after* the time interval under study. Naturally, if the landscape under study has provided neither ^{14}C-dated sites nor pottery evidence, the corresponding population will remain invisible, even if corresponding groups of people were present in large numbers. The identification of such (potentially) omnipresent and (assumed) more mobile groups that perhaps use basketry in place of pottery, and caves (or tents) instead of stone/mud brick architecture, is a vexing problem for which there is no simple solution.

Methods: key study cultures and sites (southeast Europe)

Let us turn to the site data. In Greece, our key study tell-sites are Sitagroi, Promachon, and Mandalo. In Bulgaria, a brief case study is directed at dating the Jagodina culture at its type site. Jagodina is one of the rare cases where a set of ^{14}C-ages is available for an upland archaeological site dating *within* the 6.0–5.2 ka calBP RCC-period. Together, these studies provide a preliminary *understanding* of what may have happened during this RCC-interval. We test this *understanding* – it is too early to call it a model – at the tell-settlement in Thrace, called Ezero (Tell Dipsis). Again, due to the ^{14}C-dating program, we are forced to focus on a multiply burnt-down tell site that was razed several times. This may be the chance product of enhanced ^{14}C-data visibility by way of amplified charcoal availability; however, it is perhaps not at all fortuitous that Ezero was deserted from ~6200 to 5200 calBP. In cultural terms, this corresponds to the transition from Karanovo VI to Karanovo VII. Separating these periods, the available ^{14}C-data show the existence of a major cultural hiatus. As such, as seen from within the RCC perspective, the site resettlement at Ezero at the onset of Karanovo VII dates exactly (within few decades) to the beginning of the next non-RCC period. If confirmed, this is perhaps the first time that *chronological climate determinism* is shown to allow a precise decadal-scale forecasting of periods for which major social variation may be expected. If confirmed at other sites, this would give us a viable (Greenland ice-core age-model referenced) method of forecasting exact dates at least for RCC-related social change. There will be other reasons. Turning to Romania, based on the new tell-site excavations at Pietrele (*Hansen et al. 2007; 2008*), an attempt is undertaken to derive a precise date for the collapse of the KGK VI Cultural Complex (Fig. 24). The forecasting is confirmed, but with emerging new perspectives as to the complexity of the questions under study.

To round up this introduction – although, perhaps, it is needless to state – all three study areas in southeast Europe have been carefully selected for their downwind position within the RCC corridor (Fig. 2). Here, we may expect the strongest social effects of the rapid movement of cold air masses associated with the meteorological RCC mechanism. It is beyond the scope of this paper to demonstrate whether the cultural development in neighbouring regions (*e.g.* Pannonian Basin, northwest Anatolia, and Ukrainian Steppe) was affected by RCC. Although yet lacking chronological precision, recent archaeo-botanical studies in the Troad (*Riehl and Marinova 2008*) provide further evidence for the reliability of the above mentioned forecasting.

Finally, we must again clearly emphasise our intention not to force a climate background on any of the processes under study. We rather wish to provide new data and ideas in support of further research towards the quite remarkable cultural trajectories during this period in southeast Europe. Our sole intention is to localise some of the potentially more promising regions and sites for future climate-archaeological studies.

Greece

Chronology

Beginning in Greece, Figure 19 shows the total available ^{14}C-data for the Neolithic and Early Bronze Age periods from the CalPal database (Appendix). The data are plotted in context with Greenland GISP2 ice-core stable oxygen isotope and nss [K^+] chemical series. This figure provides an overview of the main chrono-cultural subdivisions for the Greek Early Neolithic (EN), Middle Neolithic (MN), Late Neolithic 1 (LN–1), Late Neolithic 2 (LN–2) Final Neolithic (FN), and Early Bronze Age (EBA). Also given are the names of representative sites and ceramic phases (Proto-Sesklo, Sesklo, Arapi/Otzaki, Classical Dimini, and Rachmani) for the Thessalian sequence as initially defined by Gallis (*1992*). In the following, special attention is given to the cultural development of the (Chalcolithic) Rachmani period which is (i) archaeologically not well-known, and (ii) ends according to ^{14}C-ages from Mandalo (Tab. 8) with the onset of the 6.0–5.2 ka calBP RCC interval.

The existence of an ~800 yr hiatus (or change in economy, *cf.* below) that separates the Greek FN from the Greek EBA is immediately evident from the complete lack of ^{14}C-ages for this millennium in Greece (Fig. 19). As will be discussed below, the same hiatus appears in Bulgaria (Fig. 22).

According to recent reviews of the Greek Neolithic provided by Johnson and Perlès (*2004, with further references*), and in general agreement with other authors (*Coleman 1992; Johnson 1999; Perlès 2001; Alram-Stern 2004; Demoule and Perlès 2004*), the Greek FN period is expected to date between 4500 and 3500 calBC (6450–5500 calBP). In our view this dating is not supported by available ^{14}C-data. Notwithstanding, we agree with Johnson and Perlès (*2004*) that the FN period is still not known in sufficient detail to be subdivided with confidence. But the critical question concerns the dating of this very period *i.e.* the FN (Final Neolithic or Greek Chalcolithic, depending on author). The point at stake is, notably, the subdivision of the FN into three phases (Rachmani I–III). These were defined earlier by stylistic variations (*e.g.* painted spirals, incised decoration, and white incrustation) of pottery known from the synonymous Thessalian site. Today, there is agreement that the different types of Rachmani (I, II, III) pottery, as defined at Pevkakia, were found in mixed stratified contexts (*Hauptmann 1981; Weisshaar 1989; Parzinger 1991*). This is the only site where the FN in Thessaly has been excavated by modern methods and the results published (*Weisshaar 1989*).

Rachmani I has further similarities to the pottery from Sitagroi III (*e.g. Parzinger 1991; Manning 1995*). Awaiting further studies on the dating of Rachmani, it would appear parsimonious to reference the Rachmani style to available ^{14}C-ages from Mandalo Phases Ib-II (*Maniatis and Kromer 1990*; Fig. 19: 6350-6100 calBP (4400–4150 calBC). Similar dating results are achieved by using ^{14}C-ages from Sitagroi III (or other reference styles).

As a result, a large hiatus between the Greek FN and EBA becomes apparent, both in Northern Greece as well as in Thessaly (Fig. 19). Ever since the pioneering studies of Petrasch (*1991*), the existence of such a gap in the tell-settlements of southern Europe has been well known. But, with the end of Rachmani dating to ~6100 calBP, and the EBA beginning ~5200 calBP, there also appears to be a glaring gap in the Thessalian FN-EBA sequence. The gap is >800 years, just as in the tells of Northern Greece. Notwithstanding, already in the mid-1990s, Maran (*1998*) had provided evidence that the Thessalian coast was not entirely deserted during the 6000–5000 calBP, at least not in the second half of this RCC. This is shown by important cultural finds from the site of Petromagula, *i.e.* bowls (or lids) of so-called 'Bratislava' type. Similar finds are known from sites of the Boleráz/Cernavoda III cultures, with widespread distribution in Eastern and Southeastern Europe (*Maran 1998.Abb. 6*). There are further indications of a settlement of the Thessalian coast dating to the second half of the 6th millennium calBP from recent finds in Mikrothiva (*Adrymi-Sismani 2007*).

Site distribution study: Thessaly

Independent evidence in support of the proposed hiatus in the Thessalian FN/EBA transition is obtained by application of site mapping which shows the almost complete lack of FN sites in the eastern plain of Thessaly (Fig. 19). From the west plain there is little available data. Due to extensive archaeological surveys (*Gallis 1992; 1994*) and geomorphologic studies (*e.g. van Andel et al. 1990; van Andel and Runnels 1995; van Andel 1995*), as well as diachronic analysis of prehistoric settlement patterns (*e.g. Halstead, Perlès 2001; Johnson and Perlès 2004*), the fertile palaeo-floodplains of eastern Thessaly (Larissa plain) present one of the most extensively surveyed and best-studied archaeological regions in Greece.

In eastern Thessaly, the site data (Fig. 20) points strongly to a switch in settlement patterns during the FN. As already concluded by Perlès (*2001*), and again described in detail by Johnson and Perlès (*2004*), the site distribution during the FN (N = 34) reveals an almost complete desertion of areas that were previously densely settled throughout the EN (N = 112), MN (N = 117), LN–1 (N = 135), and LN–2 (N = 140) periods. Following the FN, there is a switch back to higher EBA (N = 133) site density. The numerical values given here in brackets describe the total number of settlements known for each of these periods.

Also evident from Figure 20, in the eastern (and indeed lower) part of the plain there is an area largely void of settlements during all these periods. This area is widely known as 'Lake Karla' (*Grundmann 1937*). However, there is no geomorphologic data available that actually demonstrate the existence of Lake Karla, despite speculations on its geological background (*e.g. Caputo et al. 1994*) and its influence on settlement patterns during prehistoric peri-

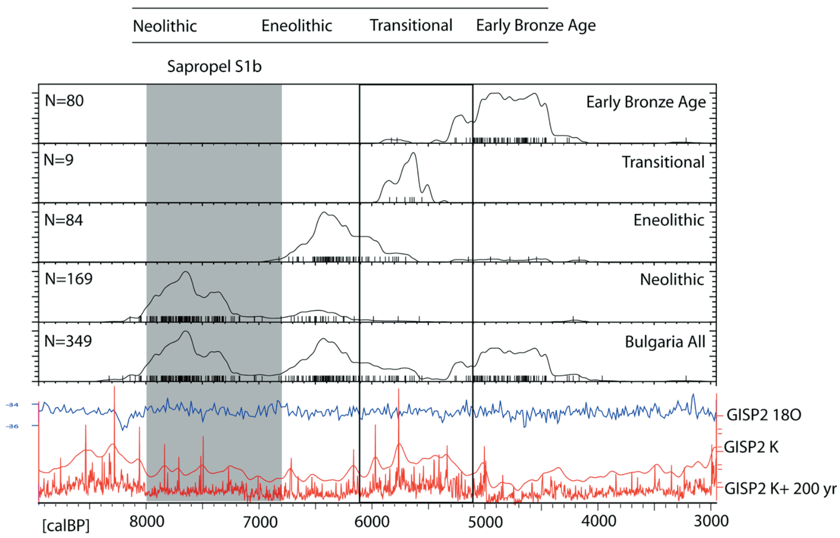


Fig. 19. Upper: Radiocarbon Data from northern Greek sites (Sitagroi, Promachon, and Mandalo) in comparison to ^{14}C-Data for the Greek Neolithic and Early Bronze Ages. Lower: Greenland GISP2 ice-core stable oxygen isotope and nss [K$^+$] chemical series. The box indicates a widespread chrono-stratigraphic hiatus at 6100–5200 calBP.

ods (*e.g. Perlès 2001*). This is crucial for RCC-interpretation. If Lake Karla did not exist then is no reason to assume a correlation between lake level fluctuations and settlement dynamics, as suggested by Perlès (*2001*). Thus, we immediately drop all considerations that the loss of settlements during the FN may be related to lake level variations. A remaining problem is how to explain the lack of settlement data in the 'Lake Karla' area. But since this applies constantly to all study periods (EN, MN, LN-1, LN-2, FN, EBA), it can hardly be explained by climatic variability, and surely not RCC.

Site study: Sitagroi (northern Greece)

Scaling up from the regional level, we now approach the 6000–5000 calBP interval at our first Greek site. It is now nearly four decades ago that a major tell-site in eastern Macedonia (Photolivos, later referred to as Sitagroi), was subjected to intensive excavations (*Renfrew 1970*). The radiocarbon ages obtained at Sitagroi were earlier proclaimed to have triggered a revolution in European Neolithic and Copper Age chronology (*Renfrew 1970*). In our judgment, the narrative underlying this revolution has remained incomplete for the past 40 years. We now attempt to complete the story by providing arguments for the fact that the many errors underlying the earlier (entirely pottery-based) archaeological chronologies were not caused by any fundamental problems of stylistic dating methods (*e.g.* for the Rachmani style at Pevkakia where major stratigraphic disturbances are encountered). For the RCC study interval (6000–5200 calBP), there is even today a quite remarkable scarcity of archaeological data in the study regions. Hence, it is no wonder that such errors in early pottery dating occurred. The crucial question instead is: what caused this lack of data?

As originally postulated by Renfrew in 1970, we first confirm that the ^{14}C-ages from Sitagroi (^{14}C-Database, Appendix) really do demonstrate the existence of a gap (here: ~1000 years) in the stratigraphic sequence of the settlement. The gap is particularly evident in excavation Trench ZA (Fig. 21), where it is situated at a depth of ~4m. The identification of this stratigraphic discontinuity was one of the main new insights provided by the original Sitagroi excavations (*Renfrew 1970*). As is well-known, it corresponds to a cultural break between the Neolithic (Sitagroi III) and the Early Bronze Age (Sitagroi IV).

Meanwhile, more archaeological data has become available, and it has become clearer that a virtually identical gap exists at the neighbouring sites of Promachon (Central Macedonia), as well as at Mandalo (West Macedonia). Unfortunately, even taken together with Sitagroi, there are still only these three sites on the Greek mainland for which Late and Final Neolithic ^{14}C-dates have been obtained (Fig. 19). Due to the complexity of pottery dating, we are best

Lab Code	^{14}C-Age (BP)	Material	Material	Period	Locus	Phase
Hd–9146	3860 ±70	–25,20	charcoal	EBA	1024	Pits near Surface
Hd–9216	4130 ± 70	–25,70	charcoal	EBA	7140	–
Hd–9835	4300 ±100	–26,00	charcoal	EBA	8152	–
Hd–9907	3920 ± 40	–25,10	charcoal	EBA	8199	Pits near Surface
Hd–9915	4130 ± 40	–25,30	charcoal	EBA	8231	Phase III
Hd–9559	5490 ± 60	–24,70	charcoal	Neolithic	2156	Phase II
Hd–9563	5430 ± 70	–24,00	charcoal	Neolithic	2202a	Phase II
Hd–9596	5290 ± 70	–24,80	charcoal	Neolithic	7229	Phase II
Hd–9602	5460 ±100	–25,20	charcoal	Neolithic	1022	Phase II
Hd–9832	5420 ± 40	–24,50	charcoal	Neolithic	7251	Phase II
Hd–9833	5460 ± 50	–24,80	charcoal	Neolithic	7253	Phase II
Hd–9834	5340 ±100	–25,90	charcoal	Neolithic	7275	Phase II
Hd–9939	5430 ± 45	–24,30	charcoal	Neolithic	2292b	Phase II
Hd–9595	6410 ±190	–24,70	charcoal	Neolithic	2224	Phase II (too early ?)
Hd–9265	5540 ± 70	–24,10	charcoal	Neolithic	4020	Phase Ib
Hd–9557	5440 ± 60	–24,10	charcoal	Neolithic	5032	Phase Ib
Hd–9603	5520 ± 80	–24,80	charcoal	Neolithic	3040	Phase Ib
Hd–9562	5600 ± 70	–25,80	charcoal	Neolithic	3120	Phase Ib
Hd–9601	5710±150	–22,00	charcoal	Neolithic	4007	Phase Ib
Hd–9597	6630 ±100	–24,80	charcoal	Neolithic	D12	too early ?

Tab. 8. Radiocarbon Ages from Mandalo (West Macedonia, 40°52' N, 22°13' E). Data Source: Maniatis and Kromer (*1990*). Outliers in italics.

advised to cite the regional specialists, especially those working on-site. Concerning the site of Promachon, Koukouli-Chryssanthaki (*2008.48*) writes:

"...architectural remains of the last phase of habitation are present (Phase IV). These strata, which also contain pottery from an earlier phase, probably come from the levelling of the ruins of the buildings from the preceding settlement levels. The last phase of habitation on the site can be dated to a late phase of the Late Neolithic, based on scattered pottery sherds. Typical [...] incised and graphite painted pottery provides links to Dikili Tas II and Sitagroi III in Eastern Macedonia, as well as to Marica I–II in North Thrace."

This evidence, which is supported by two ^{14}C-dates from the final stages of Promachon, indeed contemporaneous with Sitagroi III (Fig. 19), provides further indication for the existence of a long gap between the Greek FN and the EBA.

Let us now put the evidence together. Firstly, in chronological terms the hiatus is defined by an abrupt drop in overall ^{14}C-data from Greece (Fig. 19). This is understandable due to the above mentioned selective radiocarbon dating of major agrarian sites. Secondly, in pottery-stylistic terms the hiatus is identified by the significant lack of FN-sites in eastern Thessaly (Fig. 20). This appears to be caused by a significant switch during the FN in Thessaly from an agrarian to a pastoralist economy. Hence, corresponding sites have neither been excavated, nor have they provided samples for ^{14}C-dating. Further, our argumentation relies heavily, although not critically, on dismantling the often supposed continuity of Thessalian FN-EBA.

At Mandalo (^{14}C-dates: Tab. 8), the painted Rachmani-style pottery ends around ~6100 calBP. At this site, Rachmani pottery is in direct stratigraphic superposition below the much less glamorous EBA pottery. The same stratigraphic superposition of Late/Final Neolithic underlying EBA pottery is evident at Sitagroi, with ^{14}C-ages again in support of a large intervening time span (in the order of 1000 yrs: Fig.21). Finally, the hiatus is also apparent at the site at Promachon. Here, the site abandonment dates to a late phase of the Late Neolithic (*Koukouli-Chryssanthaki 2008*).

In search of further evidence pro (or contra) the influence of RCC, we now direct our attention to more north-easterly parts, *i.e.* along the lines of the incoming RCC-winds.

Bulgaria

Chronology

For Bulgaria, the relative and absolute chronology of prehistoric cultures is comparatively well-established, particularly for the Neolithic, Eneolithic, and Early Bronze Age periods. In addition, these periods are well synchronised with cultures in neighbouring regions (*e.g. Gaul 1948; Todorova 1984; Pernicheva 1995*). This is due not least to the outstanding richness of the local archaeological heritage that, together with other (partly historical) factors, provides us with one of the most detailed and well-dated chronological frameworks anywhere in Europe. Important factors in this respect are: (i) the unique number of deeply stratified Neolithic, Eneolithic and Bronze Age tell-settlements; (ii) early recognition of the necessity for tree-ring calibration of ^{14}C-ages by archaeologists working in Bulgaria, as early as the 1970s (*e.g. Quitta and Kohl 1969; Neustupny 1973; Todorova 1978*); and (iii) continuous support from the Berlin Radiocarbon Laboratory, where the majority of Bulgarian ^{14}C-ages were produced (*e.g. Quitta und Kohl 1969; Görsdorf and Boyadziev 1996*). Just as in Greece (excepting Rachmani), for the purposes of the present paper it is therefore entirely sufficient to make use of the pre-established Bulgarian absolute chronology. The cultural periodisation currently in use by Bulgarian researchers is as follows: Early Neolithic, Middle Neolithic, Late Neolithic; Early Eneolithic, Middle Eneolithic, Late Eneolithic; Transitional Period (with a subdivision into a Post-Eneolithic and a Proto-Bronze stage), and Early Bronze Age. We have applied this periodisation to the Bulgarian ^{14}C-database (Fig. 22).

From Figure 22 it may not perhaps become immediately apparent that there is a glaring gap in the Bulgarian ^{14}C-sequence between 6100 and 5200 calBP. In Bulgarian periodisation this time interval corresponds to the Transitional Period. Consequently, and in agreement with literary sources (*Todorova1995; Bojadžiev 1995*), we have assigned the ages of 6100 calBP to the beginning and 5200 calBP to the end of this period. As mentioned above, Bulgarian researchers have especially emphasised obtaining ^{14}C-dates for this period (*e.g.* Yagodina, Pevec). Nevertheless, there is not a single ^{14}C-sample of this period from the second half of the 6th millennium calBP.

The paucity of archaeological data from the Transitional Period is well-known to researchers working in Bulgaria. Just as in Greece during the same time window, the Bulgarian Transitional Period is charac-

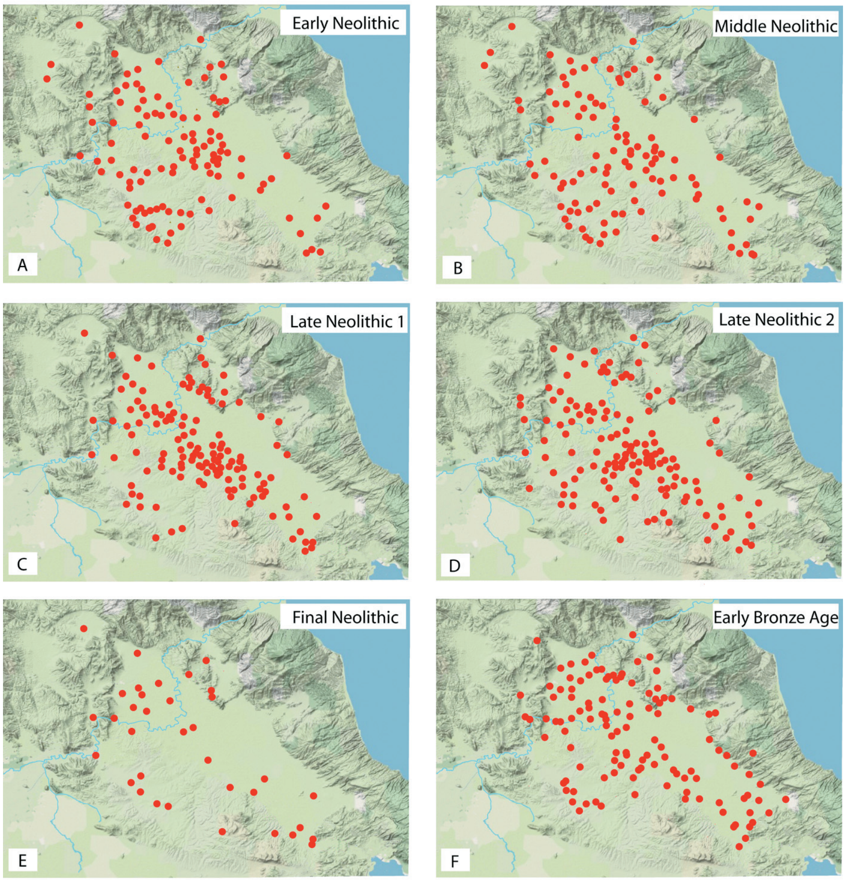


Fig. 20. Distribution of Prehistoric Settlement in Thessaly (Greece). From Top to Bottom (A): Early Neolithic, (B), Middle Neolithic, (C) Late Neolithic 1, (D) Late Neolithic 2, (E) Final Neolithic, (F) Early Bronze Age. Data from Gallis (*1992*), Perlès (*2001*), Hanschmann (*1976.Abb. 2*), van Andel (*unpubl., pers comm*).

terised by a switch from an agrarian (tell-based) economy to pastoralism (with small ephemeral settlements in upland locations). As is so eloquently summarised by Bailey and Panayotov (*1995*), the dramatic explanation for these changes given by Todorova (*1995*) reads very much like a text-book study on environmental determinism. We cite here the relevant passages from Todorova (*1995.80*), noting that the age designations she gives in years 'B.C' are derived from tree-ring calibrated ^{14}C-ages:

"*The brilliant development of the Late Eneolithic cultural block was terminated at the end of the fifth and the beginning of the fourth millennium B.C. [...] by a colossal, global and multi-causal environmental catastrophe [p. 89]. [...] The catastrophe was of colossal scope, as seen from changes in the settlement density which by the late Eneolithic included more than 600 settlements. By the start of the Transitional Period not a single site is known. It was a complete cultural caesura.*"

Due to the given complex regional differences, the construction of detailed site maps showing these settlement patterns for Bulgaria is beyond the scope of this paper. The relevant passages from Todorova (*1995.90, 91*) read as follows:

"*In the Rhodopes, there are no descendants of the Krivodol-Salcuta-Bubanj phase IV of the complex, either in northeast Bulgaria or in Thrace. The latest Eneolithic settlements in Thrace (phases IIIb/C of the KGK VI complex) were destroyed after enormous fires (*e.g. *at Yunatsite and Dolnoslave) and were not re-established. It is interesting to note that a new phenomenon (the Yagodina culture) developed in the caves of the Rhodopes during the final Eneolithic. [...] Little, if anything, is known of the cultural development in the Rhodope region after the end of the Yagodina culture.*"

"*In Thrace, there is not a single archaeological site belonging to the Transitional Period. [...] This situation has always prevented the resolution of the problem of the early Bronze Age Ezero culture, which, when it did appear in Thrace, did so without any links to any local antecedents.*"

We have little to add to this interpretation, although it should be mentioned that necessary high-resolution environmental (which includes palaeo-botanical and archaeo-zoological) data in support of the postulated catastrophic system collapse (however plausible) was not available.

Site study: Yagodina (western Bulgaria)

Whereas on the Greek Mainland there is a gap in the ^{14}C-chronology, in Bulgaria, fortunately, there is at least one site where the switch in economy during the 6000–5200 calBP RCC-period is well-dated by radiocarbon. Yagodina is a cave-site in the Rhodope Mountains (western Bulgaria) which has supplied evidence (hearths, pottery, animal bones, stone tools) for semi-permanent occupation during the Bulgarian Transitional Period (*Avramova 1991*). Due to the site-location in a semi-mountainous area, a seasonal occupation and the prevalence of stock-breeding over agriculture have been proposed (*Avramova 1991*). The site has supplied a small but consistent set of ^{14}C-ages (Tab. 9). Allowing for one outlier (Bln-2385), all samples can be assigned to the early 6th millennium calBP.

According to Bojadžiev (*1995*), a subdivision of the Yagodina occupation into two phases is possible (called Yagodina I and II) based on pottery styles. However, given that both these phases have yielded similar absolute dates (and also in view of the above mentioned Pevec dates), there are currently no indications that Yagodina (resp. the Bulgarian Intermediate Culture) extends into the second half of the 6th millennium calBP. The question arises, at least for the site occupation documented during the first half of the 6th millennium, as to which region the pastoralist occupants of Yagodina used to supply themselves with supplementary resources (*e.g.* plants and human contact). During this period, the large agrarian tell settlements – at least in the Bulgarian flood-plains – had long been in disuse. Whatever the solution to this question, in view of the steadily increasing GISP2 nss [K$^+$] values during the 6th millennium calBP, it appears that the climate finally became even too extreme to support the (assumed) less sensitive pastoralist economy. In terms of understanding RCC-impact on prehistoric communities, the Transitional Period in Bulgaria is clearly a key candidate for future studies. We also conclude that the geographic scope of present studies in Southeastern Europe needs to be expanded.

Site: Ezero (Thrace)

Following Eneolithic occupation (Karanovo V–VI), the large multilayer tell settlement called Dipsis (Ezero) in Thrace was abandoned, and subsequently resettled during the Karanovo VII in the Early Bronze Age. A number of studies by wiggle matching have aimed at deriving exact dates for the stratified EBA-horizons I–XIII at this site. These studies have been based on (i) architectural stratigraphy (*Neustupny 1973; Bojadžiev 1995; Weninger 1986*), and (ii) pottery seriation (*Weninger 1992; 1995*).

The wiggle matching results achieved at Ezero for the beginning of the Karanovo VII Period are shown schematically in Figure 23, together with results from Pietrele (see below). Allowing for the dating only of *long-lived charcoal* (*i.e.* old wood) at Ezero, the entire site chronology must be set ~100 years younger. The site chronology at Pietrele is mainly based on (short-lived) grain samples, for which case no taphonomic age corrections are necessary. When the two site chronologies are combined in a single graph and compared with the GISP2 [K$^+$] record a good correlation (i) between the end of the KGK–VI (*id est* Karanovo VI) period with large GISP2 nss [K$^+$] peak at 6162 calBP, and (ii) the beginning of Karanovo VII site occupation at Ezero with large GISP2 K$^+$ peak at 4992 calBP becomes apparent. In between these two well-dated (ice-core precision) events lies the time interval allocated to the 6000–5200 calBP RCC interval. What is more, it appears as if cultural development is being switched on and off by RCC-peak values.

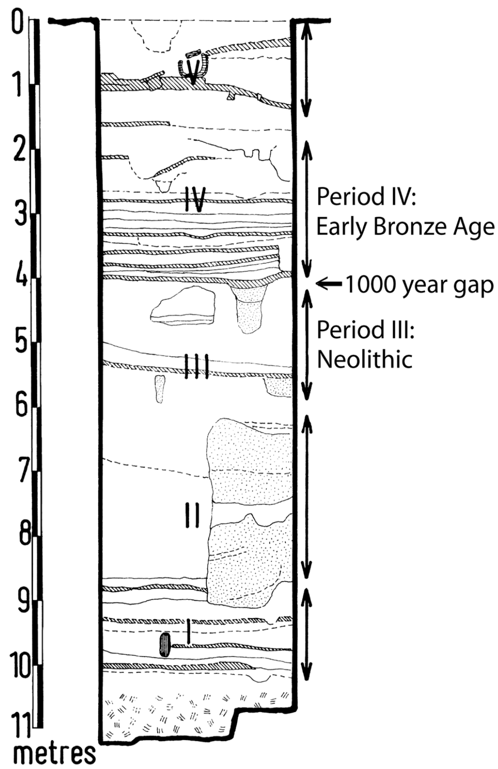


Fig. 21. Trench ZA (South Face) at Sitagroi with periods (Sitagroi I–V) according to Renfrew (*1970. Fig. 5*), redrawn and adapted. The arrow indicates the stratigraphic position of a cultural hiatus separating Sitagroi III (Late Neolithic) from Sitagroi IV (Early Bronze Age) and formerly identified by Renfrew using tree-ring calibrated ^{14}C-ages.

Romania

Site study: Pietrele (lower Danube region)

Moving northeast, we now address the 6000–5200 calBP RCC-period in Romania. Based on ongoing excavations at Pietrele, Giurgiu country, some 150km from the Black Sea littoral, it is now possible to derive an accurate date for the end of the Copper Age in Southeastern Europe, at least in the Lower Danube region. In brief, Pietrele is one of the largest tell sites in Southeastern Europe; accumulated deposits measure approximately seven metres. One of the specific aims of ongoing excavations at the site is to accurately date and study the reasons for the catastrophic termination of the Eneolithic in Southeastern Europe. With this in mind, Pietrele is a natural key site for RCC impact studies. Although the exact reasons for site abandonment are still the subject of scientific enquiry, it can be stated that the settlement was abandoned following a major conflagration (*Hansen et al. 2008.Abb. 86; Reingruber and Thissen in print*).

Recent stratigraphic analysis and application of the wiggle-matching technique provide us with a date of 6200±50 calBP for this last major burning event (Fig. 24, for details see *Weninger et al. 2009*). Within error limits, this date is directly equivalent (i) to the site abandonment at Pietrele, and (ii) the end of the KGK–VI (Kodžadermen-Gumelniţa-Karanovo-VI) complex in Romania. Previous studies (*e.g. Bojadžiev 1996; Lazarovici 2007*) concluded that the KGK–VI complex came to a close at a significantly later time, around 6000 calBP. The reasons for these dating differences concern technical limitations in ^{14}C-measurements performed at the Berlin Radiocarbon Laboratory (Bln) some 40 yrs ago (*Quitta/Kohl 1969. 238–240*). This became clear by recent re-measurements of similarly old samples from Cãscioarele in the Lower Danube-region by Jochen Görsdorf (Berlin ^{14}C-Lab). What is important is that the new Bln-measurements from Cãscioarele confirm the results obtained at Pietrele – that the end of the Chalcolithic period in SE Europe should be revised to ~6250 calBP (*Hansen et al. in print*). This complies with observations by Thomas Higham and colleagues of the Oxford Radiocarbon Laboratory that the dates for the Varna cemetery "*advance by one or two centuries the beginning of the late Copper Age in the Black Sea zone*" (*Higham et al. 2007.652*).

A question arises as to the cause of the KGK-VI system termination. Indeed, this is one of the main research incentives of the Pietrele excavations. With the aim of reconstructing the prehistoric landscape in the Lower Danube region, Jürgen Wunderlich (University of Frankfurt/M.) has recently undertaken geo-electrical investigations and drilling in the Danube floodplain. AMS-dates were obtained from organic sediments and plant remains from core Piet10 at a depth of 10 metres (*Hansen et al. 2007.103, Abb. 103*). This core is in the immediate vicinity of the Pietrele site. The drill samples show that large-scale sedimentation of fine-grained sands deposited by annual floods of the Danube at this location – and of course, rivers may change their course – did not occur prior to 5930–5750 calBP (*Hansen et al. 2008.Abb. 12*). If confirmed, the 200-year age difference between site abandonment (~6200 calBP) and the onset of flooding in the Danube plains (later than 5930 calBP) does *not* provide a likely (supra-regional) climatic-explanation for site abandonment at Pietrele. In terms of RCC, it *does* appear conspicuous that the abandonment of Pietrele dates closely

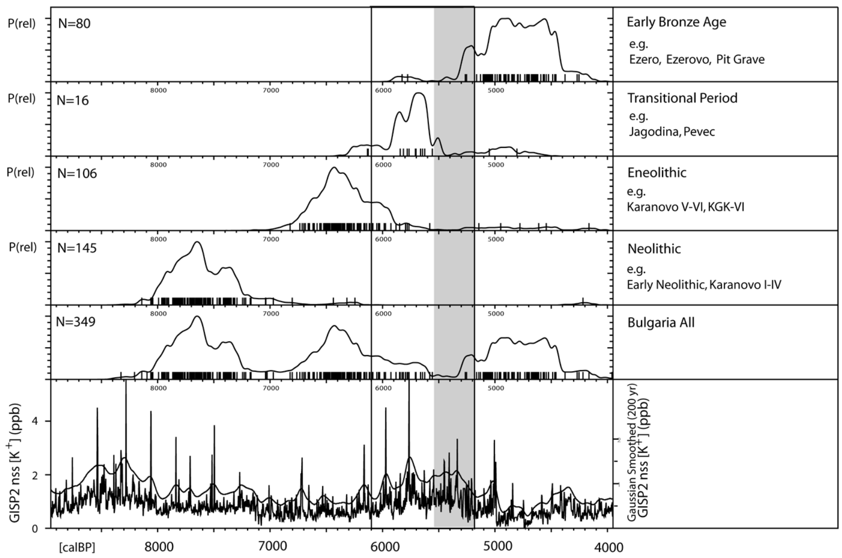


Fig. 22. Radiocarbon Chronology of the Neolithic, Eneolithic, Transitional and Early Bronze Age Periods in Bulgaria based on a number of individual site chronologies (indicated by cultural names e.g. Ezero), in comparison to high-and low resolution GISP2 nss [K⁺] proxy for the Siberian High (*Mayewski et al. 1997; Meeker and Mayewski 2002*). The Box indicates 6000–5000 calBP RCC study interval. Note the lack of dates in the second half of the Transitional Period.

(well within given decadal error limits) to the earliest (at 6165 calBP$_{GISP2}$) of the three large GISP2 nss [K^+] peaks mentioned above. This is the closest we can come, in chronological terms, to an environmental (and possibly RCC-related) explanation for the end of the Romanian Copper Age.

Site Distribution Study: Lower Danube Region

Finally, again applying the site-mapping method, we take a closer look at site distributions during the RCC-period under study. As shown in Figure 25a, by mapping the (pottery-dated) KGK-VI sites we can confidently state that prior to 6200 calBP the entire region of the Lower Danube and its tributaries was densely inhabited. Following the collapse of KGK-VI, settlement densities remain high, but a regionalisation has taken place (Fig. 25b). New settlements appear mainly on the left bank of the Danube and in the Dobrogea. The desertion of the KGK-VI core region is especially evident for the previously densely populated river valley that connected the large sites like Pietrele (in the NW) with Varna and Sava (in the SE). Interestingly, in the former northern KGK-VI area (in the area of the Gumelniţa KGK-VI variant), a new type of settlement occurs. As opposed to the multilayered KGK-VI tell-sites, the settlements of the new Cernavodã I culture are single-phased. The Cernavodã I culture is characterised by completely different pottery (with graphite-decoration and sharply profiled vessels disappearing).

Unfortunately, there is no extended ^{14}C-sequence for the Cernavodã I-culture. The three ^{14}C-ages from the eponymous site (*Meyer 2008.126–127, Taf. 38*) span such a long period (from 5700 to 4600 calBP) that they appear meaningless. According to pottery comparisons between the Cernavodã I-culture and the neighbouring Bulgarian Transitional cultures, the Cernavodã I-culture appears to date to the first half of the 6th millennium calBP (*Görsdorf and Bojadžiev 1996.107; Govedarica 2004.53*). To conclude, in Romania (just as in Greece and Bulgaria) further work is required to establish the sequence and economy of cultures dating to the 6000–5200 calBP RCC interval.

Lab Code	^{14}C-Age (BP)	Material	Phase	Calibrated Age (calBP)
Bln–2385	5980 ± 50	Charcoal	Yagodina I	6820 ± 60
Bln–2389	5265 ± 50	Charcoal	Yagodina I	6060 ± 90
Bln–2247	4960 ± 50	Grain	Yagodina II	5700 ± 60
Bln–2249	5000 ± 50	Charcoal	Yagodina II	5760 ± 90
Bln–2250	5240 ± 50	Charcoal	Yagodina II	5810 ± 70

Tab. 9. Radiocarbon ages from Yagodina (Bulgaria), Transitional Period (**Bojadžiev 1995*****).***

RAPID CLIMATE CHANGE IN SOUTHEASTERN EUROPE (3000–2930 calBP)

Excluded topics

Turning to next younger RCC, on the broader scale of ~3.5–2.5 ka calBP as defined by Mayewski *et al.* (*2004*), this time extended interval coincides with such an enormous set of cultural events in the Eastern Mediterranean that we are well-advised to begin the discussion by listing the topics not taken into consideration. These topics include the quasi-simultaneous destruction ~3150 calBP (1200 histBC) of all major Mycenaean palaces, the collapse of the Hittite Empire in Central Anatolia, a high frequency of sacked and burned towns on Cyprus and in the Levant, as well as large amounts of good archaeological and historical documentation of catastrophic raids and other atrocities on land and sea throughout the Eastern Mediterranean. Not enough, all this is paralleled by a sequence of destructive earthquakes, it seems acting simultaneously on the major Mycenaean palaces on the Peloponnese. Not surprisingly, there is mention of tsunami destruction of a Bronze Age site on the island of Paros dating to LHIIIB2. Altogether, there is so much evidence for internecine warfare, cultural collapse, human migration, social disruption, and the supra-regional catastrophic impact of earthquakes, all operating between 1250 and 1100 histBC, that we have no need for climate deterioration, on top of all this, to further complicate our understanding of these complex processes.

In search of an archaeological site that would provide the best chance to recognise the social effects of the (deliberately restricted) 3000–2930 calBP RCC event (~1050–980 histBC) the choice immediately falls on Troy. Troy is a multi-period tell-settlement located in the northwestern corner of the Aegean basin, in close vicinity to the Dardanelles. This is the perfect geographic setting to control the natural bridge connecting Asia and Europe. With strong winds blowing from the northeast essentially all year round (for monthly details see *Korfmann 2006*), the Trojans could control all shipping entering the Black Sea. The boats would have been forced to seek harbour in Besik-Bay, just a few

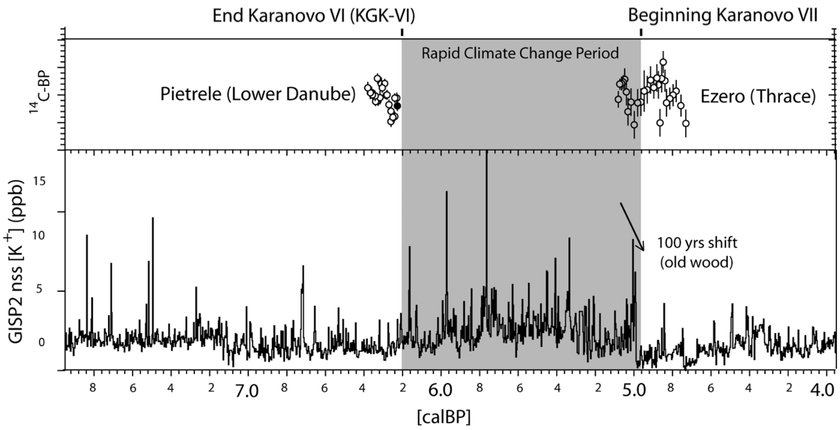


Fig. 23. (Upper): High-precision settlement chronologies for Ezero (Thrace) and Pietrele (Lower Danube) achieved by wiggle matching of stratified ¹⁴C-Ages in comparison to (Lower): high-resolution GISP2 nss [K⁺] proxy for the Siberian High (**Mayewski et al. 1997; Meeker and Mayewski 2002*****). Note: the Ezero-chronology should be adjusted younger by ~100 yrs, due to dating of old-wood charcoal. This is indicated by an arrow. The ¹⁴C-ages from Pietrele and Ezero follow the tree-ring calibration curve (not shown).***

kilometres west of Troy and some would have been dragged overland, to be launched again in the Dardanelles, a few kilometres north of Troy It is this superb geo-political location of Troy that appears to have been responsible for the unusual wealth of the Trojans throughout its many cultural phases and periods. In the present paper, we argue that this very location may ultimately have caused its downfall at the end of the Bronze Age – *i.e.* due to its position within the RCC-corridor.

Site study: Troy

Late Bronze Age chronology of Troy

The date assigned to the end of Troy (Period VIIb) by the Tübingen excavation team (*Korfmann 2006*) is ~1050 histBC, or perhaps a few decades younger. Within given error limits, this date is equivalent to the onset of the RCC at 3000 $calBP_{GISP2}$ (~1050 histBC) Fig. 26). However, due to remaining dating errors, it is not yet out ruled that the final Troy phases VIIb2–3 may extend by some decades into the RCC time-window. We note here that, based on ongoing research, it appears possible to further subdivide the Troy VIIb period by adding on a new phase (Troy VIIb3) (*Becks et al. 2006*). The chronological position of the new Troy VIIb3 phase is already shown in Figure 26. Its exact date remains to be established.

There are variations in the exact dating of all Troy VIIb1–3 phases, depending on the author. These archaeological dating errors are within the range of a few decades. Similar dating errors can be expected for the targeted GISP2 nss [K^+]-record.

Site abandonment at Troy

Not all specialists agree that Troy was actually deserted at the end of the Bronze Age. The controversies have the following background. As a result of major building activities in later periods, and especially when the central part of the hill was levelled during the construction of Roman Ilion (*Blegen et al. 1958. 247*), large parts of the inner citadel were destroyed, leaving only the outer perimeters of Troy VI, VII and VIII for later excavation. As a consequence, it remains to be established whether the observable discontinuity between the youngest preserved phase of the Late Bronze Age (VIIb2–3), and the oldest known buildings of Troy VIII (Iron Age), is the result of site abandonment (*e.g. Korfmann 2006*) or perhaps caused by the destruction of the intermediate archaeological units (*e.g. Hertel 1991; 2008*).

Korfmann (*2000.215*) gives some of the most convincing arguments in support of site abandonment, as follows:

"*In the northeast of the Citadel is a bastion with a deep cistern, as well as a spring line ... a source of water like this would only have been abandoned when nothing more was going on in the place, when there were not enough resources to keep it clean, or indeed any need for such a large water system ... By the latest during Troy VIIb2, the spring was abandoned. Five metres (!) of fill or mud are available for the entire process ... that meant the end of supplying water from a central source to an upper class that lived within the Citadel.*"

To conclude, again following Korfmann (*2000.215*) "*the very latest from* c. *1000/950 BC, there was no more settlement in Troy worthy of the name.*"

This date agrees well (within a few decades) with the 3000–2930 calBP RCC interval (~1050–980 histBC). As with the other RCC periods, the prime mechanism for the abandonment of Troy during the

3000–2930 calBP RCC would be the stochastic outbreak into the Aegean basin of cold and fast-flowing air masses, with the source in Siberia. These cold air masses would have been channelled down through the Balkan valleys, resulting in a series of unusually cold and dry winters and springs. In recognition of a dense Bronze Age farming population on the coastal plains in all regions of the northern Aegean (Macedonia, Thrace, Marmara, Troas), the first order hypothesis would be that local farming communities would have experienced repeated and devastating crop failures, often in consecutive years, for at least three decades, and probably for twice as long.

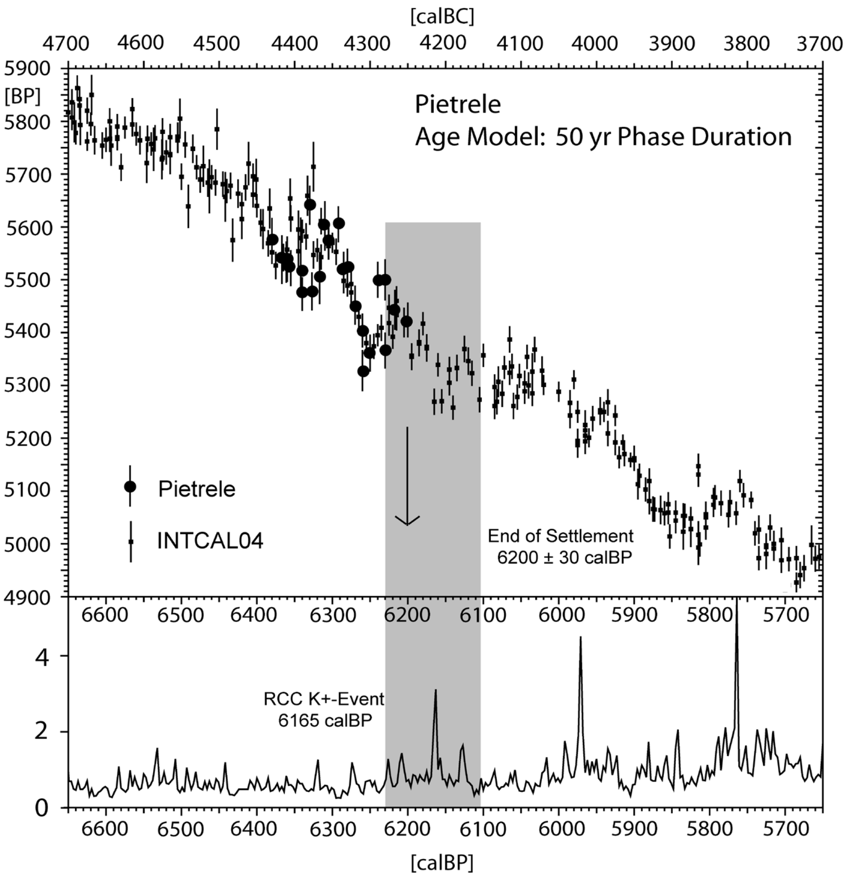


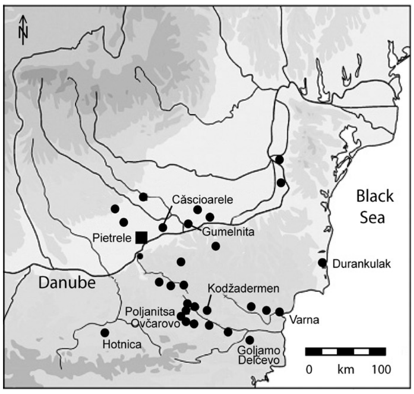
Fig. 24. Upper: Archaeological Age Model for Stratified ^{14}C-Data from Lower Danubian Multi-period Settlement at Pietrele (**Hansen et al. 2009; Weninger et al. 2009*****). Assumed 50-yr phase length. Mostly short lived samples. Lower: Greenland GISP2 nss [K^+] record (*****Mayewski et al. 1997; 2004*****). Note: close coincidence of site abandonment following major fire (6200 ± 30 calBP) with peak GISP2 nss [K^+] value at 6165 calBP$_{GISP2}$.***

However tempting this notion may be, already in terms of dating it is too early to simply postulate a causal relation between the desertion of Troy and the 3000–2930 calBP RCC event. Such a climatic explanation requires, first, a study dedicated to fine-tuning the GISP2-age model in the crucial time-window. Second, we must look yet closer at the site history. When dating is based on high-resolution pottery seriation (*Weninger 2009*), the distinct possibility arises that the 3000–2930 calBP RCC event occurred at some time during Troy VIIb2–3 (Fig. 27), *i.e.* when the site was evidently still occupied. Perhaps significant, this date covers the time when a new style of pottery was introduced into Troy – that is (curiously), hand-made *Buckelkeramik* pottery most likely deriving from the Balkans (*e.g. Hänsel 1976; Koppenhöfer 1997*). Further indications in this direction (RCC-upwind) are supplied by the use of vertical stones (Orthostats) in house foundations. This unique building technique appears for the first time during Troy VIIb2. Interestingly, it also known from Durankulak (*pers. comm. to BW by Pieniazek-Sikora 2008*). This would provide a reason to imagine RCC-downwind habitat-tracking (here: from the Black Sea region into the Troias), as has been inferred as a typical response of farming communities to climate deterioration during the 4.2 ka calBP event in northern Mesopotamia (*Weiss 2000; Staubwasser and Weiss 2006*). But further, as far as we presently know, Orthostats fall out of use again in Troy VIIb3. Around the same time (Troy VIIb3), pottery of (high quality) Protogeometric style was imported, with the probable source in Central- or North Greece (*Koppenhöfer 1997; Becks et al. 2006, with further references*).

At Troy, all these quite intricate problems, and many others (*e.g.* social structure, demographic development, food resources), require further study. We simply do not (yet) know whether site abandonment at Troy was due to climatic deterioration. It appears possible.

Regional study: Thrace

We now shift our search for RCC evidence to neighbouring regions. We first move directly north, along the track of the incoming cold RCC winds. According



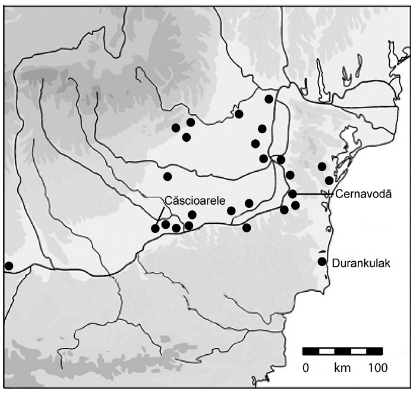


Fig. 25a (left). The Lower Danube Region in the second half of the 7th Millennium calBP. Dots: sites of KGK–VI complex (after* Mayer 2008.Karte 8*). Figure 25b (right). The Lower Danube Region in the first half of the 6th Millennium calBP. Dots: sites of Cernavoda I culture (after* Toderaş et al. 2009.Pl. 1.1*)

to Özdoğan (*1993*), in Thrace and the Marmara region, the transition from the Late Bronze to the Early Iron Age is a period of dramatic change, often quoted as 'Crisis Years'. A marked increase in small, single-period sites is observed, along with small burial mounds, as well as megalithic architecture. Many of these sites have pottery similar to the *Buckelkeramik* of Troia VIIb2, with similarities extending to the Psenchevo ware of Bulgaria. Özdoğan (*1993*) comments on the possibility of population pressure in Thrace at this time, but mentions that there are no signs of strongholds, and that all appears to have remained peaceful.

Regional study: northern Greece

In northern Greece, the general picture is one of settlement continuity throughout the restricted time window we have allocated to the 3000–2930 calBP RCC event (~1050–980 histBC). It is nevertheless fair to speak of troubled times, also in northern Greece. In the transition from the Late Bronze Age to the Early Iron Age some 30% of Central Macedonian sites are either completely abandoned or show at least temporary desertion (*Hochstetter 1984.Abb. 54*). However, such phenomena are rather common in many regions and periods. Site abandonment alone cannot be taken as evidence of climate impact. This explains our interest in a thorough archaeological evaluation of the forecasting capabilities of the RCC-mechanism.

Regional study: southern Greece

It is especially informative to search for the effects of the 3000–2930 calBP RCC event in southern Greece, since here during the Mycenaean period we have a highly vulnerable Late Bronze Age palace system. For the so-called 'palatial' period, widespread destruction is in evidence around 1200 histBC, followed by the so-called 'post-palatial' period (Late Helladic III C) and the transition to the Early Iron Age (Sub-Mycenaean and Protogeometric). We note that the Mycenaean palatial system did not develop everywhere in Greece, but only in a few regions (*e.g.* Argolid, Messenia).

In the post-palatial period – the period from *c.* 1200 to 1050 histBC – Mycenaean culture continued to thrive, but lacked the formerly highly centralised palace system. These are troubled times, that are best studied on a local level. Some researchers would speak of this period as 'Dark Ages'. But there are variations in terminology. Quite often, this term is used for the entire period 1200 to 800 histBC (covering all LH IIIC through to Geometric). However, due to increasing amounts of archaeological data, the term is now best avoided, at least for LH IIIC. Beyond terminological caution, we must be cautious in supra-regional comparisons, due to pertaining differences in the social development of different regions (*e.g. Deger-Jalkotzy 1994; Mühlenbruch 2004*). Climatic explanations for the end of the palatial system are discussed among many other scenarios by Deger-Jalkotzy (*1994*), and are taken as a more specific background for the 12th century hist BC by Falkenstein (*1997*). Altogether, climate variability does not figure among the major factors under discussion to explain societal change, in contemporary Bronze Age research. This is not due to any underestimation of its importance, which is widely acknowledged, but rather to the lack of convincing (high-resolution) climate data. Another drawback of earlier climate explanations was the lack of any plausible meteorological mechanism for climatic variability, but we are now confident in being able to supply this.

In the context of the 3000–2930 calBP RCC event, with its given (Greenland ice-core based) ultra-high dating precision we are now in a position to reconsider the question of whether the settlement system in the Late Bronze Age shows responses that could be attributed to climatic variability. Following the palace destruction around 1200 histBC, and quasi-immediate site re-occupation on a clearly reduced organisational level (for Tiryns see *Mühlenbruch 2004*), one of the next important cultural breaks comes at the end of the post-palatial period. Following this period, important changes have been identified in settlement patterns (site densities and locations; *e.g. Eder 1998.199–201; Maran 2006; Mühlenbruch 2004*). But these have dating insecurities ranging over decades. We must take further care in differentiating between the different regions. In southern Greece there are a remarkably fewer settlements showing evidence for occupation during the Sub-Mycenaean period. In this area, during the RCC time-window (~1050–980 histBC *i.e.* Sub-Mycenaean and/or Protogeometric), we must therefore either assume a particularly low population density compared with the preceding LH III C, or we assume, in view of the widespread lack of settlements dating to this period in southern Greece, that corresponding sites have been destroyed, *e.g.* by later removal of stone or erosion (*Eder 1998.199–201; Mühlenbruch 2004*).

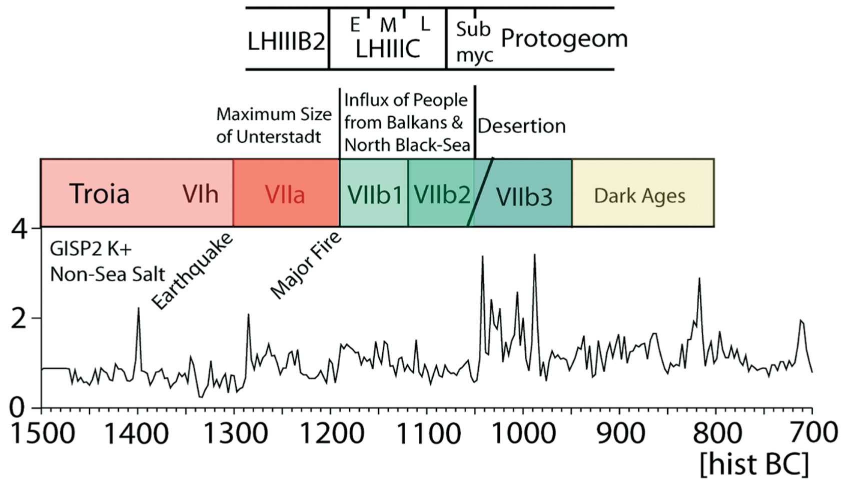


Fig. 26. Upper: Architectural Periodisation of Troy (*Korfmann 2006*). The definition of a new phase (Troia VIIb3) at the end Troy VII is subject of ongoing research (see text). Lower: Greenland GISP2 ice-core nss [K⁺] chemical series (*Mayewski et al. 1997*).

Put together, there is no great necessity to explain the archaeological vacuum on the Peloponnese as resulting from climatic deterioration. Nor do we need such an explanation to understand the troubled times in other regions of Greece at the end of the Bronze Age. Nevertheless, it does seem advisable to keep in mind the possibility that climate-induced stress may have been operating at this time, in addition to other factors, and this remains to be explored.

CONCLUSIONS

We have explored the potential impact of Rapid Climate Change (RCC) on prehistoric communities during the Holocene in the Eastern Mediterranean. The RCC cooling anomalies are well-dated (with quasi-annual resolution) due to synchronisms between marine cores and Greenland ice-core records. In our archaeological RCC-studies, we use GISP2 nss [K^+] chemical ions as proxy for the polar air outbreaks, which are caused by an intensification of the semi-permanent Siberian high pressure zone. For the Eastern Mediterranean region, recent palaeoclimatological research has inferred the existence of six periods with distinct major climatic anomalies, the most recent of which is the Little Ice Age. All these anomalies appear related to the same (but in archaeology not yet widely recognised) climatological mechanism, which would have caused the inflow of intensely cold and dry polar and continental air masses into the eastern Mediterranean basin. During RCC periods the cold air influx occurs quite regularly, although not every year, and typically only for several days to weeks during winter and early spring. The GISP2 age- model then supplies the following time-intervals for major (age-delimited) RCC-variability (1) 10.2–10.0 ka calBP, (2) 8.6–8.0 ka, (3) 6.0–5.2 ka, (4) 3000–2930 calBP (~1050–980 histBC).

We have investigated in detail contemporaneous cultural developments in the Eastern Mediterranean. Special focus was on the following archaeological events and periods, for each of which we have analysed the possibility of a climatic background. Our main research results can be summarised as follows:

(1) ~10 200 calBP & LMP
- Initial domestication of plants and animals in the Levant has *no relation* to RCC and also dates *prior to onset of LMP*.
- LMP supports major demographic expansion in Near East
- Jericho deserted due to ~10.2 ka calBP RCC

(2) ~8600–8000 calBP
- RCC- & Drought-triggered cultural collapse in Southern Levant

- RCC-related social change at Çatalhöyük
- RCC-triggered abandonment of Çatalhöyük
- RCC-triggered abandonment of Cyprus (*cf. Weninger et al. 2006*)
- RCC-triggered spread of early farming from Anatolia to SE Europe

(3) ~6000–5200 calBP
- widespread RCC-triggered social change in SE-Europe
- RCC-triggered collapse of SE-European Copper Age
- End of RCC: onset of Southeastern European Early Bronze Age

(4) ~3000–2930 calBP
- RCC-triggered abandonment of major Late Bronze sites (*e.g.* Troia VIIb)

In the northern Levant, the cultural expansion during an early phase of the PPNB appears directly related to changes in precipitation, as documented in Dead Sea Levels. The possibility that RCC was the cause of major environmental deterioration is indicated by the temporary abandonment of Jericho at around 10.1 ka calBP, and also by the occurrence of Rubble Slides in southern Jordan, at around 8.6–8.0 ka calBP. Concerning the 6.0–5.2 ka calBP RCC, it remains to be established whether the remarkable switch in economic systems in Southeastern Europe during this period, let alone the widely observed system collapse at the beginning of this period, has any relation to RCC. It does appear possible. The same applies to cultural trajectories at Troy, as well as more generally towards the end of the Bronze Age in the Eastern Mediterranean.

From these studies it follows that RCC-deterioration may well have been a major factor underlying social change, but if so, always reacting within a wide regional spectrum of social, cultural, economic and religious factors. We acknowledge the existence in the Near East of other important climatic and environmental factors, besides RCC. Interestingly, some of these factors appear to interact with the RCC mechanism. This requires further attention.

In terms of data, we have assembled substantial evidence for the existence of rapidly occurring supra-regional Holocene cooling periods in the Eastern Mediterranean, and this evidence has been cross-referenced at high temporal resolution with the prehistoric cultural development in this same region.

OUTLOOK

In terms of method, this paper highlights the importance of developing highly precise archaeological chronologies in RCC-studies. Otherwise, there is a danger of confounding different processes. The GISP2-age model probably requires fine-tuning for all RCC-periods, but this was beyond the scope of the present paper. Already now, the GISP2 nss [K+] record can be used to forecast the dates at which major social change may occur. In the Near East, some quite complex interactions of the RCC mechanism with (partly synchronous) variations of Holocene Dead Sea Lake Levels (*Migowsky et al. 2006*) have

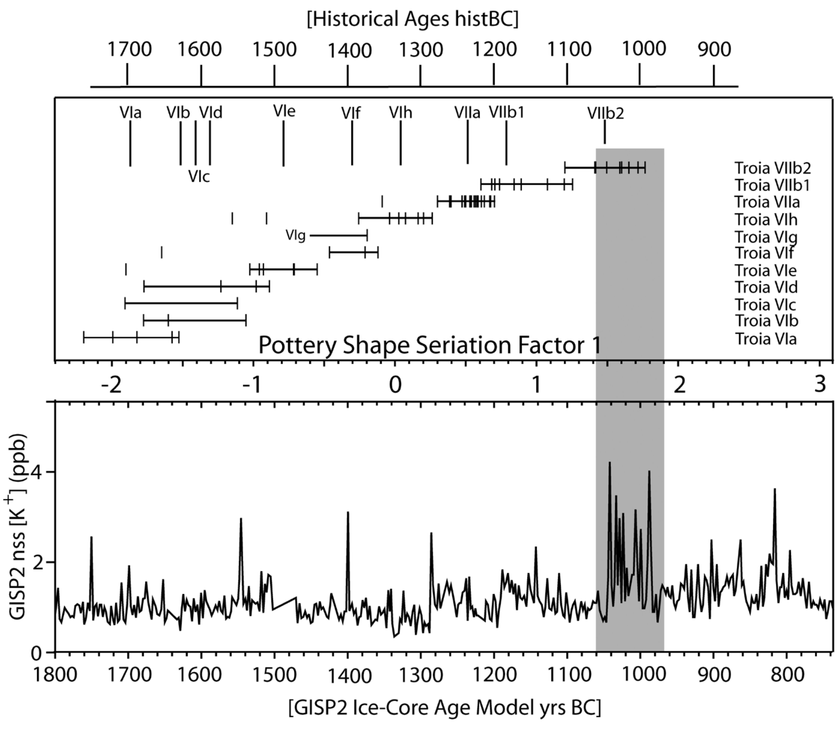


Fig. 27. Upper: Blegen Shape Pottery Seriation for Troia VI–VII by Correspondence Analysis (*Weninger 2009*). Factor 1 scores of seriated excavation units from Phases Troy VIa to Troy VIIb2 are compared with the historical age model (1700–1000 hist BC) according to Mountjoy (*1999a; 1999b*). Lower: Greenland GISP2 ice-core records; stable oxygen isotopes (*Grootes et al. 1993*) and nss [K+] chemical series (*Mayewski et al. 1997*). Site abandonment at Troiy probably occurs during Troy VIIb2–3; note that this seriation does not include finds from the new Troy VIIb3 phase (see text).

become evident. We nevertheless hope to have convincingly demonstrated the strong climatic sensitivity of cultural developments in the Levant during the early Holocene. This accepted, the GISP2 nss [K^+] RCC-proxy can be used, with foreseeable advantages in many disciplines, *e.g.* in extending results already achieved by comparing the palaeo-botanical data with the GISP2-$\delta^{18}O$- record (*Willcox et al. 2009*).

The predictability of societal change also applies to southeast Europe. Here, a climate-related switch between two modes of economy, agrarian and pastoralist, is apparent. Although such modes are surely not mutually exclusive, it does appear possible to forecast accurately (with decadal precision) the dates at which the major agrarian tell-settlements where abandoned. This also applies to the reoccupation of these sites, following the – again abrupt – onset of non-RCC-conditions. As such, the tell-communities appear especially sensitive to climatic deterioration. This is probably due to their central economic position, as well as enhanced social stratigraphy. But there are indications that even the assumedly less sensitive pastoralist communities experienced increasing climate-related stress, notably during the second half of the 6000–5200 calBP RCC interval.

Taking all regions and periods together, it is quite remarkable how rapidly human societies appear to have responded (social stress) or adapted (by economic switching) to RCC-conditions. Both modes of response are in-phase with RCC. The emerging predictability of social change in prehistoric periods may be useful to researchers in other disciplines.

ACKNOWLEDGEMENTS

We would like to thank Tjeerd van Andel (Cambridge) for many motivating discussions and for providing geo-archaeological data from Thessaly.

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Appendix

Radiocarbon Database

The studies in this paper are based on a substantial archaeological radiocarbon database for the Epipalaeolithic, Mesolithic and Neolithic periods in Europe and the Near East which presently compromises 14 627 ^{14}C-ages, of which 65% are from georeferenced sites. The ^{14}C-database contains N = 1856 different (usually multi-period) georeferenced sites, and is assembled from a number of large archaeological ^{14}C-databases compiled in recent years by different authors (*Housley 1994; Görsdorf and Bojadžiev 1996; Gérard 2001; Bischoff 2004; Bischoff et al. 2004; 2005; Rollefson pers comm 2002; Reingruber et al. 2004; 2005; Thissen 2004; Thissen et al. 2004; Weninger et al. 2006; Böhner and Schyle 2009*). In the present paper we use the Neolithic, Chalcolithic and Bronze Age components of this database with geographical focus on the Levant (Jordan, Israel/Palestine, Syria), northern Mesopotamia (Iraq, SE-Turkey), Cyprus, Bulgaria and Greece. In all these regions the ^{14}C-database is known to be characterised by some strong bias in favour of large sites, and in particular multi-phase settlements, which for historical reasons have seen more extensive excavation than smaller sites. The geographic setting of archaeological sites cited in the present study is shown in Figure 1. We typically reference both original and secondary publications. In the case of the large ^{14}C-datasets often used in this paper it is impossible to provide data sources for individual ^{14}C-ages. Detailed references for these ages are provided in the on-line databases of Gérard (*2001*), Bischoff (*2004*), Bischoff *et al*. (*2005*), Thissen (*2004*), Thissen *et al.* (*2004*), Reingruber *et al.* (*2005*), Weninger et al. (*2006*), and Böhner and Schyle (*2009*).

Time-Scales and Terminology

The archaeological chronologies discussed in this paper are mostly based on tree-ring calibrated ^{14}C-ages that are typically measured on terrestrial samples (charcoal, grain, bone). Numerical ages given on the calendric time scale using [calBP] units, with the year AD1950 = 0 calBP as reference. Conventional ^{14}C-ages are given on the ^{14}C-scale with units [^{14}C-BP]. All tree-ring calibrated ^{14}C-ages are obtained from CalPal software (www.calpal.de), based on methods described in Weninger (*1986*). For ^{14}C-age calibration, we have applied the tree-ring based data set INTCAL04 (*Reimer et al. 2004*). As an exception, the chronology of the Late Bronze Age is largely based on pottery synchronisms within the framework of Eastern Mediterranean historical-astronomical age models. In such cases, reference is made to historical ages with units [hist BC].

Data Representation

Extensive use is made in the present paper of a method for graphic representation of large archaeological ^{14}C-datasets called 'multi-group ^{14}C-age calibration' (*Weninger 2000*). This method addresses the problem of how to maintain visual control over large sets of archaeological ^{14}C-ages, without losing the often important information contained in the properties of individual ^{14}C-dates. The solution is to show the accumulative probability distribution of calibrated ^{14}C-ages as an envelope curve for the total data, in addition to showing the median values of individual calibrated ^{14}C-ages as small lines. This leads to graphic representations of calendric age data spread in a manner similar to the well-known bar-codes. Caution is to be taken, in rare cases, when the calibrated probability distribution is non-Gaussian. In such cases the median value may not have a central position within the calibrated probability distribution. For the large data densities we are aiming at, these cases become invisible.

Acronyms

AMS	Accelerator Mass Spectrometer
EBA	Early Bronze Age
EN	Early Neolithic
EPPNB	Early Pre-Pottery Neolithic B
FN	Final Neolithic
KGK-VI	Kodžadermen-Gumelniţa-Karanovo VI
LGM	Late Glacial Maximum
GISP2	Greenland Ice Sheet Project 2
LIA	Little Ice Age
LHIIIB2	Late Helladic IIIB2
LMP	Levantine Moist Period
LN–1	Late Neolithic 1
LN–2	Late Neolithic 2
[mbsl]	meters below sea level (Dead Sea)
MN	Middle Neolithic
nss [K^+]	non sea-salt Potassium concentration
PN	Pottery Neolithic
PPNA	Pre-Pottery Neolithic A
PPNB	Pre-Pottery Neolithic B
PPNC	Pre-Pottery Neolithic C
LPPNB	Late Pre-Pottery Neolithic B
MPPNB	Middle Pre-Pottery Neolithic B
PPNA	Pre-Pottery Neolithic A
RCC	Rapid Climate Change
SE	southeast
SST	Sea-Surface Temperature
THC	Thermohaline Circulation
YD	Younger Dryas

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Climate variations in the Circum-Alpine region and their influence on Neolithic-Bronze Age lacustrine communities: displacement and/or cultural adaptation

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ABSTRACT – *Because of its delicate balance, the hydrological system of the Alpine region is affected immediately by climatic variations. The most obvious evidence of hydrologic instability is reflected by natural water basins in particular rivers and lakes. Caused by climate change, but catalyzed by a myriad of environmental factors, the water levels of lakes and other natural water reservoirs fluctuate, influencing people who live in their proximity. In some cases, the irregular pattern of human occupation around prehistoric Circum-Alpine lakes shows a remarkable affinity to climatic oscillations. People's responses to environmental influence are nevertheless unpredictable, and sometimes illogical.*

IZVLEČEK – *Na hidrološki sistem alpske regije zaradi njegovega občutljivega ravnotežja takoj vplivajo spremembe klime. Najbolj očitno se dokaz o hidrološki nestabilnosti odraža pri naravnih vodnih kotanjah in še posebej pri rekah in jezerih. Zaradi klimatskih sprememb, ki jih pospešuje nešteto okoljskih dejavnikov, nihajo vodni nivoji jezer in drugih naravnih vodnih rezervoarjev, kar vpliva na kulturne skupnosti, ki živijo v njihovi bližini. Nepravilen vzorec človeške poselitve okoli prazgodovinskih alpskih jezer v nekaterih primerih kaže pomembno podobnost s klimatskimi nihanji. Vendar so človeški odgovori na okoljske vplive nepredvidljivi in včasih nelogični.*

KEY WORDS – *Alps; climate; Neolithic; Bronze Age; lacustrine; settlement*

Introduction

Patterns of occupation have always been among the most discussed topics in Circum-Alpine lake-dwelling studies. Although the lacustrine settlement tradition perpetuated itself for more than three millennia, it was certainly not homogeneous, in terms of diachronic occupations. In fact, the lake shores were not settled continuously – phases of occupation alternated with phases of abandonment.

It has been shown that most occupational phases coincided with favorable climatic conditions (*Magny 1993*). However, there were periods of climatic deterioration, when the shores continued to be occupied; and periods of favorable climate, when the shores were deserted. It is interesting to note that even during unfavorable climatic conditions, when the hydrological balance of the lakes drastically changed, only a small number of settlements were directly influenced by lake level fluctuations, and people coercively displaced (*Menotti 2003*). If and when displacement occurred, it was more the result of economic factors triggered by crop failure. In most cases, however, people found cunning alternatives in order to cope with unexpected climate variations. This prompted a series of environmental crises, which influenced the whole of the surrounding ecosystem.

Surprisingly enough, favorable climatic conditions also caused similar economic 'disasters', as a result of overexploitation of the environment and poor natural resource management.

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The lake-dwelling chronology

The lake-dwelling tradition in the northern Circum-Alpine region started at the end of the fifth Millennium BC and ended in the second half of the seventh century BC (*Menotti 2001a; 2004*). But, as much as we would like to see it as homogeneous in terms of human occupation, archaeological evidence argues for a marked discontinuity (*Suter, Hafner and Glauser 2005.18*). In fact, periods of occupation alternated with periods of abandonment, with the latter being caused by environmental as well as cultural factors, and sometimes a combination of both.

Magny (*1995; 2004*), for instance, shows that there is a plausible correlation between climate and lake-dwelling occupational patterns. Periods of favorable climate coincide with periods of lake-dwelling occupation, whereas abandonment is the result of climate deterioration (Fig. 1). Pétrequin and Bailly (*2004*), on the other hand, argue that the relationship between climate and lake shore occupation does not always work. There are in fact periods when the climatic conditions in the lacustrine environment were favorable, but the lake shores were not settled.

For instance, short-term deteriorations in the climate in the first half of the 37th and 36th centuries BC had little impact on lake shore occupation. The one which occurred in the 34th century BC, on the other hand, was more distinct, although some lakes (especially in the western part of Switzerland) continued to be occupied. Interestingly enough, during periods of favorable climate (*c.* 3500–3450 BC and 3300–3250 BC), the shores were completely deserted throughout the northern Alpine region (*Hafner and Suter 2000*). A similar situation, but in a much larger scale, is found between *c.* 2400 and 1800 BC, when, apart from very sporadic examples, the lake shores were not occupied at all.

Not only have archaeologists attempted to bridge the occupational gaps (*Menotti 2003; 2004*), but they have also tried to give plausible explanations as to why the shores were not settled during favorable climatic conditions (*Pétrequin et al. 2002; Arbogast et al. 2006*), or were occupied during climatic deterioration.

Direct influence of climate deterioration: the 'lake level fluctuation hypothesis'

Climate deterioration could have a direct impact on lacustrine settlements. An increase in humidity and precipitation could, in fact, influence the delicate hydrological balance of the lakes, causing water levels to fluctuate, hence affecting those lake villages located immediately next to the water. Of course, the extent to which the lake transgressions influenced prehistoric lacustrine settlements depended upon a variety of factors, from the size, morphology and hydrological sensitivity of the lake (*Magny 1992*), to the typology and location of the dwellings (*Menotti 2001b*). Lake Constance is known as one the most sensitive lakes in the northern Circum-Alpine region. Its normal seasonal water level fluctuations vary as much as three metres between winter (the lowest) and early summer, and/or early autumn (the highest). Abrupt changes in climatic conditions affect the lake even more, forcing people to abandon their houses situated too close to the water. In fact, the archaeological records of some excavated lacustrine villages show transgressions occurring during, and soon after, the occupation. These transgressions might have indeed been the cause of abandonment (see, for instance, Arbon-Bleiche 3 – Neolithic; and Arbon-Bleiche 2 – Bronze Age on Lake Constance, Switzerland) (*Jacomet, Leuzinger and Schibler 2004; Hochuli 1994; Menotti 2001a*). Lake level fluctuations were also witnessed on less sensitive

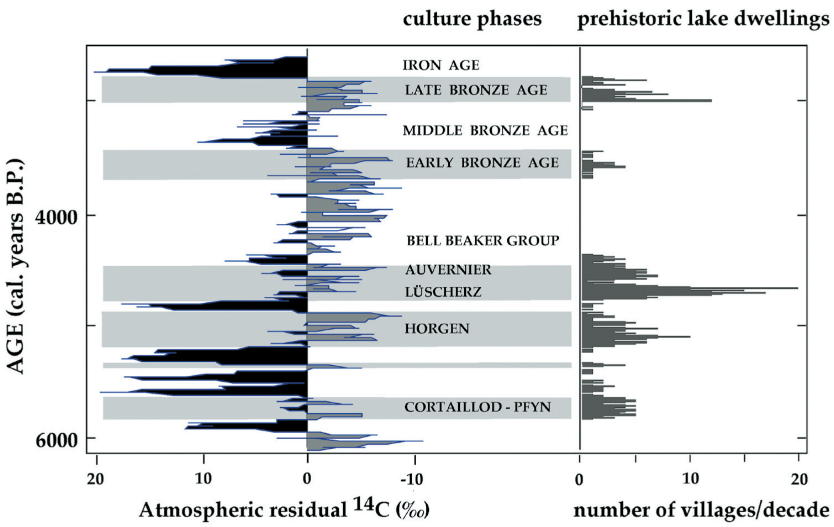

Fig. 1. Correlation between atmospheric residual ^{14}C variations (+ unfavourable climatic conditions; – Favorable climatic conditions) and lake-shore settlement occupations in the western part of the Circum-Alpine region (after* Magny 2004*).

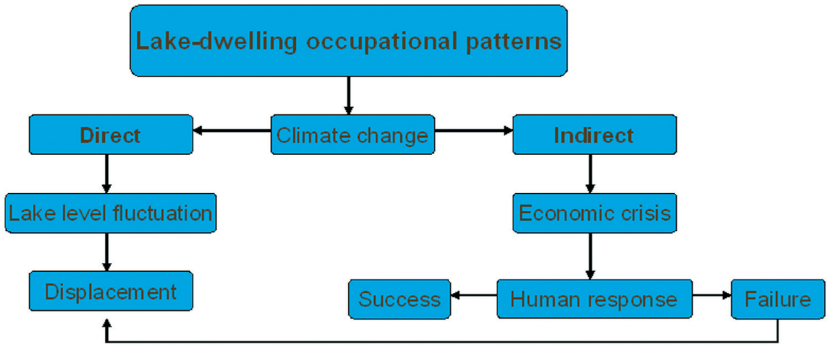

Fig. 2. Direct and indirect influence of climate change on lake-dwelling occupational patterns.

lakes and even on shrinking morainic lakes, such as Lake Feder (Siedlung-Forschner) in Germany (*Schlichtherle and Wahlster 1986*), and Lake Carera (Fiavé), Italy (*Perini 1987*).

Scholars have been trying to gauge the extent to which these sudden and abrupt transgressions might have affected villages and their surroundings. As pointed out above, the severity of the impact depended on a number of factors. Some villages had to be evacuated almost immediately, others later on, as a result of economic crises triggered by extensive flooding over the nearby agricultural land (Fig. 2). Severe displacements of more inland activities occurred quite rarely, and also in those cases, the lake-dwellers maintained vital connections with the lakes (*Menotti 2003*).

Climate influence on lake shore activities

Bad climate occupation

Although the majority of lake-dwelling activities coincided with periods of favorable climate, there were phases when the lake shores were settled despite evidence of climate deterioration. This could depend on a variety of factors: lake shore morphology, settlement location and, of course, cultural choices. However, even if these factors allowed the lake-dwellers to occupy the very proximity of the lakes, climate deterioration might have had negative influence on the economy, as a result of crop failures. Historical records show the extent to which bad climate influences agricultural activities, depending on the season in which the bad weather occurs. It has been noted, for instance, that cold and wet summers have been the main causes of major crop failures in the Alpine region and surroundings (*Pfister 2001*).

Good climate occupational hiatus

Favorable climatic conditions equal lake shore activity! However, it is also quite common that shores were not settled (or even abandoned) during phases of good climate. Looking at the lake-dwelling occupational patterns from the Neolithic to the Iron Age in the northern Alpine region, one can easily spot this apparently unusual phenomenon (see the chronology section above). Possible explanations are excessively high summer temperatures and prolonged periods of drought, which, especially in areas where the soil is not very fertile, may cause crop failure. A convincing example comes from the Middle Ages in Switzerland, when, in 1540, lack of precipitation from April to August, and excessive heat in the summer, caused a major drought, which had repercussions on both flora and fauna; agricultural activity was severely disrupted and a number of animals (wild and domestic) died of starvation (*Glaser et al. 1999*).

Another possible explanation for occupational hiatus and/or abandonment of the lake shores might be linked to demography and overexploitation of the environment (see below).

Human responses to subsistence crises

Whether caused by favorable or unfavorable climatic conditions, economic and subsistence crises linked to crop failure had enormous repercussions on the lake shore environment, and the entire ecosystem of the northern Circum-Alpine region. The insufficiency of staple food forced the lake-dwellers to seek alternative nutritional sources to compensate for their low-calorie diet. As a result, hunting activity increased in some lacustrine areas. Interestingly enough, this increase occurs during bad as well as good climatic conditions, proving that it is mainly linked to the need for a higher-calorie diet (*Arbogast et al. 2006*). More hunting activity had, of course, negative repercussions on the fauna. Archaeozoological evidence, for instance, shows that red deer almost faced extinction in the Zurich area between 3660 and 3600 BC (*Schibler 2004; Schibler et al. 1997*). This is also confirmed by the LSI (Logarithmic Size Indices) on red deer bones; in fact, a decrease in LSI values (more hunting) is noticed in the above-mentioned time span, as opposed to the increase (less hunting) occurring between 3200 and 3000 BC, and between 2700 and 2500 BC (Fig. 3). It has to be pointed out, however, that even within these periods there were phases of intensive hunting activity, but they were probably too short to influence the animal population size.

More hunting was not the only alternative adopted by the lake-dwellers to compensate for the lack of cereals, but there was also a noticeable increase in gathering (mainly plants and fruits). Evidence of this comes from the 37th-century lake village of Zurich-Mozartstrasse, Switzerland, where a fairly high proportion of hazelnuts was found in layers 4 and 5, which also contained a high number of wild animal bones and low quantities of cereals (*Brombacher and Jacomet 1997*).

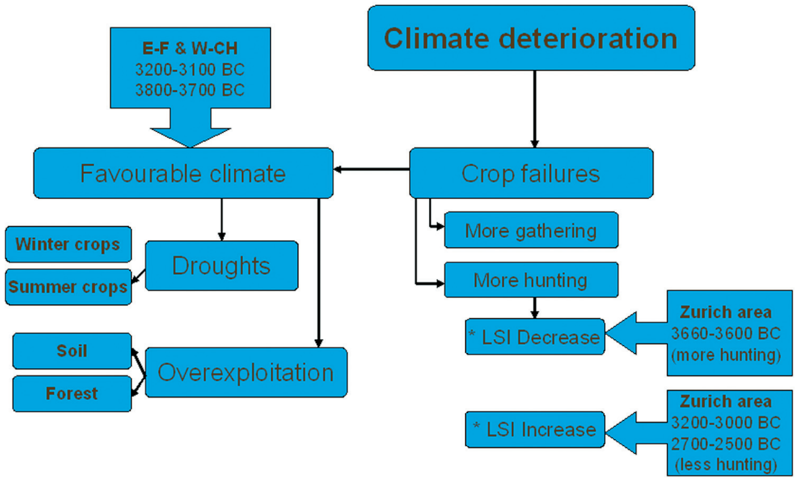

Fig. 3. Negative effects of both favorable und unfavorable climatic conditions on crop cultivation in the northern Circum-Alpine region lake-dwelling tradition (Legend: * LSI = Logarithmic Size Indices; E–F = Eastern France; W–CH = Western Switzerland).

Lake shore abandonment might also have been caused by demographic expansion linked to migrations, and environment overexploitation. A good example is that of the Neolithic lake-dwellings at Chalain (France), which, possibly due to the influx of external cultural groups (the Eastern-Swiss Horgen groups, South-west Ferrieres groups and north-western groups from the Saône Plain), experienced a demographic increment between 3200 and 3000 BC (*Pétrequin, Magny and Bailly 2005; Arbogast et al. 1996*). This triggered a series of actions, such as an increase in hunting activity (due to a higher demand for meat), overexploitation of cultivable land and the felling of primary forest trees for house building material. A combination of all the above-mentioned factors was probably what forced the lake-dwellers to move to other areas such as the Lake Clairvaux region, in search for more available natural resources (*Arbogast et al. 2006*).

Conclusions

The fascinating discontinuity in the Neolithic and Bronze Age lake-dwelling occupations in the northern slopes of the Circum-Alpine region of central Europe has triggered a number of questions on past human-environment interaction. Seeking plausible explanations, scholars have sometimes encountered inexplicable riddles which, reach far beyond rationality. Fair climate does not necessarily mean occupation, as much as bad one is not essentially linked to abandonment! Climate change certainly influences and transforms the environment, which itself, of course, affects humans. We have seen how the imbalanced hydrology of a lacustrine region could trigger significant lake level fluctuations. However, these water transgressions have little physical impact on the settlements themselves, in terms of flooding of the habitable area and consequent abandonment. More significant repercussions are linked to economic and subsistence crises resulting from crop failure. In order to compensate for a low-calorie diet caused by a lack of staple food, lake communities sought new nutritional alternatives outside the agricultural sphere (*e.g.* plant and fruit gathering, and especially hunting). As a result, overexploitation of the environment, resulting from these activities altered the natural habitat and the entire ecosystem, seriously affecting wild fauna.

Furthermore, the natural environment could also have been affected and changed by cultural phenomena, which were not necessarily triggered by climate change. In fact, we have seen how demographic growth, possibly incremented by migratory relocations, may have had similar negative effects on the environment. Higher demand for meat, led to over-hunting and possible wild animal species extinction; or overexploitation of woodlands, (including primary forests) due to a higher demand for house construction material, resulted in severe deforestation, with consequent soil erosion.

Whether triggered by natural or cultural factors, human responses to climate variability are always reflected in the environment. The severity of the consequences triggered by human responses is difficult to gauge, for they are the result of a causative chain of events. The final outcome, either in the form of success (in coping with the crisis and the permanence in the area), or defeat (abandonment and displacement) does not depend on the environment itself, but mainly on people's management skills.

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First of all, I would like to thank Prof. Budja for inviting me to the 15th Neolithic Seminar, which he organised marvellously, and from which this publication originated. I am also very grateful to Stefi Jacomet and Jörg Schibler for providing me with vital insights on this fascinating research topic, especially concerning archaeobotany and archaeozoology.

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Climate change and population dynamics during the Late Mesolithic and the Neolithic transition in Iberia

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ABSTRACT – *This paper explores how Early Holocene climate changes in the Western Mediterranean would have affected Late Mesolithic settlement distribution and subsistence strategies in Iberian Peninsula, thereby giving rise to various adaptive scenarios. The current radiocarbon data set concerning the Neolithisation process has revealed the rapidity of the spread of farming in Iberia. Considering both the implications of the last hunter-gatherers' adaptation strategies and the population dynamics of agro-pastoral communities, we address the migration patterns underlying the Mesolithic-Neolithic transition. In conclusion, we propose that the initial colonization process was the result of two successive and spatially heterogeneous migrations: Maritime Pioneer Colonization and targeted migration to places favorable to the new economic system.*

IZVLEČEK – *V članku raziskujemo kako bi zgodnje holocenske klimatske spremembe v zahodnem Sredozemlju vplivale na pozno mezolitsko razporeditev naselbin in na prehranjevalne strategije na Iberskem polotoku in s tem povzročile nastanek različnih prilagoditvenih scenarijev. Trenutna serija radiokarbonskih datumov, povezanih s procesom neolitizacije je razkrila hitrost širjenja poljedelstva na Iberskem polotoku. Ob upoštevanju obojega – vpletenosti prilagoditvenih strategij zadnjih lovcev in nabiralcev ter populacijske dinamike poljedelsko-pastirskih skupnosti, opazujemo selitvene vzorce, ki so podlaga mezolitsko – neolitskega prehoda. V zaključku predlagamo, da je bil začetni proces kolonizacije rezultat dveh zaporednih in prostorsko heterogenih migracij: pomorske pionirske kolonizacije in ciljne migracije na prostore naklonjene novemu ekonomskemu sistemu.*

KEY WORDS – *climate change; 8200 calBP event; Mesolithic-Neolithic transition; migration*

Introduction

As elsewhere in Europe, the origin of the Neolithic in Iberia is related to the introduction of technical and economic innovations in food production by means of different migration processes and subsequent cultural interaction with local populations of hunter-gatherers (*Zilhão 2001; Bernabeu 2002*). Consequently, one can expect a regionally diverse and complex process modeled by both environmental and social factors.

In the 90's, discussions on the Neolithic transition in Iberia were framed within the migrationist and indigenist debate (*e.g. Bernabeu 1996; Vicent 1997*) and the refutation of polygenist models (*Zilhão 1993; Bernabeu et al. 1999*). However, during the last 10 years, the chronology of the first ceramic contexts and domesticates have enjoyed renewed interest as a result of the incorporation of new data from the Iberian interior and the Northern Façade (see below). In the context of the whole of Iberia, both regions, as counterparts of other traditional research areas such as eastern Spain and Portugal, focus most of the current debate on the timing and mechanisms behind the farming expansion (*e.g. Al-*

day 2005; Bernabeu 2007; Cruz and Vicent 2007; Carvalho 2003; Juan-Cabanilles and Martí 2002; Martí 2008; Rojo et al. 2006 among others).

In this context, the relationship between environmental and cultural dynamics regarding the Neolithic transition has been placed on a secondary level of analysis and interpretation. With the exception of Zilhão, who has openly argued how these factors explain the absence of a Mesolithic population in the central hinterlands of Portugal and Spain (*Zilhão 2000; 2001*), very little attention has been paid to this issue until recently.

Nevertheless, new paleo-environmental evidence and archaeological data on the Late Mesolithic record seem to indicate that some transformations in the settlement and subsistence patterns erupted suddenly:

1. A geographically circumscribed distribution of Mesolithic settlement. There is still a lack of archaeological information regarding the Late Mesolithic from several areas, such as Spanish Meseta and Catalonia, and research bias alone cannot explain this.

2. Variable reliance on aquatic resources shown among the last groups of hunter-gatherers. The available information on paleodiets and isotopic analyses of Mesolithic populations from Portugal, Cantabrian Façade and the central Mediterranean coast of Spain, have provided new data of relevance to this issue, reflecting regional disparities. In this sense, the degree of dependence of the Mediterranean samples is remarkably inferior to those recorded in Portuguese and Cantabrian shell middens.

From an evolutionary perspective, if the first point can be linked to the dynamics of environmental change and to the adjustments that Mesolithic population made, the second is a direct outcome of these adaptations.

This paper will explore how Early and Middle Holocene environmental changes could have affected the geographical distribution, organization and subsistence of Late Mesolithic settlements. This period witnessed the appearance of the Neolithic in Iberia, providing various opportunities for ongoing farming dispersal processes in the western Mediterranean. A critical review of the last foragers evidence in Iberia is essential to establish a coherent frame of hypotheses about the role of indigenous populations in the economic and demographic changes that occurred during the Neolithic transition.

The paper is in two parts. First, we present a general overview of Early-Middle Holocene environmental dynamics and Late Mesolithic settlement distribution in Iberian Peninsula. Second, we discuss the effects of the 8200 calBP event on regional settlement organization and sedimentation dynamics. Finally, we suggest how these dynamics would have affected subsistence patterns on the basis of paleodietary studies.

In the second part, we present empirical evidence from the earliest Neolithic sites from the latest regional studies in the Iberian bibliography. We then revisit different models of the transition to farming in the Iberian Peninsula, prior to sketching new interpretations that emphasize population dynamics and environmental changes alongside the Mesolithic-Neolithic transition. Also, since the Neolithisation process entailed complex demographic transformations, we discuss paleogenetics and population replacement regarding the Iberian data. Finally, we propose some directions for future research.

The body of Mesolithic and Neolithic radiocarbon dates for the Iberian Peninsula has been particularly increased and enhanced in recent times due to the systematic application of sample selection protocols (*Juan-Cabanilles and Marti 2002; Rojo et al. 2006; Bernabeu 2006; Carvalho in press*). The current compilation – in Tables 1 and 3 – has been built on the basis of a series of radiocarbon dates from single, short-lived samples: cultivated plants (mainly cereals), non-domesticated short-lived fruits (acorns), domestic fauna and human bones, following Venice's 1998 conference recommendations (*Ammerman and Biagi 2003*). Individual AMS ^{14}C dating of key specimens overrides the risk of dealing with disturbed contexts and with intrusions from overlying levels (*Bernabeu et al. 1999; Zilhão 2001*) and eliminates the possibility of the 'old wood' effect in the case of charcoal (*Zilhão 2001; Zapata et al. 2004. 285*). In addition, we have excluded from this analysis the radiocarbon determinations on shell samples – although the correction can be determined, their reservoir effect values, locally and diachronically, are subject to considerable variation (*e.g. Soares and Dias 2006*) and have not been established on the basis of short-lived samples from Neolithic contexts. Consequently, an unpredictable degree of uncertainty affects radiocarbon determinations on shell samples, and do not allow a comparisons with other Iberian contexts. On the other hand, we have included the radiocarbon dates of human remains from the Muge sites (Cabeço da Arruda, Cabeço da

Amoreira and Moita do Sebastião), calibrated considering several potentially changeable factors such as the percentage of marine resources consumed revealed by isotopic analyses, and the local estuarine reservoir effect (*Martins et al. 2008*), which is different from that established by Soares (*1993*)[1].

Early-Middle Holocene environmental changes and Late Mesolithic distribution

In current debates on the Neolithic transition in Iberia, the distribution of the last hunter-gatherer populations during the Neolithisation process is one of the main issues. In the last decade, Iberian archaeology has witnessed an outstanding advance in knowledge of the Late Mesolithic, which has changed the traditional archaeological sequence (*Fortea 1973*). Today, the Mesolithic in the Iberian Peninsula (*c.* 10 800–7200 calBP) is comprised of two successive industrial complexes that led regionally different cultural traditions: the flake-rich assemblages complex that dominated during the Boreal period and the Geometric Mesolithic, also generally called the Late Mesolithic, the main cultural features of which are presented below:

● *Flake rich assemblages complex:* The main distinguishing feature of this complex is a lithic industry based on flake technology with no – or very little – evidence of blade production. Lithic assemblages vary from flint to quartzite, but flake artifacts, especially notches and denticulates, and massive tools, comprise all of them. There are several denominations in the archaeological literature to define this kind of lithic industry (Mesolithic Macrolithic or Generic Mesolithic), including archaeological entities such as the 'Notches and Denticulates Mesolithic' (henceforth ND Mesolithic) (mainly in the Mediterranean region, the Ebro Valley and the Pyrenees) (*Alday 2006a; Cava 2004*) or Asturian (see *Straus 2008* for a recent revision). This complex dates between 10 200 and 8400 calBP, except the Asturian in the western Cantabrian region, where this complex is not well distinguished in typological terms from the Late Mesolithic phase due to the scarcity of geometric microliths at many open air sites.

● *Late Mesolithic phase A:* During this phase of the Iberian Mesolithic, there is a marked technological change with the re-introduction of blade debitage technology, the microburin technique and the configuration of trapezoidal microliths with abrupt retouch. This phase lasts from 8400 to 7900 calBP.

● *Late Mesolithic phase B:* Considered an evolution from the previous phase, it is characterized by the presence of triangles among the geometric microliths. In this sense, the most outstanding phenomenon is the emergence of specific microlith types with a regionally discrete distribution: triangles with concave sides known as 'Cocina triangles' at Valencia and Aragón regions, 'Sonchamp points' in the western Pyrenees and 'Muge triangles' in Portugal very similar to their Cocina correlatives. This phase lasts from 7900 calBP up to the beginning of the Neolithic in the different regions of Mediterranean Iberia (7500–7200 calBP).

● *Late Mesolithic phase C:* this is considered the terminal development of the Mesolithic industries that paralleled the expansion of the Early Neolithic (*Fortea 1973; Juan-Cabanilles 1990*). It is characterized by triangles and segments with bifacial retouch. However, its Mesolithic cultural affiliation is now subject to review, given the recent documentation of this set of geometric armatures from the beginnings of the Neolithic at some Cardial and Epicardial sites such as Chaves Cave (*Cava 2000*) with no underlying layers of Mesolithic occupation. In fact, the identification of Phase C, in typology, technology, stratigraphy and absolute chronology is ambiguous and not clearly isolated from earlier or later occupations (*Juan Cabanilles and Martí 2007–2008*).

As noted for other southern European regions (*Biagi 2003; Binder 2000; Juan-Cabanilles and Martí 2002; Carvalho in press*), considerations about the Late Mesolithic in terms of social geography and population dynamics should be grounded on a critical evaluation of chronology and the archaeological evidence, *i.e.* on the radiocarbon framework and the lithic industries. According to this, the map in Figure 1 gives an accurate picture of Late Mesolithic distribution (phases A and B) in the Iberian Peninsula (Fig. 1). It is based on a complete compilation that encompasses different kinds of archaeological site (rock-shelters, open-air sites and lithic scatters), with radiocarbon dates or accurate typological information published until 2002 (*Juan-Cabanilles and*

1 Calibrations, as well as the corresponding graphs, were obtained using the Version 4.1. of the OxCal Program (*Bronk-Ramsey 2009*), based on the IntCal04 curve (*Reimer et al. 2005*). All radiocarbon dates mentioned are in years BP and BC after calibration, and based on extremes of the 2 sigma range.

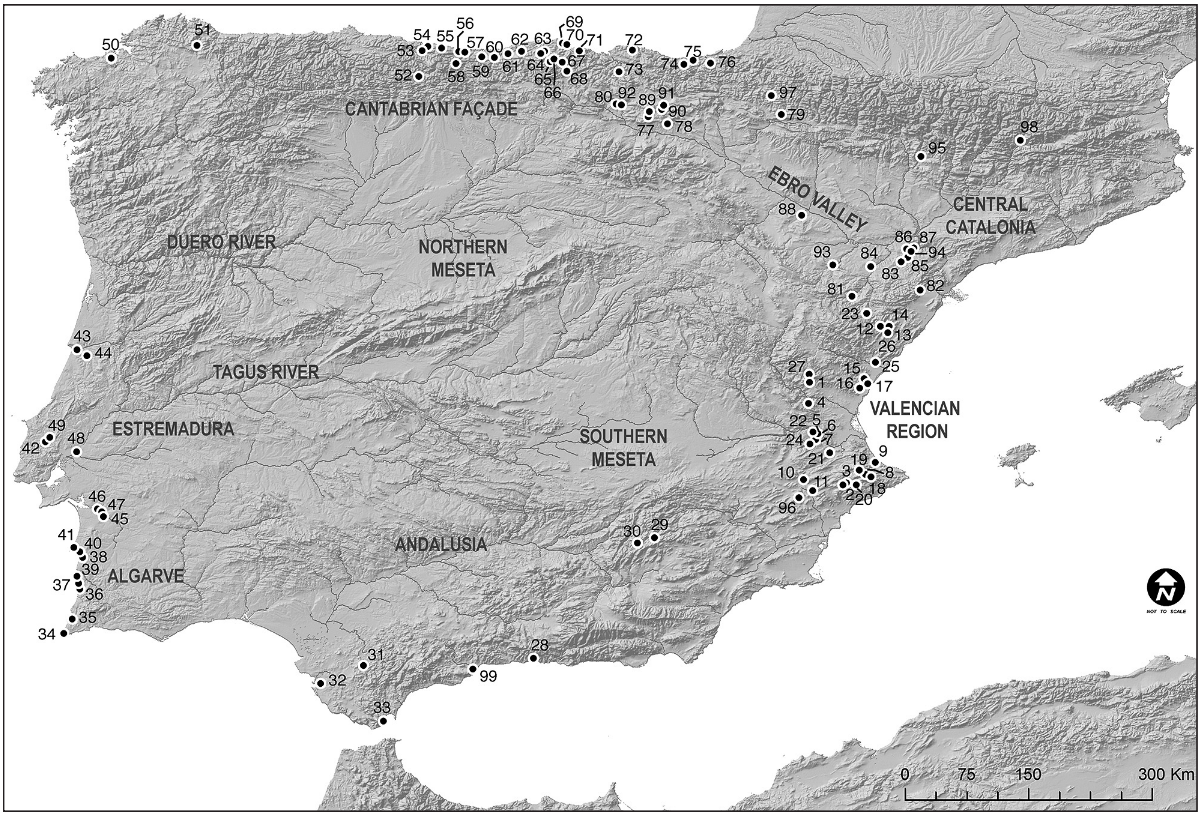

Fig. 1. Regional distribution of Late Mesolithic sites in Iberian Peninsula. 1. Llatas; 2. Gelat.; 3. Falguera; 4.Vacas; 5. Polvorosa; 6. Cocina; 7. Anna; 8. Tossal de la Roca; 9. Collado; 10. Casa de Lara; 11. Huesa Tacaña; 12. Mas Nou; 13. Mas de Martí; 14. Mas de Sanç; 15. Ballester; 16. Cavall; 17. Estany; 18. Santa Maira; 19. Encantada; 20. Regadiuet; 21. Peñeta; 22. Ceja; 23. Mas Cremat; 24. Zorra; 25. Sitjar; 26. Assud; 27. La Mangranera; 28. Nerja; 29. Nacimiento; 30. Valdecuevas; 31. Frailes; 32. Retamar; 33. Río Palmones; 34. Roca das Gaviotas; 35. Castelejo; 36. Montes Baixo; 37. Fiais; 38. Medo Tojeiro; 39. Vidigal; 40. Samouqueira; 41. Vale do Pincel; 42. Forno Telhas; 43. Forno da Cal; 44. Buraca Grande; 45. Arapouco; 46. Rebolador; 47. P. Sao Bento; 48. Muge region (Cabeço da Amoreira, Cabeço da Arruda, Moita do Sebastião); 49. Abrigo Bocas; 50. Reiro; 51. Xestido III; 52. Espertín ; 53. Colomba; 54. Coberizas; 55. La Riera; 56. Sierra Plana; 57. Mazaculos; 58. Los Canes; 59. Covajorno; 60. El Aguila; 61. Pendueles; 62. Toralete; 63. La Garma A; 64. Truchiro; 65. Cubío Redondo; 66. Cofresnedo; 67. La Chora; 68. Tarrerón; 69. La Fragua; 70. El Perro; 71. La Trecha; 72. Pareko Landa; 73. Urratxa; 74. Linatzeta; 75. Herriko Barra; 76. Marizulo; 77. Monticocha; 78. Peña Marañón; 79; Padre Areso; 80. Socuevas; 81. Angel; 82. Vidre; 83. Costalena; 84. Salada Grande; 85. Pontet; 86. Sol Piñera; 87. Serda; 88. Cabezo Cruz; 89. Mendandia; 90. Kanpanoste G.; 91. Atxoste; 92. Fuente Hoz; 93. Los Baños; 94. Botiqueria; 95. Forcas II; 96. Lagrimal; 97. Aizpea; 98. Margineda; 99. Bajondillo.

Marti 2002). We have updated it by adding new data, published since then (see below).

The body of archaeological data displays clear evidence of occupation in the Mediterranean Façade, the Ebro Valley, the Cantabrian Façade and central and south Portugal. Of course, this picture results from different regional research trajectories, which have produced quantitatively and qualitatively diverse information. However, the current distribution pattern does not differ substantially from that published seven years ago.

The central Mediterranean area (the Valencia region) has a significant number of Late Mesolithic sites (for a recent revision, see *Aura et al. in press*). Recent work has discarded previous Late Mesolithic attributions, such as the site of Arenal de la Virgen (*Fernández et al. 2008*), but added some new sites, such as Mas de Martí (*Fernández et al. 2005*), Santa Maira (*Aura et al. 2006*), Mas Gelat (*Miret el al. 2007*), Mas de Sanç (*Fernández 2006*), Cueva del Lagrimal (*Gómez and Fernández 2009*) and Mas Cremat (*Vicente et al. 2009*). Moreover, a previously known site, Falguera, has recently been published in full (*García and Aura 2006*).

As a result of continuous and intensive archaeological research, the Ebro Valley provides an outstanding Late Mesolithic record (*Alday 2002; Barandia-*

SITES	CONTEXT	SAMPLE MATERIAL		SAMPLE REFERENCE	^{14}C age (BP)	CalBP 2σ range	CalBC 2σ range	Ref.
PORTUGAL								
Cabeço da Arruda	Skeleton N	H	*Homo*	TO-356	6360 ± 80	7170-6680	5220-4730	1
Cabeço da Arruda	Skeleton D	H	*Homo*	TO-355	6780 ± 80	7690-7370	5740-5420	1
Cabeço da Arruda	Skeleton 42	H	*Homo*	TO-359a	6960± 60	7790-7440	5840-5490	1
Cabeço da Arruda	Skeleton A	H	*Homo*	TO-354	6970 ± 60	7860-7560	5910-5610	1
Cabeço da Arruda	Skeleton III	H	*Homo*	TO-360	6990 ± 110	7930-7450	5980-5500	1
Cabeço da Arruda	CA-00-01	H	*Homo*	TO-10217	6620 ± 60	7520-7230	5570-5280	1
Cabeço da Arruda	CA-00-02	H	*Homo*	TO-10216	7040 ± 60	7870-7570	5920-5620	1
Fiais	–	B	*Bone*	ICEN-141	6180± 110	7233-6913 (1s)	5400-4800	2
Fiais	S.XIX, A10, z.244	B	*Mammal*	TO-706	6260 ± 80	7126-7026 (1s)	5470-5000	2
Fiais	–	B	*Bone*	ICEN-110	6870± 220	8160-7330	6250-5350	2
Moita do Sebastiao	Skeleton CT	H	*Homo*	TO-135	6810 ± 70	7570-7250	5620-5300	1
Moita do Sebastiao	Skeleton 41	H	*Homo*	TO-134	7160 ± 80	7940-7590	5990-5640	1
Moita do Sebastiao	Skeleton 24	H	*Homo*	TO-132	7180 ± 70	7950-7620	6000-5670	1
Moita do Sebastiao	Skeleton 29	H	*Homo*	TO-133	7200 ± 70	7970-7640	6020-5690	1
Moita do Sebastiao	Skeleton 22	H	*Homo*	TO-131	7240 ± 70	7980-7640	6030-5690	1
Samouqueira I	c.2	H	*Homo*	TO-130	6370 ± 70	6800-6633 (1s)	5480-5210	2
Vidigal	c.2 (shell midden)	B	*Bones*	GX-145557	6030 ± 180	7439-6305	5490-4356	3
Vidigal	c.3 (paving)	B	*Bones*	Ly-4695	6640 ± 90	7738-7274	5789-5325	3
Cabeço da Amoreira	Skeleton ?	H	*Homo*	TO-11819R	7300 ± 80	8050-7660	6100-5710	1
Cabeço da Amoreira	Skeleton 7	H	*Homo*	Beta-127450	6850 ± 40	7610-7380	5660-5430	1
Cabeço da Amoreira	CAM-00-01	H	*Homo*	TO-10218	6630 ± 60	7460-7170	5510-5220	1
Cabeço da Amoreira	CAM-01-01 (139)	H	*Homo*	TO-10225	6550 ± 70	7980-7640	5630-5370	1
Vale de Boi	c.2	H	*Homo*	TO-12197	7500 ± 90	8551-8020	6602-6071	4
CANTABRIAN STRIP AND PYRENEES								
Linatzeta	–	H	*Homo*	KIA-33193	7315 ± 35	8300-8002	6351-6053	5
Los Canes	Skeleton 6-III	H	*Homo*	AA-6071	6930 ± 95	8015-7518	6066-5569	6
Los Canes	6-II feet	H	*Homo*	AA-5295	6860 ± 65	7932-7566	5983-5617	6
Los Canes	Skeleton 6-II	H	*Homo*	AA-5296	6770 ± 65	7826-7460	5877-5511	6
Los Canes	Skeleton 6-II	H	*Homo*	AA-11744	7025 ± 80	8052-7615	6103-5666	6
Los Canes	Skeleton 6-I	H	*Homo*	AA-5294	6265 ± 75	7424-6904	5475-4955	6
Colomba	Shell midden	H	*Homo*	TO-10223	7090 ± 60	–	5910-5534	7
Cubio Redondo	Shell midden	B	*Cervus*	Beta-106050	6630 ± 50	7622-7421	5673-5472	8
Cofresnedo	Cof.5	B	*Roe-deer*	GrA-20146	6865 ± 45	7847-7581	5898-5632	7
Urratxa	Level fertile	B	*Bone*	Ua-11435	6995 ± 80	8025-7607	6076-5658	7
Urratxa	Level fertile	B	*Bone*	Ua-11434	6940 ± 75	7969-7585	6020-5636	7
MEDITERRANEAN REGION AND EBRO VALLEY								
El Collado	Burial 12	H	*Homo*	UBAR-281	7640 ± 120	8989-8050	7040-6101	9
El Collado	Burial 12	H	*Homo*	UBAR-280	7570 ± 180	9033-7858	7084-5909	9
Mas Cremat	Level_III	F	*Sorbus*	Beta-232342	6780 ± 50	7787-7507	5838-5558	10
Cingle Mas Nou ent	–	H	*Homo*	Beta-170715	6920 ± 40	7929-7623	5980-5674	11
Cingle Mas Nou 3	–	H	*Homo*	Beta-170714	6910 ± 40	7924-7620	5975-5671	11
Falguera	–	S	*Olea sp.*	AA-2295	7410 ± 70	8404-8013	6455-6064	12
Lagrimal	Level_IV	B	*Ibex*	Beta-249933	6990 ± 50	7960-7676	6011-5727	13
Botiquería	Level_4	B	*Bone*	GrA-13267	6830 ± 50	7835-7568	5734-5663	14
Botiqueria	Level_2	B	*Bone*	GrA.13265	7600 ± 50	8554-8205	6605-6256	14
Aizpea	Level_B	B	*Bones*	GrA-779	6600 ± 50	76133-7335	5664-5386	15

Tab. 1. Late Mesolithic radiocarbon dates on short lived samples. H = human bone; B = bone; F = fruit; S = seed. References. 1: **Martins et al 2008*****; 2:*** **Lubell et al. 2007*****; 3:*** **Carvalho in press*****; 4:*** **Carvalho et al. 2008*****; 5:*** **Tapia et al. 2008*****; 6:*** **Arias 2005/2006*****; 7:*** **Fano 2004*****; 8:*** **Ruíz and Smith 2001*****; 9:*** **Guixé et al. 2006*****; 10:*** **Vicente et al. 2009*****; 11:*** **Olària and Gusi 2005*****; 12:*** **Barton et al. 1990*****; 13: Inedit; 14:*** **Barandiarán and Cava 2000*****; 15:*** **Barandiarán and Cava 2001.**

rán and Cava 2000; Cava 2004; Utrilla et al. 1998). Sites extend from the Lower Aragon region, with a clear spatial continuity into north Valencia, through the High Ebro Valley and the central and western Pre-Pyrenees. Recently, some new sites has been published in full, such as Mendandia (*Alday 2006b*) or Los Baños (*Utrilla and Rodanés 2004*), and some new Late Mesolithic sites with radiocarbon dates have been reported, such as Cova del Vidre (*Bosch 2008*) and Cabezo de la Cruz (*Picazo and Rodanés 2008*). The latter site fills the gap in the Late Mesolithic record in the south central area of the Ebro Valley.

In Andalusia, in southern Iberia, the Late Mesolithic remains understudied. The references traditionally cited are some interior rock shelter sites, such as Nacimiento and Valdecuevas, or possible lithic scatters like Los Frailes (*Juan-Cabanilles and Martí 2002*). In recent years, a few open-air Late Mesolithic sites have been published in full for the Algeciras Bay area, such as Embarcadero del Rio Palmones (*Ramos and Castañeda 2005*) and El Retamar, on the Atlantic coast of Cadiz (*Ramos et al. 2002*). El Retamar is considered Neolithic by its excavator (*Ramos et al. 2005*), although the lithic assemblage – overwhelmingly dominated by trapezoidal microliths and microburins – and the radiocarbon dates suggest the existence of a preceramic occupation phase[2]. At the Malaga coast, the recent revision of two long cave sequences – Nerja and Bajondillo caves- has yielded Late Mesolithic evidence (*Aura et al. 2005; Cortés 2007*, respectively).

In Portugal, the main clusters of Late Mesolithic sites are located around the Lower Tagus, Sado and Mira estuaries and the Alemtejo coastline (for regional syntheses, see *Bicho 1994; Zilhão 2000; Carvalho 2002; 2003*). A secondary cluster is documented in the Rio Maior at the Estremadura region (Forno da Telha and Abrigo das Bocas), which is interpreted in terms of logistic dependence on the Muge Mesolithic sites (*Carvalho 2003*). Recently, new research projects have added some New Late Mesolithic sites in the Algarve (*Carvalho et al. 2005; 2008; Stiner et al. 2003*). To the north, in the Alto Douro, only the Prazo site has produced possible evidence of Late Mesolithic occupation; however, in the light of the provenance and nature of the radiocarbon dates (charcoal samples), its Mesolithic attribution is not unanimously accepted (for a detailed discussion, see *Carvalho 2003; Zilhão 2003; Monteiro-Rodrigues 2003*).

Along the north Iberian coast, some dispersed Late Mesolithic sites have been reported in Galicia (*Vázquez 2004*); however, the main archaeological evidence comes from an area between the eastern half of Asturias and the Basque Country (*Fano 2004; Straus 2004; 2008*). Previous approaches to this region traditionally outlined the importance of coastal adaptations in the settlement distribution with the abandonment of the mountain inland after the Azilian. However, archaeological research in recent years has changed this perspective. Late Mesolithic occupations are also documented for inland locations, such as Los Canes Cave (*Arias 2005*), and even in high mountain areas such as Espertin (*Fuertes and Neira 2006*). Also, some Late Mesolithic sites (most of them shell middens) dated to 7700–6600 BP have been reported recently, such as Linatzeta (*Tapia et al. 2008*), Cubio Redondo (*Ruiz and Smith 2001*), Colomba (*Arias 2005/2006*), Truchiro, Toralete, Coberizas, Covajorno, El Aguila, Pendueles, and Sierra Plana (*Fano 2004*). Complete publications of new Late Mesolithic sites include Cofresnedo (*Ruiz and Smith 2003*).

In contrast to the regions mentioned above, there is a lack of Late Mesolithic data in two large Iberian regions: the central region, the Tertiary plateau known as the Spanish Meseta, and Catalonia in northeast Spain. The interpretation of this 'archaeological silence' requires detailed discussion, using both paleoenvironmental evidence and the representativeness of the archaeological research. Some scholars have suggested that the human population of the Iberian Peninsula interior during the Early and Middle Holocene was rather low until the beginning of the Neolithic (*Zilhão 2000.144; Straus 2008*). Early Holocene reforestation would have produced a reduction in herbivorous biomass, making the area less attractive relative to coastal and estuarine areas. Consequently, scattered settlement or very low population densities lead to a poor archaeological record. At present, this interpretation is still supported by current paleo-environmental and archaeological evidence.

Effectively, North Meseta pollen records indicate a forest re-colonization from the beginning of the Ho-

2 Radiocarbon dates from this site also display a disparity with different statistical result. For instance, a single feature -hearth 18- provides two radiocarbon dates elaborated on shell samples with a difference of 500 years (Sac 1525: 6900±70 BP and Beta–90122: 6400±85 BP); the oldest one is statistically similar to another one coming from a different sector of the same site (Sac–7020±100 BP), which fit within the chronological limits of the Late Mesolithic.

locene, and the progressive replacement of pine formations by oak forests. During the Boreal period, forest expansion reached its maximum extent, as reflected in both the Sanabria reservoir and the Sanguijuelas Lagoon pollen diagrams, where tree pollen dominated by Quercus comprises 70% and 90% respectively (*McKeever 1984; Muñoz et al. 2001*).

During this period of forest expansion, the number of archaeological sites declines drastically. Final Paleolithic sites with Magdalenian industries are well known in the North Meseta (*Diez and Delibes 2006*). In contrast, the number of Preboreal sites decreases significantly, and there is no (stratigraphic, chronological or industrial) reliable evidence of Boreal sites or Late Mesolithic sites from North Meseta (*Alday 2005; Corchón 2006*).

In this sense, some presumed Mesolithic attributions published recently need to be revisited. For example, Jiménez-Guijarro (*2005 and 2008*) has pointed out the presence of Late Mesolithic occupations in the Madrid region at the Ventana Cave and at the open air site of Verona II. However, the published archaeological evidence lacks radiocarbon dates, stratigraphy or diagnostic artifacts to confirm such an attribution[3]. In addition, other archaeological deposits considered by this author as Late Mesolithic, such as Verdelpino or the Níspero caves (*Jiménez-Guijarro 1999*) are not Late Mesolithic, but Epipaleolithic, dating to the Early Holocene.

There is still a notable lack of Late Mesolithic, especially considering that systematic extensive survey programs have been developed in the North Meseta (*Balbín et al. 1997; Rojo and Kunst 1999*). Furthermore, several Holocene archaeological sequences have been excavated in recent years, such as El Mirador Cave (*Vergès et al. 2008*), El Portalón Cave (*Ortega et al. 2008*), and the Carlos Alvarez rock shelter (*Rojo et al. 2008*), but no Late Mesolithic levels have been reported.

Catalonia, in north-east Spain, is another second region where no Late Mesolithic sites have been documented. This lack of data does not seem to be the result of bias in archaeological research. Early Holocene occupations with Epipaleolithic and Sauveterrian industries on the central coast of Catalonia and in the Interior Valleys of Lerida (sites like Parco, Filador, and Balma de Gai) (*García-Argüelles 2006*) are well documented. In addition, many Boreal ND Mesolithic sites are documented for the same areas (Parco and Filador) (*García-Argüelles 2006*), the south east Pyrenean foothills (*Martínez-Moreno 2006*) and in central and southern Catalonia (*Vaquero 2006*). The last Mesolithic occupations documented in Catalonia are from the ND Mesolithic complex – level A of the rock-shelter at Cativera – dating to 9000–8600 calBC (*Allué et al. 2000*). A gap of more than 1200 years separates the most recent evidence of foragers from the earliest Cardial Neolithic context.

The lack of Late Mesolithic sites in Catalonia might be related to a broader process of settlement reorganization documented in the Mediterranean at the end of the Boreal period (*Fernández and Jochim in press*). In this sense, it should be noted that the last ND Mesolithic occupations documented in Catalonia – the Cativera and Molí del Salt sites – are recorded in the upper section of their stratigraphic sequences, while in the neighboring central Ebro Valley, the ND Mesolithic inaugurates the occupation of many rock shelters which display a clear occupational continuity thereafter, during the Late Mesolithic (*Montes et al. 2006*).

The settlement reorganization implies a general increase in the number of Late Mesolithic sites, as well as changes in the settlement pattern, with a significant increase in open-air sites around inland and coastal lagoons. Necropolises, such as El Collado (*Aparicio 1990; García Guixé et al. 2006*) or Mas Nou (*Olària et al. 2005*), completely absent in the ND Mesolithic archaeological record, are another innovation of this period.

In Portugal, the Late Mesolithic witnessed the emergence of year-round residential campsites located in highly productive estuarine areas. The most visible manifestations from the Atlantic period are shell middens with a complex interior spatial organization that included a number of post-holes and pit structures, such as roasting and storage pits, hearths, etc, and necropolises formed by numerous inhumations (*i.e.* Moita do Sebastião) (*Roche 1972*). Regarding the Boreal period, the settlement pattern was reorganized, and sites are clustered only in estuarine areas, leaving inland territories, like the Estremadura plateau case, uninhabited (*Araujo 2003*).

3 At the Ventana Cave, the presence of trapezes with bifacial retouch and the length and width of the trapezes with abrupt retouch is quite similar to the microlith assemblages founded in Megalithic tombs during the Middle Neolithic (*Alegre 2005; Fernández et al. 2009*).

Environmental dynamics and Late Mesolithic settlement organization: the 8200 calBP event

The 8200 calBP event in southern Europe is currently being considered as the main environmental factor triggering the dispersal of agriculture (*Weninger et al. 2006; Budja 2007*), land use changes (*González-Sampériz et al. 2008; Fernández and Jochim in press*), or the cause of the chronological gaps observed in the radiocarbon record between the Late Mesolithic and the Early Neolithic periods (*Berger and Guilaine 2009*).

In contrast to the eastern Mediterranean, the 8200 calBP event in Iberia fell between Late Mesolithic phases A and B. Recently, scholars have used its effects to explain changes in land use patterns that potentially affected both the regional distribution and settlement organization of the last forager populations in Portugal (*Zilhão 2003; Carvalho in press*), the Ebro Valley (*Utrilla 2005; González-Sampériz et al. 2008*) and the Mediterranean region (*Fernández and Jochim in press*). A different issue turns on the potential relationship between this climatic event and sedimentation dynamics, as might be suggested by the increasing documentation of sites having a stratigraphic hiatus between the Late and the Early Neolithic occupations (*Berger and Guilaine 2009*).

In Portugal, the relationship between the 8200 calBP event and the decline in marine productivity has been pointed out to explain the habitat concentration on the large estuarine areas such as the Lower Tagus and the Sado (*Zilhão 2003; Carvalho in press*). According to this hypothesis, this climatic episode allowed a freshwater current to reach the Portuguese coast, reducing coastal upwelling activity. The main indicator to support this relies on the diachronic variation in the reservoir effect along the Portuguese coast during the Holocene being considered as a coastal upwelling proxy (*Soares and Dias 2006*). However, the chronological correlation between coastal upwelling activity and changes in the settlement pattern is not completely clear due to the current chronological scale for determining the reservoir effect on the basis of radiocarbon dates of shell and charcoal samples.

What seems clear from the archaeological evidence is the crucial effect of this climatic crisis on the abrupt change in coastal occupation and subsistence patterns documented from the Boreal to the Late Mesolithic periods (*Araujo 2003; Bicho 2006; Carvalho in press*). For the former period, a higher number of small or medium size shell middens have been documented at different coastal locations in the Algarve, Alemtejo and Estremadura regions, while the Late Mesolithic witnessed habitat concentration around the main estuaries, with a significant increase in shell midden size. A lower degree of residential mobility, with mostly round year occupation, is reflected by the documentation of necropolises on the shell middens, and a higher dependence on aquatic resources, estimated at around the 40%–50% of the diet on the basis of the stable isotopic evidence (*Lubell et al. 1994*). In this sense, a strong chronological correlation between Lower Tagus estuarine adaptations and the beginning of the 8200 calBP event can be established if isotopic corrected human bone samples are considered on the basis of the local determination of the reservoir effect at the Muge region (*Martins et al. 2008.83*)[4]. In addition, around 8150 calBP, the development of the Lower Muge shell middens was enabled with an abrupt change from fluvial to estuarine environments, which led the to formation of productive shell beds (*van der Shrieck et al. 2008*).

In the Mediterranean climatic region of Iberian Peninsula, a significant number of paleo-environmental studies – including both marine and lake cores – have recorded short-term stepped variations in temperature, water balance input and vegetation during the 8200 calBP (Fig. 2). Isotopic analysis from three marine cores located in the Alborán sea (*Cacho et al. 1999*) and close to the Menorca island (*Frigola et al. 2007; Jiménez-Espejo et al. 2007*) have documented a downturn of 2° C in sea surface temperature. According to Frigola *et al.* (*2007.13*), this change was associated with a persistent positive index in the North Atlantic Oscillation that produced colder and drier conditions in the Iberian Peninsula (Fig. 2).

Multi-proxy studies from several continental lakes show a chronological correlation with lower lake levels in La Estanya Lake in the pre-Pyrenean mountains (*Morellón et al. 2007.12–13*) and in Salinas Playa Lake, more than 600km further south in southeast Spain (*Giralt and Julià 2003.321*).

Vegetation changes have been documented in several natural and archaeological deposits in eastern Spain, indicating an interruption in the temperate

4 The old wood effect problems in radiocarbon dating on Muge shell middens have been broadly discussed in recent approaches (*Zilhão 2001; Jackes and Meicklejohn 2006; Roksandić 2006; van der Shriek et al. 2008*).

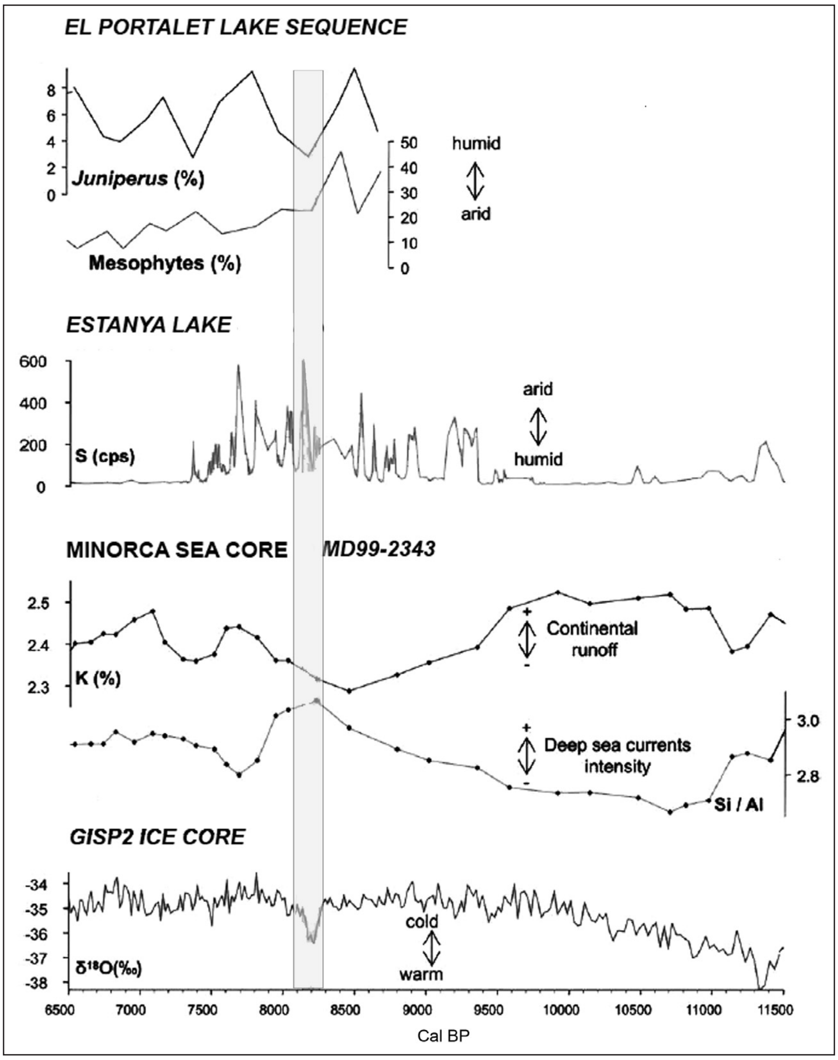

Fig. 2. Early to Middle Holocene environmental dynamics from different paleoclimatic proxies in the Mediterranean region of Iberia where the 8200 cal yr BP event is detected (source: **González-Sampériz et al. 2009.Fig.4** ***adapted). Juniperus and Mesophhytes percentages at Portalet lake sequence (*****González-Sampériz et al. 2006*****); Sulphur (S) content (count per seconds) (*****Morellón et al. 2008*****); Minorca Drift record (Core MD99–2343, Mediterranean Sea) Potassium (K) -percentage (%) and Silicon/Aluminium (Si/Al) ratio (*****Frigola et al. 2007*****) and Greenland GISP2 ice core oxygen isotope curve (*****Grootes and Stuiver 1997*****). A grey band marks the 8.2 ka event as referenced at the GISP2 ice core (*****Grootes and Stuiver 1997*****).***

and moister conditions that had resulted in forest expansion since the beginning of the Holocene (*López Sáez et al. 2007*). During the 8200 calBP event, El Portalet Lake underwent an abrupt decrease in Juniperus, Betula, Corylus and deciduous Quercus taxa (*González-Sampériz et al. 2006.49*). Further south, the San Rafael sequence at Almeria also records an abrupt change from mesic to xeric vegetation (*López Sáez et al. 2007*). In the Central Ebro Desert, multi-proxy lake records of Guallar and Hoya del Castillo lagoons show a stepped increase of microfossil charcoals around 8.3 ka BP caused by natural fires as a result of a general decline in annual rainfall. The increase in microfossil charcoal is also associated with vegetation changes, mainly the development of fire-resistant evergreen oaks such as hermes oak and, especially, cork oak, which replaced the pine forests (*Davis and Stevenson 2007.1706*). Finally, although pollen reconstructions from Late Mesolithic archaeological deposits in caves or rock shelters are deficient to document the 8200 calBP event, several sites such as the El Nacimiento or El Bajondillo caves saw an increase in xeric species (*López Sáez et al. 2007*).

In Northern Iberia, the paleo-environmental data required to detect the short-term vegetation changes produced by such climatic crisis are less informative. In the north west sector (Galicia), an episode of oak forest retreat has been recently correlated with the 8200 calBP event, changing the traditional interpretation by which the regression of forest biomass was caused by Epipaleolithic populations (*Martínez-Cortizas et al. 2009.82*). In contrast, in the central sector of the northern Iberian Peninsula (the Western Pyrenees, East Cantabrian Mountains and the Upper Ebro Valley), no relevant vegetation changes have been documented for the 8th millenium, which displays a continuous expansion of deciduous forests and a progressive decline in pine formations (*Iriarte 2009*). Unfortunately, the archaeological information is biased, given the poor preservation of palynomorphs at relevant Late Mesolithic sites such as Mendandia, Kanpanoste and Kanpanoste Goikoa (*Iriarte 2009.70*).

The ecological impact and its consequences on human land-use patterns in the Mediterranean region, especially in the Central Ebro Valley, are the subject of lively debate. The climate in this particular area is Mediterranean, with a continental influence, resulting in semi-arid conditions manifested by hot summers, cold winters, low annual precipitation and high evapo-transpiration index. Some scholars, like P. Utrilla and P. González-Sampériz, have correlated the lack of Mesolithic sites dated *c.* 7300–6800 BP at the Bajo Aragón with this aridity crisis. This chronological gap is related to the documentation of sterile levels in the main Mesolithic rock shelters of the area, such as Botiqueria, Los Baños, Angel, and Pontet. These authors argue that these arid conditions compelled people to move to other, wetter areas such as the High Ebro Valley, the eastern, central Pyrenees, or the Maestrazgo (*Utrilla 2005; González-Sampériz et al. 2008*). Consequently, Lower Aragon witnessed no human occupation or very low occupation intensity until the beginning of the Neolithic.

Nevertheless, other authors have recently argued for a shorter chronological influence, considering an individual evaluation of the stratigraphy and the radiocarbon dates (*Fernández and Jochim in press*). Furthermore, similar situations of site abandonment might potentially be identified in other Iberian areas under Mediterranean-continental influence, such as South Valencia or the central Pre-Pyrenees foothills. Effectively, sites such as Forcas II and Falguera also document sterile layers formed during part of the 8200 calBP climate crisis bounded by Mesolithic occupations (*Fernández and Jochim in press*). However, the main discussion point relies on the human responses to such abandonment episodes. Utrilla and González-Sampériz interpret the sterile levels in terms of population dynamics, arguing for a depopulation of Lower Aragon and subsequent migration to other, wetter areas (*Utrilla 2005; González-Sampériz et al. 2008*).

In contrast, we consider that these might be better explained as result of readjustments in the logistic mobility system, due to the functional characteristics of the archaeological sites, with desertion episodes as forest logistic sites whose faunal assemblages are mainly composed of red deer among the ungulates (Botiqueria, Los Baños and Pontet). The potential effects of water availability and vegetation changes on key herbivore biomass, such as red deer, might explain an increase in the risk assumed in hunting parties (*Fernández and Jochim in press*). In fact, such readjustments to the logistic mobility system implies the appearance of alternative logistic campsites in high altitude mountain areas specializing in ibex, such as La Cova del Vidre (*Bosch 2008*), with a clear connection with Lower Aragón.

In this sense, one of the clearest examples of the strategic interest of this kind of high-altitude mountain area on land use patterns in the Mediterranean façade of Iberia is represented by the Mas Nou site. This is an open-air site located in the highlands of the limestone plateau of Sierra d'en Seller (Castellón) at 940m a.s.l. with an inhumation pit containing the human remains of seven individuals (*Olària et al. 2005*). This particular case, which is completely different from the burial contexts associated with coastal or estuarine occupations, could reflect the exertion of property rights over mountain areas as a result of the climatic crisis (*Fernández 2006*).

The last point to be stressed regarding the impact of the 8200 calBP event on the Iberian Late Mesolithic record relies on taphonomic and archaeological formation processes. In the Mediterranean region of Spain, the presence of a significant stratigraphic hiatus between the Late Paleolithic levels (Magdalenian) and the earliest Neolithic occupations has been recurrently documented in long archaeological sequences in cave deposits such as Cendres Cave, Malladetes Cave (*Fumanal 1995*) and En Pardo Cave (*Soler et al. 2008*). Even though its genesis regarding such climatic events still needs to be confirmed, it is clear that any Late Mesolithic traces in these archaeological deposits have been beheaded or severely affected. A closer causal relationship might be argued to explain, in the same geographic area, the increasing number of rock shelters, which document chronological gaps, eroded surfaces or the stratigraphic hiatus between the Late Mesolithic (phase A) and the Early Neolithic occupations. At Balma Margineda site (Andorra), level 4S corresponding to a Late Mesolithic trapeze phase, was affected by a clear truncation episode which separate this occupations from the Early Cardial Neolithic levels (*Berger and Guilaine 2009; Brochier 1995*). At Mas de Marti rock shelter (Castellon); several gravel laminations interpreted as eroded surfaces have been recorded between level 3 (Late Mesolithic trapezes phase) and level 2 (Early Neolithic Epicardial phase) (*Fernández et al. 2005*). At Tossal de la Roca site, the upper section of the archaeological sequence comprises level I, with a lithic industry of trapezes and a radiocarbon date, overlaid in erosive contact by level Sup, which contains cardial ceramics (*Cacho et al. 1995*). Finally, at Falguera site, an erosive hiatus 25cm thick (level VII) separates the Late Mesolithic level VIII (with trapezes) from the subsequent Early Neolithic occupations documented in level VI (*García and Aura 2006*).

These examples warn against the problems of detecting the Final Mesolithic in the current archaeological record. Obviously, to avoid biased interpretations, considerations of population dynamics should be grounded on the evaluation of the archaeological evidence on a micro-regional scale, considering the role of site formation processes in the chronological gaps – something that still need to be done.

A possible way to detect such terminal Mesolithic evidence in disturbed archaeological contexts is to use individual short-lived samples. For instance, at the Lagrimal Cave in Alicante, the AMS radiocarbon determination of an ibex bone from level IV with anthropogenic fractures and cut marks has provided the most recent chronological evidence for a Late Mesolithic context (Phase B) in the southern Valencia region (Tab. 1). This fact clarifies previous approaches that had outlined the presence of a chronological hiatus of six centuries between the last Late Mesolithic (Phase A) and the first Early Neolithic contexts in this area (*Bernabeu 2006*).

Paleodiets: varying reliance on aquatic resources

One of the biggest contributions to Iberian Mesolithic archaeological research in recent years has come from paleodiet studies on the basis of δC^{13} and δN^{15} isotopic analyses. Although this kind of approach can be traced back to the mid-90's in Portugal (*Lubell et al. 1994*), fresh evidence from another Iberian regions such as Cantabria and the Central Mediterranean have recently been published (*Arias 2005/2006; García Guixé et al. 2006*), providing a first data set to compare Late Mesolithic subsistence patterns on a broader scale (Tab. 2).

Portugal has the biggest regional data set in terms of number of sites and individuals analyzed (*Lubell et al. 1994; Jackes and Meiklejhon 2004; Roksandic 2006; [Umbelino 2006 in Carvalho 2007]*). Notoriously representative, the Muge shell middens record concentrates the highest number of isotopic determinations for the Late Mesolithic period: Cabeço da Arruda (10)[5], Moita do Sebastião (9), Cabeço da Amoreira (5), and Cova da Onça (1). In the Alemtejo region, mainly the Sado estuary, isotopic determinations are less significant quantitatively: Cabeço do Pez (3), Amoreira (2), Arapouco (1), Poças de Sao Bento (1), Vale de Romeiras (1) and Algarão da Goldra (2) (*Umbelino 2006 in Carvalho 2007*). Finally, in the Algarve, the site of Vale de Boi provides a single determination (*Carvalho et al. 2008*).

For the Neolithic period (*c.* 5200–3000 calBC), the Portuguese data set comprises an outstanding number of sites and determinations, mainly in the Estremadura region: Gruta do Caldeirão (2), Algar do Picoto (2), Lapa dos Namorados (1), Lapa da Bougalheira (1), Costa do Pereiro, Algar do Barrao, Lugar do Canto, Casa da Moura (4), Algar do Bom Santo (5), Pedreira de Salemas (1), Gruta do Correiro Mor (1), Monte do Castelo, and Lapa do Fumo (*Carvalho 2007*).

The first paleodiet studies undertaken for Muge sites estimated a diet contribution of aquatic origin proteins at about 40–50% (*Lubell et al. 1994*). However, the pattern is more complex if radiocarbon chronology and new isotopic determinations are considered. For instance, Jackes and Meiklejohn (*2004*) suggest a trend along the Late Mesolithic occupation towards a more terrestrial diet, which they interpret in terms of decreasing shellfish availability due to variations in tidal influence at the Lower Tagus estuary (*Van der Schreck et al. 2007*). Furthermore, the relationship between changes in the estuarine regime and the reliability of aquatic resources in Muge has been pointed out to interpret the isotopic values from the oldest individual (skeleton 6 from Cabeço da Arruda), which has a lower significant marine protein contribution (24%) and who lived right before the estuary's maximum extent (*Martins et al. 2008*). Thus, the Muge area points to a sequence of dietary changes closely related to the local evolution of the estuarine regime, which led to the formation of rich shell beds: a first occupation with a lower reliance on aquatic resources (24%), followed by a phase with a significant increase in marine protein input (45–50%) and, finally, a trend towards a more terrestrial diet, when the tidal influence decreased, becoming less productive in terms of shellfish availability.

Apart from Muge, the available data from other Portuguese regions during the Late Mesolithic is quite variable. For instance, at the Sado estuary, the shell midden of Arapouco reflects a comparable aquatic protein input to that of the Muge sites, while other Late Mesolithic sites located far inland, such as Amo-

5 The number indicates the quantity of individuals analyzed.

reiras and Cabeço do Pez, reflect a more terrestrial input. This dual pattern might be interpreted as the result of the geographic coexistence of human groups with varying reliance on aquatic and terrestrial resources (*Umbelino 2006 in Carvalho 2007*).

In contrast, the Portuguese data for the Early Neolithic (Caldeirao, Correio Mor, Casa Moura) indicates a significantly different subsistence pattern based on terrestrial origin diet (*Lubell et al. 1994; Carvalho 2007*).

Further North, in the Cantabrian region, the paleodiet studies of Late Mesolithic samples comprise six individual determinations from two different sites: a shell midden at Colomba (1 individual) and a sepulchral cave at Los Canes (five individuals) (*Arias 2005/2006*). The isotopic value from the Colomba sample indicates a similar diet contribution from aquatic (marine) and terrestrial proteins. This pattern is very similar to those obtained in other, older Cantabrian shell middens dated to the Boreal period, such as J3 and Poza l'Egua. In contrast, the five individual determinations from the Los Canes site show the main protein contribution was of terrestrial origin. On this basis, P. Arias has suggested the coexistence of different populations with a differential reliance on marine and terrestrial resources during the Late Mesolithic. For the Neolithic period, the only Cantabrian determination comes from the Megalithic tomb of Cotero de la Mina, which indicates a terrestrial origin diet (*Arias 2005/2006*).

In the Mediterranean region, the shell midden at El Collado is the only Late Mesolithic site with paleodiet reconstructions based on stable isotopic analysis. This site includes a cemetery with fifteen individual burials, with nine skeletons analyzed (*García Guixé et al. 2006*). The most striking result from this shell midden is the low reliance on marine foods – only 25% for two individuals, with the highest $\delta\ ^{13}C$ values, while the rest of the sample has lower values, and in three cases the diet proteins are all terrestrial. García Guixé *et al.* interpret these results considering two hypotheses: either a different dietary adaptation, where the use of terrestrial resources played a higher role in subsistence patterns than in other European Mesolithic populations, or the less productive nature of Mediterranean sea shellfish compared to Atlantic species.

Although the current body of data is still too thin to reach meaningful conclusions on the Iberian scale, several observations can be made.

First, a different evolutionary pattern of reliance on aquatic resources can be established in those areas where anthropological series allow a diachronic approach (Portugal and Cantabrian strip). In Portugal, a clear trend towards an increasing contribution of aquatic diets from the Boreal Mesolithic to the Late Mesolithic is observed, which fit with changes documented in the settlement pattern. In contrast, the Cantabrian samples record significant aquatic protein input in the Boreal period, while the Late Mesolithic ones show the opposite situation, with samples from coastal sites having about 50% of marine proteins and an inland site whose diet is mostly terrestrial. In both regions, Neolithic samples indicate a dietary shift, with a higher contribution from terrestrial proteins.

Second, the reliance on aquatic resources between the Muge and the Mediterranean samples is considerably different. It is true that in the El Collado case, the lower number of radiocarbon dates (just two determinations from the same individual) does not allow a determination of diachronic trends. However, it should be noted that the same kind of adaptations – shell middens – led to different results in terms of protein intake.

Third, the current data set suggests the coexistence of neighboring coastal and inland Mesolithic populations, with different diets. As Arias states, the Cantabrian case mentioned above is paradigmatic, but a similar situation has been recently suggested for the Sado estuary (*Martins et al. 2008*). Finally, there are no discernible differences in isotope values between males and females in any studies published thus far.

Even though it is always necessary to incorporate new sites and samples, the main hypothesis is that during the Neolithic transition, the last Iberian hunter-gatherer populations faced various cultural contacts under distinctive subsistence conditions.

The dispersal of agriculture in Iberia: chronological framework and spatial distribution

In the last seven years, remarkable advances have been achieved regarding the chronology and geography of the initial spread of farming in Iberia. Unlike previous Iberian syntheses (*Zilhão 2000; Bernabeu 2002; Juan-Cabanilles and Martí 2002*), mainly focused in traditional research areas such as the Spanish Mediterranean coast and Portugal, new Neolithic archaeological sites located in Iberian Meseta or in the Cantabrian façade have provided fresh evidences, including direct radiocarbon dates on crops (*Zapata et al. 2004; Stika 2005*). Figure 3 and Table 3 show the geographic location and absolute chronology of the earliest farming contexts dated by radiocarbon in the different Iberian regions. The distribution information for all 38 dates is plotted in Figure 4.

Considering both the radiometric data and the geographical distribution of the present evidence, some observations on the timing and spatial patterning of first Neolithic contexts in Iberian Peninsula can be made.

● The earlier antiquity of the Iberian Neolithic coastal regions (except the North façade) and its clustered and discontinuous spatial distribution. Dates from the Mediterranean coast of Spain (Mas d'Is and Nerja cave) and Portuguese Estremadura remain the oldest Neolithic contexts (5600–5500 calBC), that is, assemblages of pottery and domesticates (plants and animals). The chronology of these first farmer sites

SITE	CONTEXT	REF. LAB.	DATA BP	$\delta^{13}C$ (‰)	$\delta^{15}N$ (‰)	Ref.
PORTUGAL						
Moita do Sebastião	Ossada 22	TO–131	7240±70	–16.1	12.2	1
Moita do Sebastião	Ossada 29	TO–133	7200±70	–16.9	10.4	1
Moita do Sebastião	Ossada 24	TO–132	7180±70	–16.8	11.9	1
Moita do Sebastião	Ossada 41	TO–134	7160±80	–16.7	11.2	1
Moita do Sebastião	Skeleton 16	Beta–127449	7120±70	–16.8	–	2
Moita do Sebastião	Ossada CT	TO–135	6810±70	–15.3	13.4	1
Cabeço da Amoreira	Skeleton ?	TO–11819R	7300±80	–16.3	–	3
Cabeço da Amoreira	Skeleton 7	Beta–127450	6850±40	–16.5	11.9	2
Cabeço da Amoreira	Burial CAM–00–01	TO–10218	6630±60	–17.1	–	4
Cabeço da Amoreira	Burial CAM–01–01	TO–10225	6550±70	–20.1	8.2	4
Cabeço da Arruda	Skeleton 6	Beta–127451	7550±100	–19	–	2
Cabeço da Arruda	Burial CA–00–02	TO–10216	7040±60	–17.9	10.6	4
Cabeço da Arruda	Ossada III	TO–360	6990±110	–17.7	11.2	1
Cabeço da Arruda	Ossada A	TO–354	6970±60	–19	12.2	1
Cabeço da Arruda	Ossada 42	TO–359a	6960±70	–17.2	11.8	1
Cabeço da Arruda	Ossada D	TO–355	6780±80	–18.9	10.3	1
Cabeço da Arruda	Burial CA–00–01	TO–10217	6620±60	–18.1	10.5	4
Cabeço da Arruda	Ossada N	TO–356	6360±80	–15.3	12.5	1
Cova da Onça	Skeleton ?	Beta–127448	7140±40	–17.2	–	2
Vale Boi	c.2	TO–12197	7500±90	–18.3	11.6	5
MEDITERRANEAN REGION AND EBRO VALLEY						
El Collado	Ind. 1 (indet.)	–	–	–19.5	10.2	6
El Collado	Ind. 2 (female)	–	–	–19.1	8.9	6
El Collado	Ind. 3 (male)	–	–	–17.6	10.2	6
El Collado	Ind. 4 (male)	–	–	–17.6	12.8	6
El Collado	Ind. 5 (female)	–	–	–18.2	10.6	6
El Collado	Ind. 6 (male)	–	–	–18.2	10.9	6
El Collado	Ind. 7 (female)	–	–	–17.9	8.9	6
El Collado	Ind. 12 (male)	UBAR–281	7640 ± 120	–19	9.5	6
El Collado	Ind. 12 (male)	UBAR–280	7570 ± 180	–	–	6
El Collado	Ind. 13 (male)	–	–	–18.1	10.4	6
CANTABRIAN STRIP						
Colomba	Shell midden	TO–10223	7090±60	–15.8	12.5	7
Los Canes	6–III	AA–6071	6930±05	–19.3	7.7	7
Los Canes	6–II (feet)	AA–5295	6860±65	–19.2	9.4	7
Los Canes	6–II (skeleton)	AA–5296	6770±65	–19.7	8.1	7
Los Canes	6–II (skeleton)	AA–11744	7025±80	–19.6	7.8	7
Los Canes	6–I	AA–5294	6265±75	–20	7.9	7

Tab. 2. Stable isotopic values ($\delta^{13}C$ and $\delta^{15}N$) of Late Mesolithic skeletons from different Iberian regions. References: 1: **Lubell and Jackes 1994*****; 2:*** **Umbelino 2006*****; 3:*** **Detry 2007*****; 4:*** **Roksandić 2006*****; 5:*** **Carvalho 2007*****; 6:*** **Guixé et al. 2006*****; 7:*** **Arias 2005/2006.**

partly overlaps. Moreover, their geographical distribution offers a clustered pattern in several regions, such as in southern Valencia, central Catalonia, Algarve and Estremadura, and south of Andalusia.

The Valencia region is now the area with the oldest radiocarbon dates on cereals retrieved from open-air sites like Mas d'Is (*Bernabeu et al. 2003*). Caves were used as habitations (*e.g.* Or Cave, Cendres Cave) (*Marti et al. 1980; Bernabeu et al. 2001*), and together with rock shelters, they were also used for stabling (*e.g.* Falguera) (*García and Aura 2006*). Recently, a new Early Neolithic site resulting from rescue excavations – El Barranquet – has yielded an old radiocarbon date in sheep bone (*Esquembre et al. 2008*), and one ceramic context dominated by impressed non-Cardial ceramics very similar to the Ligurian phasies of Sillon d'Impressions documented in southern France (*Bernabeu et al. in press*).

Central Catalonia is the second cluster of Early Cardial Neolithic sites documented in Iberia, containing information of both open-air sites (village dwellings) and caves, but until recently poorly dated with radiocarbon determinations based on non-determined charcoal samples (*Mestres 1995*). Recently, Can Sadurní Cave has provided the earliest dates on cereal for the area (5470–5300 calBC), although the sample is a cluster of charred cereals (27 gr.) retrieved from the same ceramic ware (*Blasco 2005*).

In Portugal, the empirical regional evidence of some of the earliest Neolithic contexts derive from the western Algarve and northern Estremadura (*Zilhão 2000; Carvalho et al. 2008*). Radiocarbon determinations from the early Neolithic contexts in the Algarve region are based on shell samples (Cabranosa and Padrão) (*Zilhão 1997.36*). In northern Estremadura, the caves of Almonda and Caldeirão have yielded dates from short-lived materials (adornments, and sheep and human bones) dated to 5400 calBC and 5300 calBC, respectively (*Zilhão 1992; 2001*).

Finally, in the southern Mediterranean region of Andalusia, Nerja cave contained one of the oldest sheep bone samples (*c.* 5600–5400 calBC), although the archaeological context of the sample was disturbed (*Aura et al. 2005*).

● Agriculture rapidly reached the deep interior of Iberia. Traditionally, Spanish research considered some Cardial inland enclaves such as the site of Chaves and Forcas II in Upper Aragon (*Utrilla et al. 1998*) and Carigüela in Upper Andalusia (*Juan-Ca-*

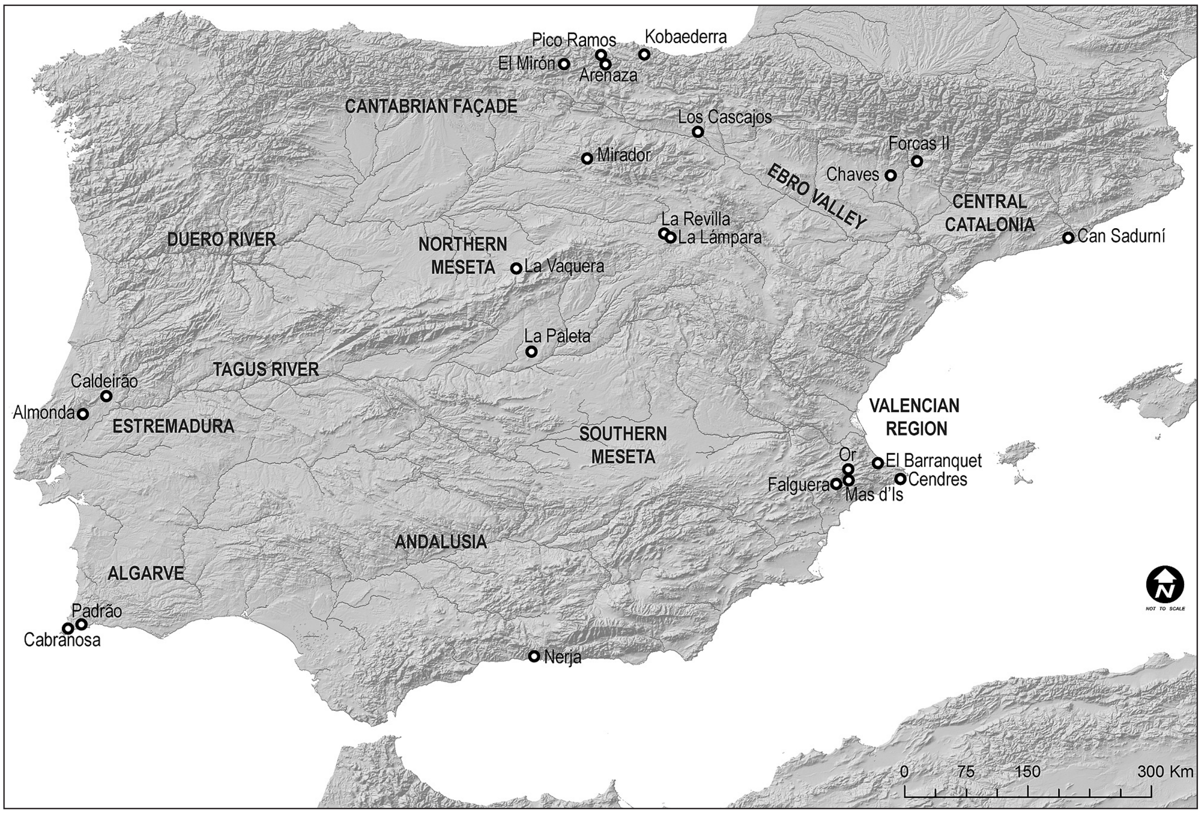

Fig. 3. Regional distribution of the earliest farming contexts in different Iberian regions (see Tab. 3 and Fig. 4).

SITES	CONTEXT	SAMPLE MATERIAL	SAMPLE REFERENCE	^{14}C age (BP)	CalBP 2σ range	CalBC 2σ range	Ref.
MEDITERRANEAN AREA							
Mas D'Is	80205	S *H. vulgare*	Beta-166727	6600 ± 50	7613-7335	5664-5386	1
Mas D'Is	80219	S *H. vulgare*	Beta-162092	6600 ± 50	7613-7335	5664-5386	1
Or	Basal Cardial (1955-58)	S Cereal	KN51	6510 ± 160	7855-6886	5906-4937	2
Or	J4, level 17	S *T. aestivum*	OxA-10192	6310 ± 70	7430-6960	5481-5011	2
Or	J4, level 14	S *T. aestivum*	OxA-10191	6275 ± 70	7425-6937	5476-4988	2
Or	Upper Cardial (1955-58)	S Cereal	H-1754/1208	6265 ± 75	7424-6904	5475-4955	2
Oliva	UE79	B *Ovis aries*	Beta-221431	6510 ± 50	7566-7272	5617-5323	3
Falguera	2051b	S *T. monococcum*	Beta-142289	6510 ± 80	7609-7174	5660-5225	4
Cendres	H16	S *T. dicoccum*	Gif-10136	6490 ± 90	7620-7160	5671-5211	5
Chaves	Ib	F Acorn	GrA-28341	6380 ± 40	7427-7172	5478-5223	6
Chaves	Ia	H *Homo*	GrA-26912	6230 ± 45	7278-6948	5329-4999	6
Can Sadurní	18	S cereal	UBAR-760	6405 ± 55	7460-7167	5511-5218	7
Nerja	NV-2	B *Ovis aries*	Beta-131577	6590 ± 40	7578-7421	5629-5472	8
PORTUGAL							
Almonda	Level 1	P *Cervus elaphus*	OxA-9287	6445 ± 45	7421-6851	5529-5305	2
Almonda	Level 1	Bb –	OxA-9288	6445 ± 45	7315-6675	5529-5305	2
Caldeirão	NA2	B *Ovis aries*	OxA-1035	6330 ± 80	7478-7254	5516-5001	2
Caldeirão	NA2	B *Ovis aries*	OxA-1034	6230 ± 80	7478-7254	5472-4902	2
Caldeirão	NA2	H *Homo*	OxA-1033	6130 ± 90	7465-6950	5366-4726	2
MESETA							
La Paleta	Pit 219	S Cerealia sp.	Beta-223092	6600 ± 60	7622-7322	5673-5373	9
Mirador	Level MIR 23	S *T. dicoccum*	Beta-208134	6300 ± 50	7420-7008	5471-5059	10
Mirador	Level MIR 22	S *T. aestivum/durum*	Beta-208133	6110 ± 40	7167-6797	5218-4848	10
La Vaquera	Level 94	F Acorn	GrA-9226	6440 ± 50	7491-7177	5542-5228	11
La Revilla	E 9	S Cereal	UtC-13347	6313 ± 48	7421-7020	5472-5071	12
La Revilla	E 2	S Cereal	UtC-13269	6250 ± 50	7323-6949	5374-5000	12
La Revilla	E 2	S Cereal	UtC-13350	6210 ± 60	7315-6949	5366-5000	12
La Revilla	Pit 12	S Cereal	UtC-13295	6250 ± 50	7323-6049	5374-5000	12
La Revilla	Pit 12	B Ovicaprid	KIA-21353	6156 ± 33	7243-6946	5294-4997	13
La Revilla	Pit 4	B Ovicaprid	KIA-21356	6355 ± 30	7415-7177	5466-5228	13
La Revilla	Pit 4	B *Sus sp.*	KIA-21359	6245 ± 34	7270-7002	5321-5053	13
La Revilla	Pit 4	S Cereal	UtC-13348	6120 ± 60	7235-6897	5286-4948	13
La Revilla	E 13	B Ovicaprid	KIA-21354	6177 ± 31	7318-6885	5369-4936	13
La Lampara	Pit 1	S *T. monococcum*	UtC-13346	6280 ± 50	7417-6996	5468-5047	13
La Lampara	Pit 1	H *Homo*	KIA-6740	6144 ± 46	7247-6856	5298-4907	14
La Lampara	Pit 1	B *Bos s.p.*	KIA-21348	6125 ± 33	7167-6882	5218-4933	13
CANTABRIA BASIN							
Arenaza	Ic2	B *Bos Taurus*	OxA-7157	6040 ± 75	7241-6640	5292-4691	15
Mirón	303.3	S *T. dicoccum*	GX-30910	5550 ± 44	6467-6216	4518-4267	16
Kobaederra	level 1	S *H. vulgare*	AA-29110	5375 ± 90	6414-5901	4465-3952	17
Pico Ramos	-	S *H. vulgare*	Beta-181689	5370 ± 40	6290-5994	4341-4045	17

Tab. 3. Early Neolithic radiocarbon dates on short lived samples. B = bone; Bb = bone bead; H = human bone; F = fruit; P = pierced canine; S = seed. References. 1. **Bernabeu et al. 2003*****; 2.*** **Zilhão 2001*****; 3.*** **Esquembre et al. 2008*****; 4.*** **Bernabeu 2006*****; 5.*** **Bernabeu et al. 2001*****; 6.*** **Utrilla et al. 2008*****; 7.*** **Blasco et al. 2005*****; 8.*** **Aura et al. 2005*****; 9.*** **Jiménez et al. 2008*****; 10.*** **Vergés et al. 2008*****; 10.*** **Estremera 2003*****; 12.*** **Stika 2005*****; 13.*** **Rojo et al. 2006*****; 14.*** **Rojo and Kunst 1999*****; 15.*** **Arias et al. 1999*****; 16.*** **Peña-Cocarro et al. 2005*****; 17.*** **Zapata et al. 2005.**

banilles and Marti 2002). However, new evidence from the North Meseta show that incursions were not isolated but distributed over a wide area in the hinterland during the same chronological span, *c.* 5300–5200 calBC.

Chaves Cave, a site located in the southern pre-Pyrenean foothills, contains two Neolithic levels (Ia and Ib) with storage pits and hearth structures. The short-lived dated materials, an acorn from level Ib and a human bone from level Ia, have yielded a slightly younger chronology (5300–5200 calBC) than the previous dates based on charcoal samples (*Utrilla et al. 2008*).

In the North Meseta, the first Neolithic occupations occurred almost coevally in different locations where domesticates appear in villages and stabling caves. La Paleta is an open-air site with over 200 hundred pit structures excavated in different chronologies from the Early Neolithic to the Bronze Age. A preliminary paper has published one radiocarbon date from a cerealia sp. seed, which derives from the organic material used as temper in anthropomorphic ware with cardial decoration; this date is statistically similar to the oldest coastal Iberian Neolithic contexts – 5673–5373 calBC – (*Jiménez-Guijarro et al. 2008*). Nevertheless, the presence of such an old occupation associated with cardial pottery should be confirmed and better characterized in future publications.

In the case of La Vaquera Cave (Valladolid), an acorn recovered in level 94 that belongs to the first and most intense occupation of the cave – Phase I – was dated to the second half of the sixth millennium calBC – 5542–5228 cal BC– (*Estremera 2003*). Associated with this material, in the same level, other indirect indicators of farming activity such as wheat seeds and blades with use-wear sickle polish have also been found.

In the Atapuerca chain, the El Mirador Cave stratigraphy recently produced a detailed sequence spanning from the Early Neolithic to the middle/upper Bronze Age. For the purposes of this paper, the earliest acceptable radiocarbon date comes from two cereal seeds found in the lowest levels of the cave (22 and 23) and dated to the beginning of the Neolithic, *i.e.* to *c.* 5400–5200 calBC (*Vergès et al. 2008*).

Finally, in the Ambrona Valley, there is a long series of radiocarbon dates that situate the appearance of the Neolithic at the beginning of the sixth millennium calBC. However, considering only short-lived materials unequivocally identified as domesticates (plants or animals), La Revilla produced dates in the last third of the 6th millennium calBC (*c.* 5472–5071 to *c.* 5374–5000 calBC). Again, a single cereal grain (*Stika 2005*) and one animal bone fragment yielded the oldest Neolithic radiocarbon dates in La Lámpara (*c.* 5400–5200 calBC). Among the archaeological records from both sites, a large number of pit structures have been identified, mainly storage pits in the former, and some pit structures (storage pits, rubbish pits), but also a singular ditched enclosure in the latter. The extended sequence of ^{14}C dates provided by samples coming from the same pit suggests certain problems. Since the same space was continuously reused, materials from different periods have been displaced by post-depositional processes and become part of the filling in some features. That is the case of pit 4 in La Revilla, where three consecutive radiocarbon dates (6355±30 BP, 6245±34 BP, and 6120±60 BP), separated by some centuries when calibrated (Tab. 3), appeared at different depths in a disorderly stratigraphic sequence. Subsequently, the interpretation of the occupation phases of these sites remains controversial, above all regarding the degree of mobility developed by early farmers.

● The later appearance of agriculture and domesticates in the Cantabrian façade. Direct radiocarbon evidence of domesticates in this region displays a significant chronological delay compared to other areas such as North Meseta or the Mediterranean and Portuguese coasts. The chronological frame is variable, depending on whether the radiocarbon samples are from domestic cattle or crops. On the one hand, Arenaza Cave has a 'post-Mesolithic' level (Ic = IC2) with geometric microliths, undecorated ceramics and two bovine remains classified as cattle (*Bos taurus*), the oldest being directly dated to *c.* 5292–4691 calBC (*Arias and Altuna 1999*). Nevertheless, a third cattle jaw bone, supposedly from the same level, yielded an AMS date of 10 860±120 BP. Thus, it seems that the stratigraphy is plagued by uncertainties. On the other hand, the oldest cereal in the Cantabrian area, from El Mirón Cave, has been dated to the second half of the fifth millennium calBC; level 303.3 provided a charred grain identified as Triticum dicoccum (emmer), dated to *c.* 4518–4267 calBC (*Peña-Chocarro et al. 2005*). Lastly, we can mention two dates from barley grains, one associated with a few high-quality combed and digitally impressed ceramics, geometric microliths and marine mollusks in Kobaederra cave (*c.* 4465–3952 calBC) (*Zapata 2002*); and

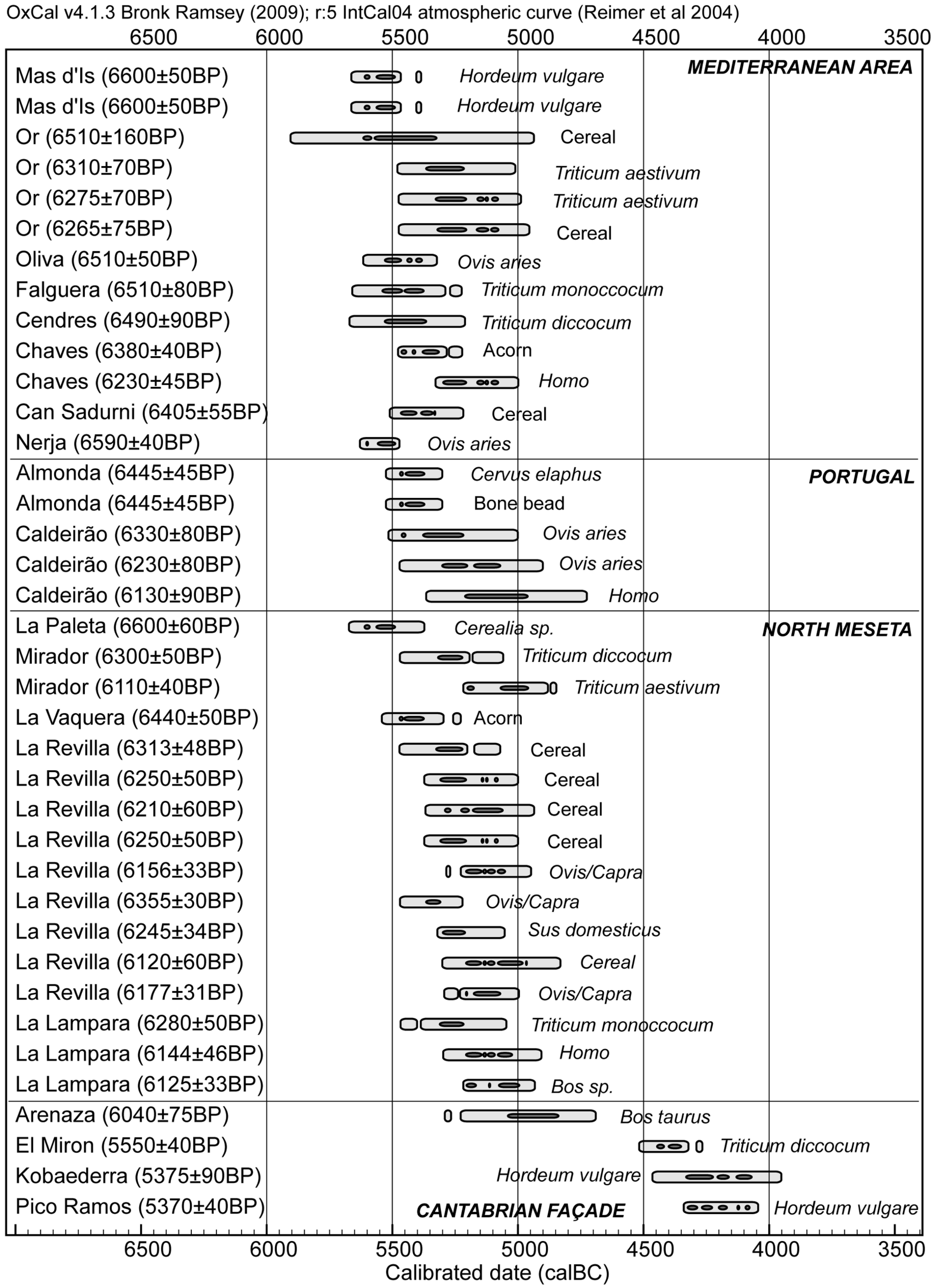

Fig. 4. Chronological framework of farming dispersal in Iberia, with the earliest radiocarbon dates on short lived sample (see Fig. 3).

the second one at the Pico Ramos site (*c.* 4341–4045 calBC), a small cave where cereal was found, but neither ceramics nor domesticated animals (*Zapata 1995*).

Revisting the distribution of farming on the Iberian peninsula: discussion

In the light of new paleo-environmental information and archaeological data on the Late Mesolithic record, and taking into consideration current chronological information and the distribution pattern of the earliest Neolithic contexts on the Iberian Peninsula, we can raise new questions about how farming spread during the Mesolithic-Neolithic transition.

Regarding previous syntheses (*Zilhão, 2001; Juan-Cabanilles and Martí 2002*), the main question still turns on discovering the driving forces behind the rapid Neolithic expansion through the interior Iberian regions. In about 200 years (or nearly 8 generations), all the components of the 'Neolithic package' (domesticates, pottery, village dwellings, houses) simultaneously appear from the oldest coastal enclaves and throughout the interior locations. This phenomenon requires a reformulation of traditional expansion mechanisms previously invoked to explain the early appearance of the Neolithic in the Spanish Meseta (*Rojo et al. 2006.85–86*). Furthermore, a more complex historical rather than contingent (migration vs. adoption) perspective is need to consider both the demographic and cultural factors behind the underlying migration mechanisms.

Bearing in mind the updated chronological overview presented above and the most recent archaeological evidence, we can inquire into the validity of the main farming dispersal models proposed for the Iberian case so far: the cultural diffusion model, maritime pioneer colonization and demic diffusion.

In Iberia, the most elaborated cultural diffusion model is the 'Capillary Model' (*Vicent 1997; Cruz and Vicent 2007*; among others). This model assumes continuity of human occupation between the Mesolithic and Neolithic periods to explain the introduction and spread of pottery and domesticates in hunter-gatherer social networks. Rather than refute its validity here, we wish simply point out that this modality could be considered only in those areas where archaeological evidence of local hunter-gatherers exists; in other words, where Late Mesolithic sites would have been documented. In this sense, this model is not adequate to explain Neolithic distribution in the North Meseta or in Catalonia because of the lack of Late Mesolithic sites in these regions, as shown above. However, it also should be noted that some of the theoretical assumptions of this hypothesis, such as seasonal storage and cycles of delayed return consumption (*Vicent 1997*) are completely absent from the Iberian Late Mesolithic record.

On the other hand, this model requires the documentation of transitional forms, for instance the use of pottery or domesticates in Late Mesolithic contexts, to be correctly contrasted. Still, the identification of this situation in the archaeological record is complex, given the necessary critical evaluation of archaeological formation processes that lead to these kinds of association (*Zilhão 1998; Bernabeu 2002; 2006; Juan-Cabanilles and Martí 2006*). At present, most of the Iberian Late Mesolithic contexts with ceramics are documented in rock-shelters consisting of multi-stratified archaeological deposits with ceramic and preceramic levels represented in the stratigraphy, or even in the same stratigraphic unit. In all these cases, the relationship between cultural remains and the dated material should be regarded with caution, given the taphonomic factors, the sedimentary processes and potential post-depositional disturbance[6]. The Cantabrian coast is the only Iberian region where adoption processes were likely to have occurred, given the long geographic coexistence of foraging groups there with the neighboring North Meseta and High Ebro Valley farming populations during the last

6 During last years, the most debated study case of ceramics found in terminal Mesolithic contexts is represented by Mendandia site, where the oldest ceramics were retrieved from Level III–Sup dated in 7210±80 BP and 7180±45 BP. As A. Alday has pointed out, the typology of the ceramic assemblage of this level is simpler (mainly bowls and 'S' shaped wares) and stylistically different (mainly slight incisions and some plain cords) than the Mediterranean Impressed and Cardial complexes. This author has defended the validity of such chronology invoking for a some kind of parallelism with other Western European Mesolithic cultures, which developed their own ceramic styles such as the Rocadourien, La Hoguette and Limbourg complexes (*Alday 2005.489*). However, even accepting the fact that Mendandia might represent a kind of different ceramic style, there are stratigraphic and archaeological arguments to refuse such old chronology: First, level III whose stratigraphic depth is about 25 cm was arbitrarily divided in two sections, the oldest (III inf) preceramic and the more recent ceramic (III sup). Regarding to this, the nature of radiocarbon samples from level III sup are clusters of bones (250 gr from the excavation unit Z2 and 115 gr from Z3) retrieved at different depths (–120 to –125 cm from excavation unit Z2 and –125 to –130 from excavation unit Z3). This fact implies that each radiocarbon date is composed by aggregates of organic materials from different occupation episodes that were grouped and interpreted as singular occupational events; Second, the chronology of level III sup falls into the chronological limits of Late Mesolithic phase A and

quarter of the sixth and the first half of the fifth millennia calBC.

A second farming dispersal model proposed for the Iberian case is Maritime Pioneer Colonization (MPC) (*Zilhão 1993; 1997; 2001*). According to the most recent radiocarbon evidence, the appearance of the Neolithic in Iberia still fits with the expectations of MPC, as proposed by Zilhão. The earliest data on farming are linked to coastal or neighboring coastal areas on the Mediterranean coast of Spain (Central Catalonia, South Valencia and Malaga) and Portugal (the Algarve and North Estremadura). No evidence or very little evidence of previous Late Mesolithic occupations is known in those areas, suggesting an elusive, non-overlapping strategy for the first Neolithic installations regarding local forager populations. Expansion by sea, which produced long-distance relocation episodes in early Neolithic enclaves, could potentially explain the rapidity of expansion, as well as similarities in material culture (especially in ceramic decoration).

However, the main interpretative challenge for this model still comes from the driving forces that caused this mode of farming dispersal. In this sense, when comparing several Iberian Neolithic enclaves, the archaeological record contains significant differences in terms of material culture (suggesting different cultural affiliations) and settlement data (site densities, rock art, habitat features, etc).

Moreover, the cultural homogeneity of the first ceramic contexts is the subject of recent discussion. Recently, Manen *et al.* (*2007*) and Carvalho (*in press*) have suggested a possible Maroquain origin for the Early Neolithic in South Portugal on the basis of some similarities in ceramics (back-lip shapes and almagra) and lithics (heat treatment, pressure debitage, and dominance of lunates among the microliths). As noted by these authors, these characteristics are not common in traditional Cardial Franco-Iberian archaeological culture.

In addition, Bernabeu (*Bernabeu et al. in press*) has recently identified an early Neolithic context at the El Barranquet site (Oliva, Valencia) dominated by impressed non-Cardial ceramics similar to the Ligurian phacies of Sillon d'Impressions documented in southern France (sites of Peiro Signado and Pont de Roque-Haut) and northern Italy (Arene Candide). Bernabeu goes further suggesting that this ceramic impressed horizon could even be pre-cardial, representing the first Neolithic cultural complex in Iberia before 5500 calBC, and being on the bases of subsequent Cardial culture and the earliest North Meseta Neolithic contexts (*i.e.* La Revilla, La Lámpara sites).

On the other hand, it should be noted that the archaeological record indicates significant differences in complexity (number of sites, density of occupation, rock art and monuments) among the different early Neolithic enclaves. For example, the southern Valencia region displays an Early Neolithic Cardial record of villages, rock art sanctuaries, and monumental enclosures (*Bernabeu et al. 2003*) significantly much more complex than sites in the Algarve or Portuguese Estremadura regions.

To recapitulate, as regards the first farming enclaves, a developing variety and complexity not contemplated by the MPC model assumptions, has been discovered. Placed in the general Iberia context, such differences in complexity and settlement densities might indicate the existence of social presure and attractive factors such as segregation and aggregation processes governed by rank and social competition strategies (*Anthony 1997; Fiedel and Anthony 2003*).

Finally, demic diffusion has also been invoked as an interpretative model to explain the populating of many Iberian regions during the Early Neolithic Epicardial phase (*c.* 5200–4800 calBC) (*Juan-Cabanilles and Martí 2002; Carvalho in press*). The chronological framework and the regional distribution of sites of this chronology attest to a subsequent and gradual expansion process from the Cardial enclaves through neighboring or adjacent areas following fission and short-distance relocation logic (*e.g. Mestres 1992*).

However, the earliest radiocarbon dates provided by the North Meseta sites (*c.* 5400–5300 calBC) cannot be simply explained by this model, because of the geographic discontinuity and distance from the coastal Neolithic enclaves (more than 500km). On the

about 6 centuries older than the first Cardial or Impressed ceramic contexts found in the Iberian coasts dated on the basis of stratigraphic associations with short lived individual samples (see Fig. 4). However the lithic industry, dominated by lunates with bifacial retouch among the geometric microliths is discordant too with the chronology displayed by this type of armatures in Iberia (see *Fernández et al. 2009*). Finally, considering a micro-regional scale validation, the appearance of ceramics at Mendandia is about 700 years older than other neighbor sites such as Zatoya, Atxoste or Aizpea where the first ceramics are found overlying Late Mesolithic contexts (*Alday 2003*). As J. Bernabeu has recently stated (*2006*) it is difficult to accept Mendandia as the only site in the High Ebro Valley where pottery is present during 600–800 years while in other neighbor locations is absent.

one hand, this fact implies a lower rate of spread than MPC (10–20km per year), but higher than demic diffusion (1km per year). In this sense, although the present paleo-anthropological data on the Iberian Peninsula is too limited to provide enough information to test the demographic growth of farming communities (also known as the Neolithic demographic transition) recognized in other European regions (*Bocquet-Appel 2002; 2008*), population growth does not seem to have been the only cause for the rapid dispersal that the radiocarbon dates indicate. Moreover, as Shennan remarks, in Central Europe (*Shennan 2007*) demographic growth would not necessarily have triggered spatial expansion, since settlement data show that new places were colonized before others reached any sort of maximum carrying capacity.

Additionally, this situation would demand alternative farming dispersal models to set off the migration of coastal farming groups to inland regions. For instance, long distance inland colonization as a result of fission and settlement relocation logic driven by household decision-making might be invoked (*Bogucki 2003; Martí 2008*). Similarly, an ideal free distribution pattern as a spatial behavior might have been carried out by farmers, whereby they tended to occupy sites giving the best yields (*Shennan 2007; McClure et al. 2009*).

According to this view, in the very first wave of migration, household decision-making would have consciously evaluated the costs and benefits of farming strategies and settlement relocation according both to the ecological suitability of the territories and dynamic social networks (*Boguki 2003*). In this sense, the spectrum of crops identified at Early Neolithic sites in the northern Meseta and the agrarian practices involved, indicate agricultural activity was well-established and perfectly adapted to the local ecological conditions (*Zapata et al. 2004*). It is likely that crops identified in La Lámpara and La Revilla sites, hulled wheats and barley, might have been selected because they were suited to that area (resistance to poor soil conditions and fungal disease; toleration of drier conditions).

The last issue to be discussed here is how the distribution pattern of both Late Mesolithic and Early Neolithic settlements and the chronological trends in the spread of farming would be reflected in the genetic composition of ancient Iberian populations. The key question, however, is whether the farming transition was a process of cultural and economic change, but not marked gene flow, or if it implied the arrival of genetically distinct populations which replaced the Mesolithic ones; this matter should be addressed in terms of the regional variability of socio-cultural processes.

During the 90's, anthropological studies reached contradictory conclusions on this issue. On the basis of skeletal differences Lalueza-Fox (*1996*) suggested population replacement, while others have observed that there is no evidence of discontinuity in Portuguese dental morphology (*Jackes et al. 1997; 2001*). In the same way, using craniometric data in a broader European context, Pinhasi and Pluciennik see no marked difference between Late Mesolithic and Early Neolithic human remains in the Western Mediterranean region, which might be interpreted as a result of a higher level of biological admixture (*Pinhasi and Pluciennik 2004*, but see also *Zilhão 2004* for comments on biases in the Iberian data set).

From the beginning of the 21st century, this matter has been addressed on the basis of molecular studies of archaeological data. However, in dealing with the genetic issues involved in the Iberian Peninsula Mesolithic-Neolithic transition, two major problems arise:

❶ There is remarkable regional disparity in the relevant data sets to address this question, most of them from Portugal (*Bamforth et al. 2003; Chandler et al. 2005*). Obviously, such regional bias challenges any attempt to reach equivalent conclusions for other Iberian areas whose geographic, environmental and demographic conditions were different. Regarding ancient mtDNA, new sites have been analyzed recently in the Mediterranean region, such as Sant Pau (Catalonia) (*Fernández-Dominguez 2005*) and Can Grau (Catalonia) (*Sampietro et al. 2007*); however the skeletal samples do not date to the Neolithic transition, but to the Post-cardial and Middle Neolithic phases, or to the Chalcolithic period (*Gamba et al. 2008*).

❷ On the other hand, there is no consensus among geneticists regarding the origin of the first European farmers or what one may infer from the geographic distribution of various genetic markers (*e.g. Haak et al. 2005 vs. Ammerman et al. 2006* for Central Europe). For instance, Haplogroup J, widely considered one of the main genetic signatures of Neolithic expansions (*Wells 2007*), is completely absent among the oldest Iberian Neolithic samples, but also lacks for skeletal material analyzed in Syria (Tell Halula and Tell Ramad) dated to the PPNB period (*Fernández-Dominguez 2005*). Consequently, as far as the Iberian material is concerned, the absence of haplogroup J among the Neolithic samples does not necessarily mean the absence of Neolithic expansion.

Bearing in mind the problems mentioned above, the first study published on ancient mtDNA Iberian material, comparing 15 Mesolithic with 13 Neolithic samples, suggests genetic continuity in the female line, given the presence of two individuals from Arruda (Late Mesolithic) and another from Feteira (Neolithic) in haplogroup K (*Bamforth et al. 2003*). Another interesting conclusion of this study was the lack of haplogroup I (predominant in Northern and Eastern Europe) and U6 (of North African origin).

In contrast, a more recent study (*Chandler et al. 2005*) reports genetic discontinuity between the Early Neolithic (the Algar do Bom Santo, Caldeirao and Perdigoes sites) and the Late Mesolithic populations (the Cabeço da Amoreira, Cabeço do Pez, Poças de Sao Bento, Toledo, Fiais, Vale de Romeiras sites) based on significantly different frequencies of common haplogroups between them; however, their relationship is closer to other Iberian than Near Eastern populations. The authors interpret this discontinuity as support for the MPC model. In this sense, the absence of haplogroup J in the Portuguese Neolithic samples was interpreted as a result of the lack contribution of women of Near Eastern origin in the colonization process, considering the uniparental transmission mode (*Zilhão 2004.78*).

Concluding remarks and directions for future research

It was not our intention in this paper to discuss the reasons behind the adoption of farming, or to discuss in detail the broad array of archaeological situations led by the cultural interaction between foragers and farmers in Iberia. We wish simply to stress some structural problems not widely discussed on the Iberian scale, drawing attention to paleo-environmental evolution and population dynamics.

According to the chronological evidence, with the exception of the Northern façade, Iberia witnessed a rapid Neolithic transition process. From the standpoint of evolutionary theories, the spread of farming in Iberia is an example of dispersal opportunities. Early and Middle Holocene environmental changes seem to have affected not only the regional distribution of hunter-gatherer populations, but also the outcomes of such adaptations in terms of subsistence and demography. We have already mentioned that such divergences might have been especially important because of the relationship between coastal and estuarine adaptations, with year-round sedentary or semi-sedentary settlements and potential for demographic growth. For instance, assuming the El Collado data as representative of the central Iberian Mediterranean coast, the last foragers relied less on aquatic resources than their Portuguese counterparts in the Tagus estuary, and were possibly more mobile. Consequently, such a structural constrain might explain the rapid extinction of forager subsistence systems after a short period of cultural contact with the first farming groups.

Thus, farming expanded to other regions, bringing about different migration processes and interaction phenomena. Even though some regional bias in the Late Mesolithic record needs to be corrected (Andalusia), the current evidence indicates broad areas such as Catalonia and North Meseta had no forager population when the first farmers arrived.

In contrast, in those areas where the Late Mesolithic record is present, one could expect a broad range of different cultural contact situations, including small-scale migratory phenomena such as infiltration (*Zvelebil 2000*), as proposed for the Ebro Valley (*Bernabeu 2002*). However, the role of forager populations in farming expansion, whether by means of rapid adoption through exchange or assimilation by direct interaction with farming groups, is not clear in the Ebro Valley archaeological record, concentrating current debates. In the same way, it is unwise to neglect a priori the possible contribution of such populations to farming expansion in the North Meseta.

It is true that many of the migration debates in this paper center on the North Meseta data. Of course, this region raises new questions about the timing of, and specific ways in which the Neolithic reached the deep interior of Iberia, as a counterpart to other traditional research regions. What seems clear, however, is the need to incorporate new models that present farming dispersal migration as a more complex process driven by social factors, and not merely the simple result of aimless demic growth.

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Climate fluctuations and trajectories to complexity in the Neolithic: towards a theory

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ABSTRACT – *Theories about the emergence and spread of farming in western Eurasia have a long research history. Occasionally, climate fluctuations have served as explanations for short-term culture change. However, the entire Holocene climate fluctuation sequence has so far not been regarded. First steps towards a theory which combines the successive stages in Neolithization and early to Mid-Holocene climate fluctuations are described.*

IZVLEČEK – *Za teorijami o pojavu in razširitvi kmetovanja v zahodni Evraziji stoji dolga zgodovina raziskav. Klimatska nihanja so občasno služila kot pojasnilo za kratkoročne spremembe kulture. Vendar pa do sedaj ni bila pregledana celotna sekvenca holocenskih klimatskih nihanj. Opisani so prvi koraki k postavitvi teorije, ki združuje zaporedne stopnje neolitizacije in zgodnje do srednje holocenska klimatska nihanja.*

KEY WORDS – *climate fluctuations; Neolithization; crises; socio-political trajectories*

Climate anomalies in the Early to Mid-Holocene North-Atlantic realm

In the past decade, it has become increasingly apparent that the Holocene in western Eurasia was punctuated by climate fluctuations. The most severe of these events was the so-called 8.2 ka event towards the end of the 7th millennium calBC, which can be detected in a variety of Northern Hemisphere marine and terrestrial climate records (*e.g. Muscheler et al. 2004; Alley and Ágústsdóttir 2005; Rohling and Pälike 2005*).

The 8.2 ka event was preceded and followed by other, less severe cooling phases. Such periodically occurring fluctuations have been postulated by a variety of research groups, occasionally for the entire globe (*e.g. Bond et al. 2001; Schulz and Paul 2002; Mayewski et al. 2004; Wanner et al. 2008*). For the North Atlantic realm, these cooling phases are explained with changes in salinity caused by shrinking stages of the Laurentidian ice shield and related fresh-water outbursts into the North Atlantic, as well as iceberg discharges which equally supplied fresh-water to the North Atlantic (*Teller and Leverington 2004*), the so-called Holocene IRD events (IRD – ice rafted debris). As IRD-events show a good correlation with insolation cycles, solar triggering is considered (*Bond et al. 2001; Bard and Frank 2006; Beer et al. 2006; Kromer and Friedrich 2007*). A less active sun, presumably, would not only have resulted in the cooling of the North Atlantic; but hemispherical effects, with teleconnections to the monsoonal cycles have been discussed (*Alley and Ágústsdóttir 2005; Wanner et al. 2008*). However, possible links between North Atlantic and Near Eastern climate fluctuations (*Migowski et al. 2006*) are not yet well understood, although Gupta (*et al. 2003*) found that cooling phases in the North Atlantic correlate with signals for weak monsoon periods in the Arabian Sea, and Hong (*et al. 2009*) postulate correlations between the North Pacific and the North Atlantic. Equally not yet well understood is the relation between Holocene IRD-phases and Glacial Heinrich events (*Bond 1999; Peck et al. 2007*).

The suggested connection between IRD-events and solar activity is not only helpful in controlling the rather loosely dated marine IRD-event record (*Bond et al. 2001*), but also helps to link terrestrial climatic events with marine data-set (Figs. 1, 2). Although no chronological fine-tuning has been applied to the proxy records in Figures 1 and 2, and all data-sets are depicted according to the originally published age models, it still does become apparent that, on the coarse level of resolution represented, certain anomalies in the North Atlantic marine records and the selected southern Central European terrestrial records are contemporaneous.

Holocene IRD phases and the Neolithic transition

The spread of farming and the spread of pottery in western Eurasia are processes that took several millennia and may be subsumed under the designation 'Neolithic Transition' or 'Neolithization Process' (*Gronenborn in press a*). Here, only the spread of farming is discussed, the spread of pottery is treated elsewhere (*Gronenborn 2003; in press b; Dolukhanov et al. 2005*). In the Anglo-American literature, the spread of farming has often been viewed as a steady process radiating from a core zone – the Fertile Crescent – to the outer margins of arable land in Eurasia (*e.g. Amermann and Cavalli-Sforza 1984; Pinhasi et al. 2005; Gkiasta et al. 2003*). However, continental European research stresses the step-wise advance of farming (*Uerpmann 1979; Guilaine 2001; Gronenborn 2003; Bocquet-Appel et al. 2009*). Occasionally, environmental boundaries are discussed as determinant factors for phases of stasis in the expansion process (*Kertèsz and Sümegi 2001; Kreuz et al. 2005; Kreuz 2007*), but climatic factors are also considered (*Bar-Yosef and Belfer-Cohen 2002; Bonsall et al. 2002; Strien and Gronenborn 2005; Cooney 2007; Gronenborn 2007a*): When examined at a coarse level of chronological resolution, IRD phases are contemporaneous to the expansion phases of farming (Fig. 1). This is particularly evident for the alpine cold-events (CE) compiled by Haas (*et al. 1998*) and the IRD-events, but also for the Main-river oak anomaly and depositional rate curve (*Spurk et al. 2002*). Already, the onset of cereal domestication is correlated with the beginning of the Holocene when, following Willcox (*et al. 2009*), a warmer, more humid and possibly more

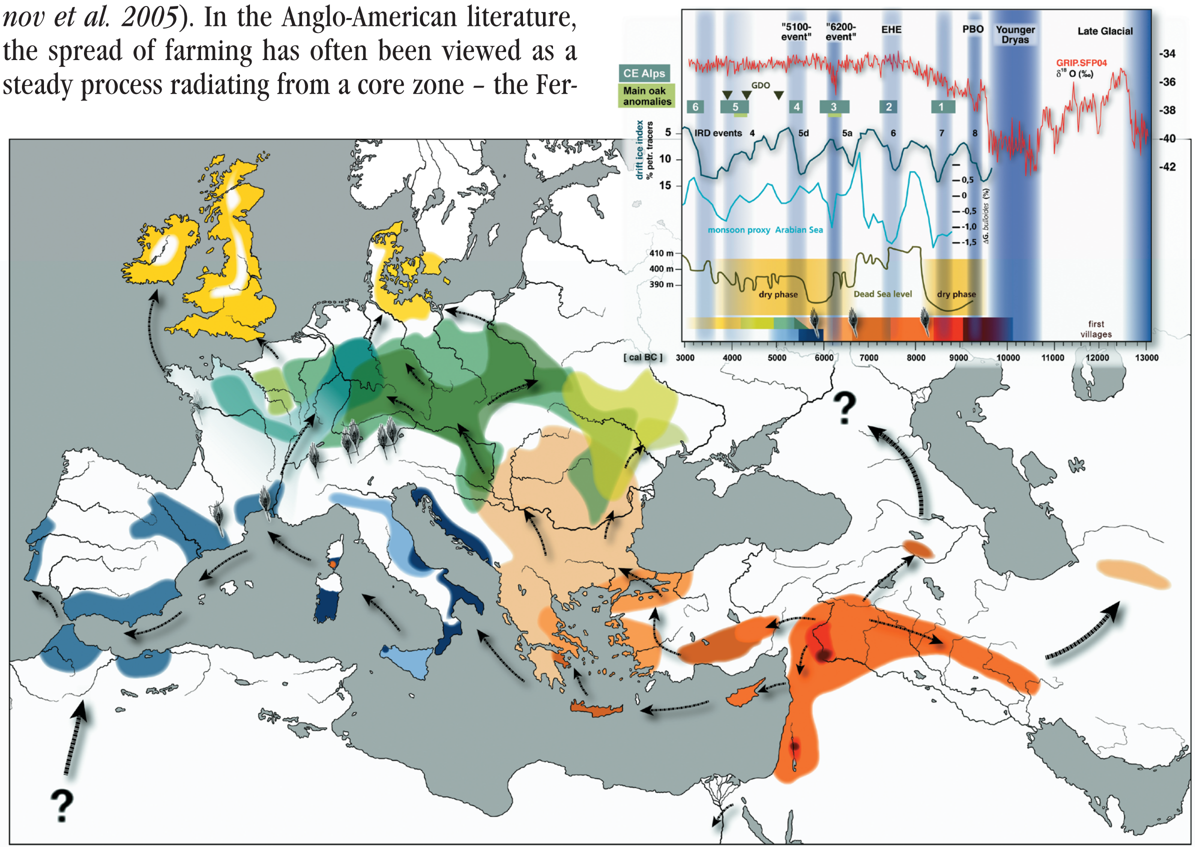

Fig. 1. Culture history-informed interpretative chronozone model of the spread of farming across western Eurasia (telescoped time-slice layers, non-geo-referenced). YD – Younger Dryas; PBO – pre-Boreal oscillation; EHE – early Holocene event; 6.2-E – 6.2 event; 5.1-E – 5.1 event; LIA – Little Ice Age; CE – cold events; GDO – germination/dying-off events (modified after* Zimmermann 2002; Gronenborn 2003*; for further sources see Appendix).

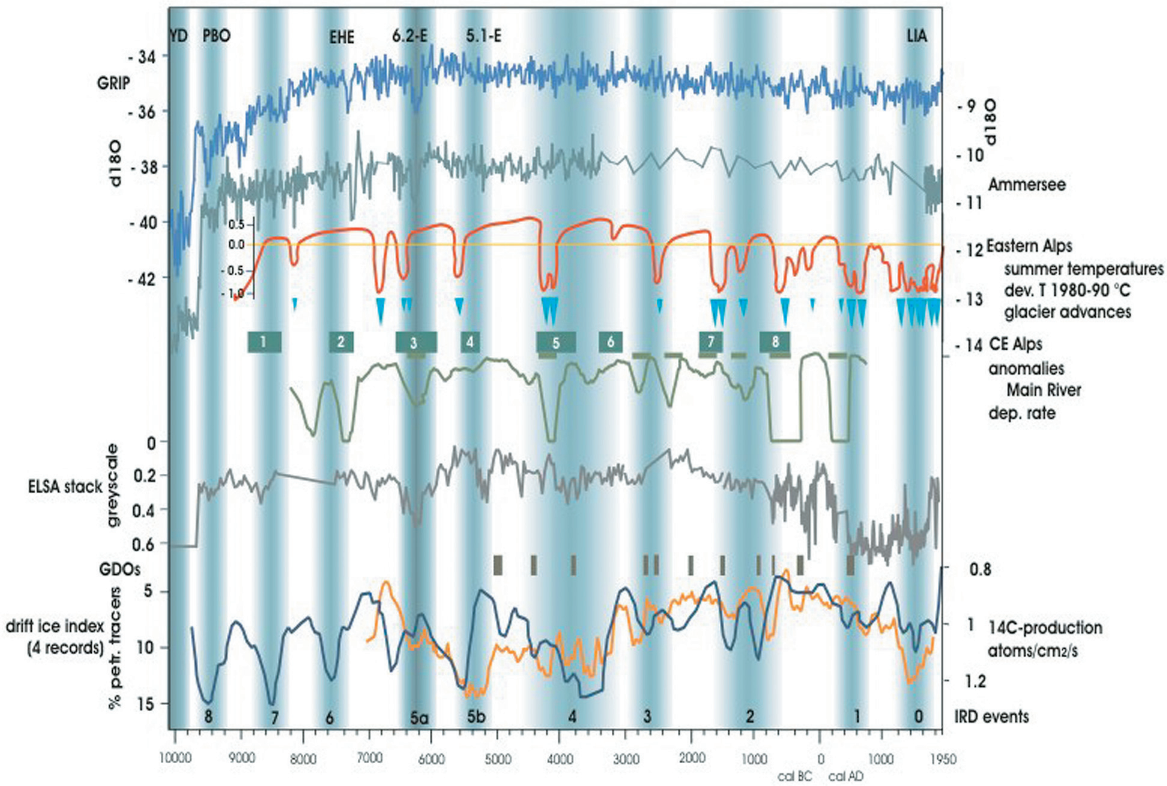

Fig. 2. Selected marine and terrestrial palaeoclimate proxy-data for Central Europe. PBO – pre-Boreal oscillation; EHE – early Holocene event; CE – cold events; GDO – germination/dying-off events (for sources see Appendix).

stable climate supported and facilitated the emergence of agriculture.

The possible role of the Pre-Boreal Oscillation (PBO) in the spread of cereal domestication outward from the immediate centers in the southern Levant and northern Syria is unclear; however, the PBO predates the appearance of domesticates in eastern Anatolia (*Willcox 2005*). IRD 7 is roughly contemporaneous with the spread of farming to Cyprus (*Peltenburg et al. 2000; 2001*) and Cappadocia (Fig. 1). IRD 7 is also contemporaneous with a notable increase in the level of the Dead Sea (*Migowski et al. 2006*), hence more humid conditions in the southern Levant. Another pronounced anomaly in a number of records (Fig. 2), among them the Ammersee record (*von Grafenstein et al. 1999*), is the Early-Holocene-Event (EHE) or 9.2 ka event, which is contemporaneous to CE-event 2 in the Alps, a notable decrease in the Main oak deposition rate and which apparently slightly postdates IRD event 6 (*Fleitmann et al. 2008*). These signals cluster towards the end of the 8th millennium calBC, and are thus contemporary with the terminal Early Mesolithic across Europe (*e.g. Gehlen 1999; Crombè and Cauwe 2001; Street et al. 2001*). Quite well known is the fact that, across Europe, the Late Mesolithic with its characteristic lithic inventory makes its appearance in the following centuries. Unfortunately, the exact first appearance of this 'blade-and-trapeze-horizon' cannot be dated with the necessary accuracy, due to a plateau in the ^{14}C-curve (*Gronenborn 1997a*). Moreover, exactly how trapezes and the effects of IRD 6 may be linked is another problem. Any postulations are currently mere speculation – the entire range of the Early-to-Late-Mesolithic transition is only coarsely researched, and the necessary information from Eastern Europe and the Russian steppe zones is spotty. But what should also be taken into account when approaching this complex set of questions is the expansion of pottery from Eurasian centers across eastern Europe (*Gronenborn 2003; in press b; Dolukhanov et al. 2005*), with its earliest appearance around Samara (*Vybornov 2008*). Both trapezes and ceramics spread west-ward and may have their origins somewhere in Central Asia or further east (*e.g. Brunet 2002*). Future investigations should focus on the possible connections of this general westward drift and the climate fluctuations towards the end of the 8th millennium. Equally unclear is the situation for the 7th millennium calBC: Crete seems to have been settled by Neolithic farmers during the earlier half of the millennium (*Efstratiou et al. 2004*), but the early phases of IRD 5a setting in around 6500 calBC appear to be contemporary with current models of the spread of farming to Western Anatolia and Central Greece (*e.g. Perlès 2003; 2005; Lichter 2005; Reingruber 2008*). During these centuries, evidence for the possible appearance of cereals across Temperate Europe appears (*Gehlen and Schön 2003; Tinner et al. 2007* – but for a critique see *Behre 2007*).

The 8.2 ka-event is part of IRD 5a (*Heiri et al. 2004*). Culture change-climate fluctuation interrelations for this phase are better researched; it marks the spread into the Balkans and southeastern Central Europe (*Weninger et al. 2006; Bonsall 2008; Budja 2007; Gehlen and Schön 2005; Berger and Guilaine 2009*). During the 6.2 ka-event, long-distance contacts existed across temperate Europe, connecting the transitional Late Mesolithic societies of temperate Europe with early farmers in the South-East (*Gronenborn 1999; Mauvilly et al. 2008*). After IRD 5a/8.2 ka, farming societies also appear in Turkmenistan (*Harris et al. 1993*) and in the Caucasus (*Chataigner et al. 2007*). IRD 5b sets in around 5700 calBC and ends relatively abruptly around 5100 calBC with the 5.1-event (*Strien and Gronenborn 2005*). With these outer margins it covers more or less the entire extension of the LBK (*Gronenborn 2007a; Dubouloz 2008*). Particularly the end is contemporaneous with the shift to the Middle Neolithic with the Hinkelstein Group in the West, the appearance of Stichbandkeramik (STK) in central parts (*Zápotocká 2007; Jeunesse and Strien 2009*), but also of Proto-Lengyel/Lužianky further East (*Pavúk 2007*).

In the western Mediterranean, the Neolithic apparently starts around 5800 calBC (*Manen and Sabatier 2003*). This type of Neolithic seems to have been introduced by small settler communities thought to originate in Liguria, where the earliest dates center around 6000 calBC (*Guilaine and Manen 2007*). The Cardial might have started at, or somewhat earlier than 5350 calBC (*van Willigen et al. 2008*), but a date of 5600 calBC is equally discussed (*Guilaine and Manen 2007*). Early dates in North Africa indicate the arrival of the Neolithic economy there around 5600 calBC (*Linstädter 2004*), but technological innovations possibly originating from the African continent are thought to have reached the southern Iberian peninsula towards the latter sixth millennium calBC (*Manen et al. 2007*). The somewhat complicated and intensively debated situation in the western Mediterranean makes it currently difficult to come to any robust conclusions about possible links to climate fluctuations, but for the 8.2 ka-event at least hypotheses may be formulated, and lately IRD events where found to have had an influence on sedimentation rates of fluvial systems in Morocco and Tunesia (*Zielhofer et al. 2008*).

IRD 4 sets in around 4400 calBC and terminates around 3200 calBC with the so-called Piora II/Rotmoos II cold phase, or CE 6 in the Alps (*Haas et al. 1998*), the event which might have led to the conservation of the Similaun glacier mummy (*Magny and Haas 2004*). IRD 4 is the most extensive of all IRD phases, covering more than 1000 years, but the ^{14}C-Production curve shows several marked peaks, the first around 4200 calBC, the second around 3600 calBC (Fig. 2). These correlate with terrestrial markers in the River-Main oak curve (*Spurk et al. 2002*) and possibly rainfall patterns in the Eifel (*Gronenborn and Sirocko 2009*). The onset correlates with the shift from the Middle Neolithic to the Upper Neolithic (Germ. Jungneolithikum), notably the Michelsberg Culture in Western Europe and western Central Europe and Boleraz 2 and Baden in the Southeast (*e.g. Eisenhauer 2002; Jeunesse et al. 2004*). With Trichterbecher (TRB) in the North and Northeast, IRD 4 also covers the spread of farming to northern Europe (*Karlén and Larsson 2007; Larsson 2007; Hartz et al. 2007*) and the British Isles (*Sheridan 2007; Whittle 2007*).

The contemporaneity of climate fluctuation phases and shifts in the spread of farming are evident on a coarse scale of chronological resolution of one to several centuries on a supra-regional level. Particularly striking is the Temperate European situation, with IRD-events 5 and 4 being contemporaneous with the two major shifts in the Neolithization Process (*Gronenborn in press a*). For further evaluation of any possible correlations, the next step has to be to 'zoom' into the chronologies, down to the level of decades or below where possible (dendrochronology), and to compare local and regional fine-resolution archaeological chronologies with local and regional fine-resolution proxy-data age models. This has already been attempted for some periods and regions, such as the 8.2 ka-event (see above), but also the expansion and the end of LBK in the years following the 5.1-event (*Schmidt et al. 2004; Strien and Gronenborn 2005; Dubouloz 2008*), or the 37th century calBC, which might have had an effect on the end of Michelsberg (*Gronenborn and Sirocko 2009; Schibler et al. 1997; Seidel in press*). But the general and historically most important question as to how IRD events affected humans and their modes of subsistence on the ground is still poorly researched. This may first and foremost be due to the scarcity of studies integrating local and regional terrestrial data from archaeobotany, geology, sedimentology or archaeology with supra-regional or hemispherical marine and solar proxy-data. Often, only very general assumptions are phrased – as in this paper – or possible relations between the different levels and scales are simply not discussed. Hence, at this point, questions around the actual effects of IRD events for humans on the ground are rather difficult to address. In any case, these effects are not expected to be homogeneous, but highly variable in time and space. General trends may be a cooling of summer temperatures, as has been suggested as a result of melt-water flux for the early and mid-Holocene (*Heiri et al. 2004*), and as is also visible in some of the proxy data shown in Figure 2. However, it must be kept in mind that the period in question experienced the warmest temperatures during the Holocene (*Wanner et al. 2008*) and thus any relative cooling must be seen against this background.

Also helpful in understanding how IRD-event phases may have directly and indirectly affected human societies may be a look at the historical climatology of the Little Ice Age (LIA). Such analogical endeavors are based on the assumption that the LIA may be equaled with IRD 0 (*Bond et al. 2001*), or at least resemble an IRD-situation; there are, however, problems with this general assumption, as the climatic effects of LIA seem to be composed of a number of unique late Holocene orbital and terrestrial forcings not entirely comparable to earlier periods (*Wanner et al. 2008.1819*). However, one particularity of the LIA may be worth considering, namely the greater rate of anomalies with more pronounced amplitudes (*Bradley and Jones 1993; Pfister 1999; Luterbacher et al. 2001*); this seems to have been particularly the case in the transitional phases from the Medieval Warm Period to the solar minima (*Glaser 2001.209*). Also, spring seasons appear to have been affected most during these transition phases (*ibid; Luterbacher et al. 2001.442*).

Extreme anomalies during IRD phases – situations of increased socio-political unrest?

It may indeed have been those particularly extreme anomalies, or series of anomalies, which had the most consequential effects on Neolithic societies. A simplified scenario extracted from a model constructed by Pfister and Brazdil (*2006*) for the effects of the Little Ice Age may be helpful here (Fig. 3). It was adapted to the tribal societies of the Temperate European Neolithic, where long-distance transport of food-stuffs or state-level aid for impoverished, crises-stricken groups and regions would have been non-existent. Neolithic – or Mesolithic – responses to external, non-human and human threats were organized on a local, at best a regional level in complex chiefdoms (*Earle 1997*). External climate or weather-induced shortages would have resulted in almost immediate economic and socio-political reactions as societies destabilized. Simple agrarian economies might not have been able to subsist for more than two to three years on the basis of stored foods. Relatively rapid changes in food-obtaining strategies would have been the result of shortages, but such economic changes should have also left traces in the forms of political organization. Established forms of organization, based on established economic systems, would have been shaken when harvests failed (*e.g. Anderson et al. 1995* for tribal societies in woodland environments). Economically and socio-politically destabilized societies would have drifted into phases of segmentation and political cycling. Violent conflicts could well have been the results of such destabilization phases (*Milner 1999; Gronenborn 2007; Zhang et al. 2007*). With more stable – as a homage to processualism, here termed 'equilibrium' – conditions returning, societies would have re-organized

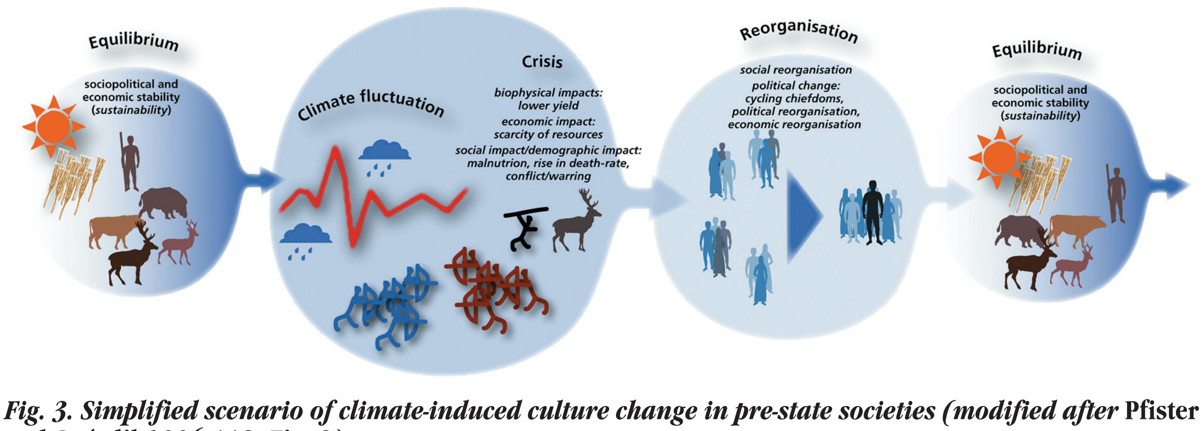

Fig. 3. Simplified scenario of climate-induced culture change in pre-state societies (modified after* Pfister and Brázdil 2006.118, Fig. 2*).

and adapted to the new situation (*Adger 2003*). Apart from violent conflicts and/or sociopolitical reorganization, societies might also have responded to stress situations with migration. Such phases of increased mobility have, for instance, been suggested for the 8.2 ka-event (*Clare et al. in press*).

This simple – indeed somewhat simplistic – model of a one-off, single-incidence fluctuation can nevertheless be taken as a basic module of what in reality are much more complex scenarios (*e.g. Redman 2005*), where eventually it needs to be embedded; but it helps to underline the effects of climate fluctuations on the non-state-level of simple agrarian or complex hunter-gatherer societies.

Thus, as a working hypothesis, apart from periods of generally cooler and moister conditions, IRD-event phases may also be understood as periods during which an increased rate and intensity of climate fluctuations occurred. The latter effect in particular might have had a greater impact on human societies and would have resulted in periods of increased socio-political unrest.

Trajectories to complexity? An example from southern Central Europe

Such periods of increased socio-political unrest and economic instability may not only be seen as periods during which societies collapsed, but also as turning points during which societies reorganized and eventually evolved into more – or less – complex political entities (*e.g. Anderson 1994; 1996*). If we look at the history of cultures of the southern Central European Neolithic during the period between 7000 calBC and 3000 calBC, the succession of archaeological cultures may also be tentatively understood as a succession and cycling of stages of socio-political complexity (Fig. 4). The terms applied here derive from classic neo-evolutionism and are applied solely for this first hypothetical model, which only coarsely depicts the historical processes. Certainly, any actual variation or shifting levels of complexity will be much more differentiated and eventually better described with more appropriate terms which may relate better to the specific conditions of temperate European societies (initial discussion in *Gronenborn 2006*). Nevertheless, for the time being, the terminology applied in Figure 4 may suffice: Late Mesolithic socio-political scaling is not depicted, but the Early Neolithic (LBK etc.) may – in neo-evolutionary terms – be described as 'segmentary societies' which then evolve into more complex 'chiefdom'-type entities with the onset of the Middle Neolithic. With the beginning of the Upper Neolithic (Germ. Jungneolithikum), southern Central Europe undergoes a further shift towards complexity, which in the French literature (*Coudart et al. 1999*) is subsumed under the term 'chalcolithisation'. With the termination of Michelsberg around 3600/3500 calBC, societies seem to collapse into less complex entities, which dominate the political landscape of the Late Neolithic in southern Central Europe.

When this simple scheme is compared to the climate proxy-data from Figure 2, certain fluctuations are contemporaneous with the suggested socio-political turning points. This may, of course, be simply coincidental; however, the apparent sychronicity and regularity with which climate fluctuations are intertwined with cultural trajectories warrants future closer examination. Specifically, these cultural turning points need to be investigated in order to come to a better understanding of the dynamics of Neolithic societies in southern Central Europe and elsewhere. To sum up: what I have attempted to present is a simple working hypothesis as part of a theory yet to be developed – it concerns the emergence and spread of farming, as well as associated socio-political chan-

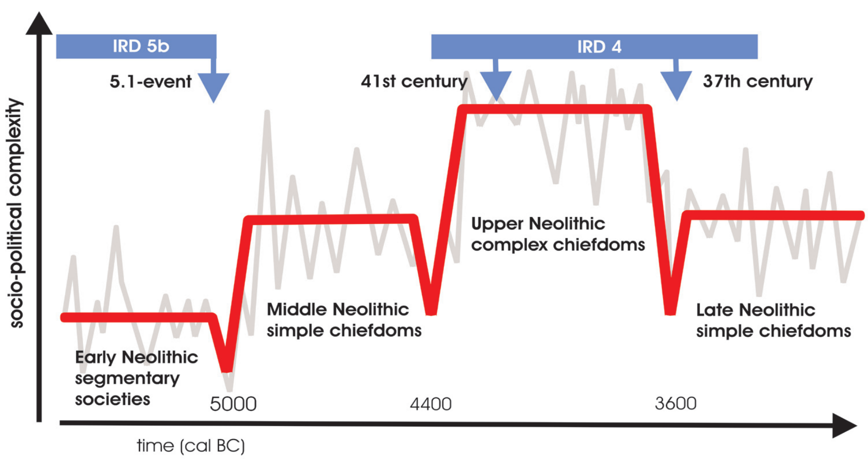

Fig. 4. Schematic (light grey line) and smoothed (thick red line) socio-political trajectory for southern Central European Neolithic societies with selected schematic prominent climate phases and events (not to scale).

ges, and is based on archaeological and palaeo-climatological empirical observation.

I posit that Early to Mid Holocene climate fluctuations affect farming, but other innovations like pottery, perhaps, spread across western Eurasia, and these fluctuations also had an effect on socio-political dynamics. The effects varied greatly across the continent and in time, as the actual impact of the fluctuations differed, but societies also underwent considerable transformations. Generally, within the frame of this hypothesis, the spread of the Neolithic – but also the emergence of farming, perhaps – is seen as having been paced by crisis periods which led to an amplification of socio-political dynamics, such as political cycling and/or migrations. This hypothesis is based to a certain degree on climatic determinism, but only in so far as it regards long-term climate development as a component in a complex interplay of diverse internal and external factors.

Current field projects aimed at validating the above hypothesis focus on regional and local fine-grained studies of the interrelation between climate, environment and human societies in southwestern Central Europe (*e.g. Gronenborn 2007; Bleicher in press; Regner-Kamlah 2009*). Of course, the envisaged theory may be developed further in any other study area across western Eurasia.

Beyond fieldwork

Archaeologically and economically based theories about the emergence and spread of the Neolithic and the associated socio-political changes have been formulated for more than a century (*e.g. Benz 2000; Scharl 2004; Weisdorf 2005*), and climate has often played a role in these endeavors (*Gronenborn 2005*). What has so far not been formulated in the archaeologies is a hypothesis like the one presented above, in which the overall process of the spread of farming across western Eurasia is connected with the entire sequence of Early- to Mid-Holocene climate fluctuations in the North Atlantic realm. However, outside archaeology, Wirtz and Lemmen (*2003*) transformed archaeological knowledge into a mathematical model which entails Holocene climate fluctuation cycles. The model reproduces the emergence and spread of farming worldwide. The spread of farming in western Eurasia is particularly well represented. Further results of this – in the archaeologies, so far largely unnoticed – study may be subsumed as follows: the major factors for the spread of the Neolithic are continuous innovation and competition between resource strategies; population pressure is a less prominent agent – climate fluctuation expressed as food extraction potential determines the rate and pace of migrations, and on a global level may also account for the time lag in the emergence of farming between the Americas and Afro-Eurasia. The latter result is further refined in newer model versions (*Lemmen and Wirtz in press*): climate fluctuations delay the onset of farming in the respective centers – the Fertile Crescent and Ecuador were selected – with increasing intensity, but they do not prevent the onset entirely.

Such simulation studies – so far, rarely applied in any of the historical sciences – will in the future be mandatory to test archaeologically formulated hypotheses. They may become increasingly valuable in assessing complex archaeological-palaeo-climatological models such as the one presented here. The first results formulated by Lemmen and Wirtz already indicate the potential: rather than arguing for simple climate-determined trajectories, the model indicates that while climate fluctuations under Holocene climatic conditions do have an impetus on cultural trajectories, this impetus does not fully explain the process. The model studies show that, rather than looking for simple, triggered, push or pull mechanisms, future investigations will have to consider the manifold complex and diverse interactions between climate, environment and internal socio-political and interconnected economic processing constantly in operation. Apart from mathematical testing, future work will have to focus on the construction of detailed fine-grained histories of the immediate turning-points in cultural history. However, contrary to past post-processual 'anti-climate' paradigms, these theoretical approaches will have to regard climate effects on global, hemispherical, supra-regional, regional and local levels. Once a new 'climate-friendly' paradigm has eventually emerged, it may become intellectually challenging to conceive certain changes in the archaeological record – such as sudden shifts in settlement patterns or economic strategies – as cultural proxies for which adequate explanations may be sought in the palaeo-climatic archives (*Bleicher in press*). For many, such reasoning is still unthinkable.

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Appendix

Sources for Figure 1

Climate proxies

GRIP δ [18]O: *Shackleton et al. 2004*; GDO: *Leuschner et al. 2002*; Cold events Alps: *Haas et al. 1998*; Main River oak anomalies: *Spurk et al. 2002*; IRD events: *Bond et al. 2001*; Monsoon proxy Arabian Sea: *Overpeck et al. 1996*; Dead Sea level: *Migowski et al. 2006*.

Farming-spread chronozones/archaeological cultures

British Isles: A. Whittle, pers. information; interpolation by author; early Funnel Beaker Culture: *Midgley 1992*; later LBK/Villeneuf-Saint-Germain/Augy-Sainte-Pallaye: *Lüning 1988; Jeunesse 1998–99*; earliest LBK/La Hoguette: *Gronenborn 1997b*; early cereal horticulture: *Erny-Rodmann et al. 1997; Jeunesse 2003*; Cucuteni-Tripolye/Bug-Dnestr: *Kozłowski 1993*; Impressa/Cardial: *van Willigen 2006*; Italian Impressa: *Fugazzola Delpino, Pessina and Tiné 2002*; Balkanic Early Neolithic (Starčevo-Körös-Criş; Greek Middle Neolithic): *Kalicz/Virág/Biró 1998*; Greek/Bulgarian Early Neolithic: *Böhner and Schyle 2008*; Djeitun: *Harris et al. 1993*; Georgian Neolithic: *Chataigner et al. 2007*; West Anatolian Early Neolithic/PPNA/Incipient Neolithic/Neolithic core zones: *Böhner and Schyle 2008; Willcox 2005*.

Sources for Figure 2

GRIP: *Shackleton et al. 2004*; Ammersee: *von Grafenstein et al. 1999*; Eastern Alps temperature/glaciers: *Nicolussi and Patzelt 2006*; Cold events Alps: *Haas et al. 1998*; Main River anomalies/deposition rate: *Spurk et al. 2002*; ELSA stack greyscale: *Sirocko et al. 2005*; GDOs: *Leuschner et al. 2002*; IRD events: *Bond et al. 2001*; [14]C-production rate: *Kromer and Friedrich 2007*.

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Implications of the role of Southeastern Europe in the origins and diffusion of major Eurasian paternal lineages

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ABSTRACT – *The aim of this study is to give an overview of the extent and nature of Southeastern Europe (SEE) paternal genetic variation in relation to potential episodes of gene flow during dispersals of the Upper Paleolithic and Neolithic. A survey based on studies of the paternal gene pool of the region revealed consistency with the typical European paternal gene pool, as five major haplogroups E3b1, I1b*, J2, R1a, and R1b contribute more than 70% to the total genetic variation in SEE. Comprehensive characterization and dating of major paternal lineages imply that SEE has been both an important source and recipient of gene flow.*

IZVLEČEK – *Cilj študije je podati pregled o obsegu in naravi jugovzhodno evropske (JVE) očetovske genetske variance v povezavi s potencialnimi epizodami genskega toka med širitvama mlajšega paleolitika in neolitika. Pregled, ki temelji na študijah očetovskega genetskega fonda v regiji, je razkril skladnost z značilnim evropskim očetovskim genetskim fondom, kajti kar pet glavnih haploskupin E3b1, I1b*, J2, R1a, in R1b prispeva več kot 70% k celotni genetski varianci v JVE. Obsežna karakterizacija in datiranje glavnih očetovskih linij nakazujeta, da je bila JVE tako pomemben vir, kot prejemnik genskega toka.*

KEY WORDS – Southeastern Europe; human Y-chromosomal gene pool; Paleolithic lineages; Neolithic paternal component

Introduction

The main biological importance of the Y chromosome is its role in sex determination and male fertility. Understanding its genetics is, therefore, of wide medical importance. That, however, does not exhaust its use as an object of research in population genetics. As we have witnessed recently, the Y chromosome (due to its specific structure and strictly paternal inheritance) has became a powerful instrument in the study of the population genetics of bisexual organisms, including humans. In humans, there have been studies of Y-chromosomal variation for more than 20 years by now. Many polymorphisms in the non-recombining region of Y have been described, including approximately 600 biallelic markers in the last YCC nomenclature (*Karafet et al. 2008*), thereby constantly improving the resolution of the phylogenetic tree of the Y chromosome and thus proving the usefulness of the Y-chromosome for studying the phylogeny and phylogeography spread of Y-chromosomal lineages worldwide and regionally.

The most comprehensive early picture of the European Y chromosomal landscape was offered by two parallel surveys by Semino *et al.* (*2000*) and Rosser *et al.* (*2000*), which both revealed similar clinal patterns for major European haplogroups. Semino *et al.* (*2000*) found that more than 95% of European Y chromosomes studied could be grouped into 10 phylogenetically defined haplogroups. The geographic distribution and age estimates were interpreted as testifying to two Paleolithic and one Neolithic migratory episode that contributed to the modern European gene pool. The majority of European Y chromo-

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somes belong to haplogroups R1a, R1b, I, and N3, which, taken together, cover about 70–80% of the total Y chromosome pool. The remaining 20% of males belong to haplogroups J2, E3b, or G. While the general distribution patterns of European paternal lineages were revealed in the two aforementioned studies, there are numerous studies by different research groups who have focused on detailed region or population-specific studies. In this respect, the Y-chromosomal variation of Southeast Europe has been studied to determine the source regions of the inhabitation of the region, as well as to attempt to indicate the potential episodes of gene flow during the dispersals of the Upper Paleolithic and Neolithic period. These topics have been raised, discussed and debated in many different studies during the last decade.

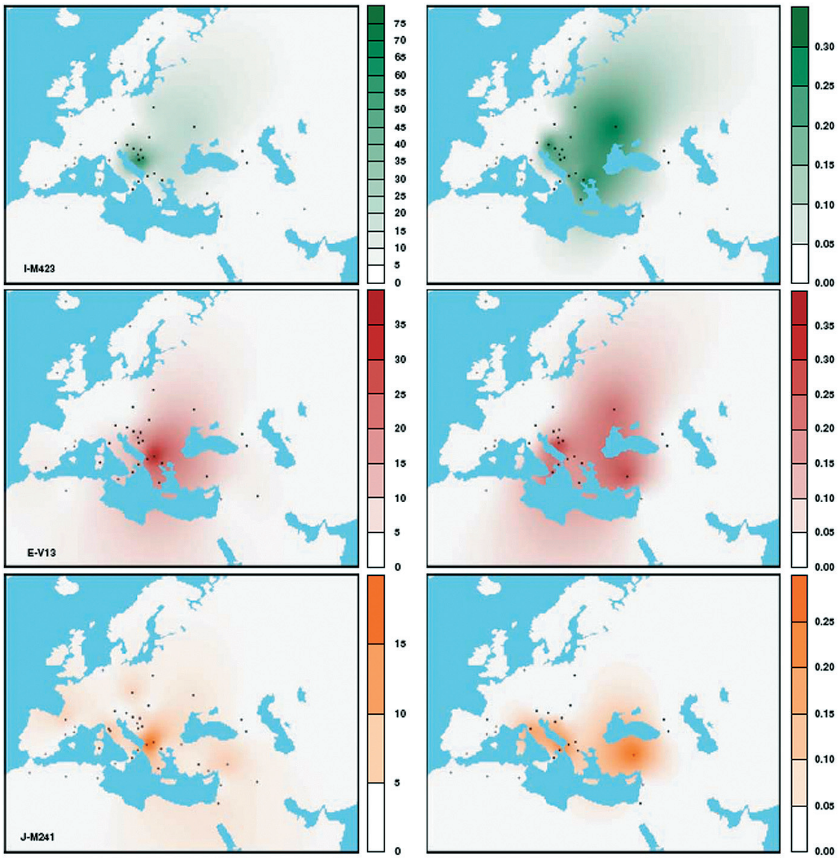


***Fig. 1. Frequency (left) and variance (right) distributions of the main Y-chromosome haplogroups, I–M423, E–V13 and J–M241 in SEE region; observed in* Battaglia et al. 2009.**

Results and discussion

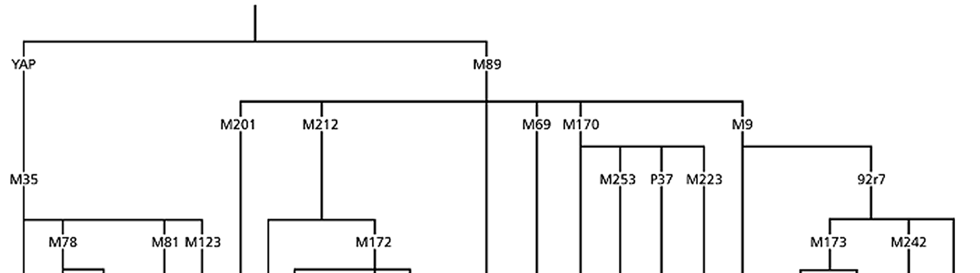
The objective of the present study is to give an overview and to attempt to evaluate the extent and nature of Balkan (SEE) paternal genetic variation in relation to potential episodes of gene flow during the dispersals of Upper Paleolithic and Neolithic hunter-gathering and farming populations in light of the knowledge accumulated by recent studies about the paternal heritage of this region (*Semino et al. 2000; Barac et al. 2003; Semino et al. 2004; Pericic et al. 2005; Marijanovic et al. 2005; Martinez et al. 2007; King et al. 2008; Battaglia et al. 2008*). The understanding of the temporal aspects of the spread and distribution of paternal lineages in SEE is especially relevant, as the Balkans are located on an important trajectory in the colonization process of Europe, migrations along which have taken place at least twice, in Paleolithic times and during the Neolithic (*Mellars 2004; 2006*). Moreover, SEE has been stated to be a starting-point of the spread of the European-specific autochthonic paternal lineage I–P37 (*Semino et al. 2000; Barac et al. 2003, Rootsi et al. 2004, Pericic et al. 2005; Underhill et al. 2007*) in the re-colonization process of Europe after the LGM in the Early Holocene; and later in the Neolithic period, J–M12(M102) lineages trace the diffusion of people from the southern Balkans to the west (*Semino et al. 2004*).

One of the first studies focusing on the distribution of paternal lineages in North-western Balkan was published by Barac *et al.* (*2003*), where Y chromosome variation in 457 Croatian samples (mainland and four island populations) was studied using 16 SNPs/indels and eight STR loci. The study was the first to reveal the high frequency of haplogroup I in Croatian populations and to suggest the Adriatic coast as one likely source for the re-colonization of Europe following the Last Glacial Maximum, according to phylogeography and the STR diversity pattern. In contrast, R1a frequency was suggested as a sign of the Slavic impact in the Balkan region. Haplogroups J, G, and E, related to the spread of farming, characterized a minor part (12.5%) of Croatian paternal lineages. Similar conclusions about the spread pattern and proportions of paternal lineages were reached in a study by Marjanovic *et al.* (*2005*) regarding the peopling of Bosnia-Herzegovina. The variation at 28 Y-chromosome biallelic markers was analyzed in 256 males (90 Croats, 81 Serbs and 85 Bosniacs) from Bosnia-Herzegovina. The three main groups of Bosnia-Herzegovina, in spite of some quantitative differences, share a large fraction of the same ancient gene pool (high frequency of the I–P37 lineage) distinctive for the Balkan area.

In comparison to the north-western area of the Balkans, the populations of the southern part of the Balkan Peninsula, like the Greek, have a somewhat different haplogroup frequency distribution. Two studies, King *et al.* (*2007*) and Martinez *et al.* (*2007*), present the distribution patterns of Y-chromosomal lineages in populations from the Southern Balkans, which partly overlap with those in the other Balkan populations described earlier, but partly reveal more similarities to Middle Eastern/Anatolian populations. The main hgs observed in Europe (E, I, J, R1a and R1b) contribute differently to the gene pool of the various SEE regions, Hg I (mostly I–P37 or I–M423 according to more recent nomenclature) and Hg R (both R1a and R1b), being the most represented in the whole Balkan region, while Hg E (V13) and Hg J2 (M12 sub-lineages) are mainly frequent in the southern Balkan populations.

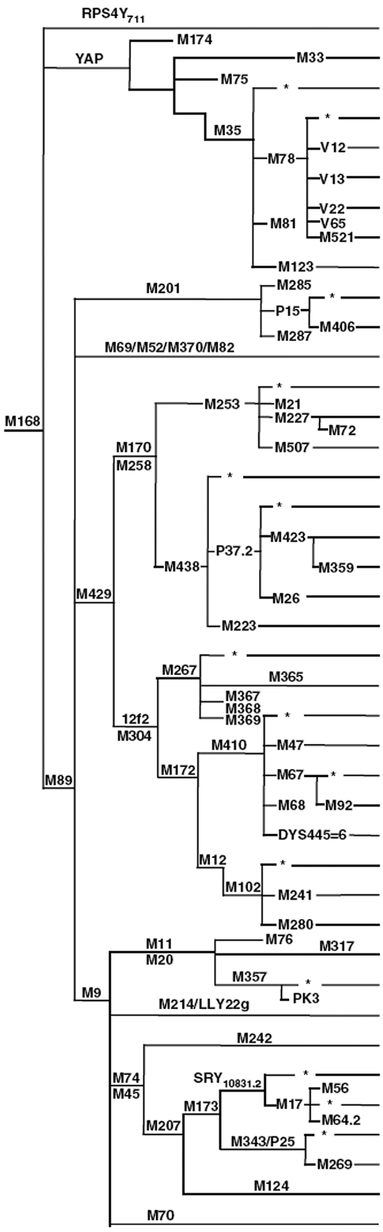
In the study by King *et al.* (*2008*), 171 samples were collected from areas near three known early Neolithic settlements in Greece together with 193 samples from Crete. An analysis of Y-chromosome haplogroups determined that the samples from the Greek Neolithic sites showed a strong affinity with Balkan data, while Crete showed an affinity with central/ Mediterranean Anatolia. Haplogroup J2b–M12 was frequent in Thessaly and Greek Macedonia, while haplogroup J2a–M410 was scarce. Conversely, Crete, like Anatolia, showed a high frequency of J2a–M410 and low frequency of J2b–M12. The expansion time of Y–STR variation for haplogroup E3b1a2–V13 in the Peloponnese was consistent with an indigenous Mesolithic presence. In turn, two distinct haplogroups, J2a1h–M319 and J2a1b1–M92, had demographic properties consistent with Bronze Age expansions to Crete, arguably from NW/W Anatolia and Syro-Palestine, while a later mainland (Mycenaean) contribution to Crete was indicated by the presence of of V13.

Another study, dedicated specifically to elucidating the Cretan paternal gene pool, was published by Martinez *et al.* (*2007*). The geographic stratification of the contemporary Cretan Y-chromosome gene pool was assessed by high-resolution haplotyping to investigate the potential imprints of past colonization episodes and the population substructure. In addition to analyzing the possible geographic origins of Y-chromosome lineages in relatively accessible areas of the island, the study included samples from the isolated interior of the Lasithi Plateau – a highland plain located in eastern Crete. The potential significance of the results from the latter region was underscored by the possibility that this region was used as a Minoan refugium. Comparisons of Y-haplogroup frequencies among three Cretan populations as well as with published data from additional Mediterranean locations revealed significant differences in the frequency distributions of paternal haplogroups within the island. The most outstanding differences were observed in the cases of haplogroups J2 and R1, with a predominance of haplogroup R lineages in the Lasithi Plateau and that of haplogroup J lin-



Population	n	E3b*	E3b1	E3b1-α	E3b2	E3b3	G	J	J2e*	J2e1	J2*	J2f*	J2f1	F*	H1	I*	I1a	I1b* (xM26)	I1c	K*(xP)	R1b	R1a	Q*	P* (xQ,R1)
Croatians (mainland)*	108			5.60			0.90			1.90				1.90		0.90	2.80	32.40	0.90	0.90	15.70	34.30		1.90
Bosnians	69			10.14			4.35										1.45	52.20			1.40	24.60		
Herzegovinians	141		0.70	7.80					0.70		0.70					2.13	4.95	63.83		2.84	3.55	12.06	0.71	
Serbians	113		1.77	18.58		0.90			4.40	0.90			2.70		0.90	1.77	5.31	29.20		7.08	10.62	15.93		
Kosovar Albanians	114		1.75	43.85	0.90	0.90				16.70							5.31	2.65			21.10	4.42		1.77
Macedonians	79		2.53	21.53			5.10		2.50	3.80	3.80		2.50	1.30			5.06	29.11		1.27	5.06	15.19		
Macedonian Romani	57			29.82						1.80					59.60		1.75	3.51			1.75	1.75		

Tab. 1. Y-chromosomal SNP tree and haplogroup frequencies in seven SEE populations (from* Peričić et al. *2005).



	Greeks	Macedonian-Greeks	Albanians	FYROM-Albanians	Bosnia-Serbs	Bosniacs	Bosnia-Croats	Osijek-Croats	Croats	Slovenians	North-East-Italians	Hungarians	Czechs	Poles	Ukrainians	Georgians	Balkarians
N	92	57	55	64	81	84	90	29	89	75	67	53	75	99	92	66	38
C	1.1																
E1a											1.5						
E*1b1b1					2.5												
E1b1b1a*			1.8	1.6													
E1b1b1a1																	2.6
E1b1b1a2	16.3	19.3	23.6	34.4	19.8	13.1	8.9	10.3	6.7	2.7	1.5	7.5		4.0	7.6	1.5	
E1b1b1a3	1.1	1.8							1.1								
E1b1b1a5	2.2																
E1b1b1c	2.2	1.8		3.1					1.1		1.5	1.9			1.1	1.5	
G2a*	2.2		1.8	1.6	1.2	3.6	1.1	13.8	1.1	1.3	11.9	1.9	4.0		3.3	30.3	26.3
G2a3c	1.1	1.8								1.3						1.5	2.6
H1a11.8															1.1		2.6
I1*	2.2	7.0	3.6	4.7	2.5	3.6			7.9	6.7	9.0	3.8	9.3	4.0	1.1	1.5	
I1b*		1.8				1.2									1.1		
I1e									1.1								
I2*	1.1	3.5			2.5					1.3							2.6
I2a*				1.6													
I2a1*	6.5	17.5	14.5	9.4	34.6	42.9	73.3	27.6	32.6	20.0	9.4	14.1	17.4				
I2a1a						2.4			1.1								
I2a2				1.6													
I2b1			3.6		1.2				1.1	2.7	1.5		1.3				
J1*	2.2	1.8	3.6	6.3	1.2	2.4				1.3				1.0		3.0	
J1b																1.5	
J2a*	3.3	3.5				2.4				1.3	3.0					10.6	15.8
J2a1a																1.5	
J2a1b*	4.3	3.5	3.6	1.6		4.8		3.4			6.0	1.9			1.1	15.2	5.3
J2a1b1	3.3		1.8			1.2				1.3	1.5				1.1	3.0	
J2a1k	1.1	1.8			2.5		1.1		1.1		3.0				1.1	1.5	
J2b*	2.2	3.5			3.7	1.2	1.1	3.4	2.2				1.3		1.1		2.6
J2b2	4.3	1.8	14.5	14.1	2.5	2.4		3.4	1.1				4.0	1.0	2.2		
J2b3	2.2																
L2	1.1										4.5						5.3
L3																1.5	
N1					6.2				2.2				2.7	1.0	6.5		
Q															1.1		
R1a*		1.8															
R1a1*	16.3	10.5	9.1	1.6	13.6	15.5	12.2	37.9	27.0	38.7	10.4	56.6	41.3	56.6	50.0	10.6	13.2
R1b1*	2.2												1.3				5.3
R1b1b2	17.4	14.0	18.2	18.8	6.2	3.6	2.2		12.4	21.3	41.8	15.1	33.3	18.2	2.2	9.1	7.9
R2																4.5	7.9
T	4.3	1.8									3.3	1.9	1.3		1.1	1.5	
H^a	0.910	0.904	0.870	0.822	0.821	0.776	0.443	0.773	0.802	0.768	0.795	0.652	0.714	0.630	0.714	0.862	0.888

Tab. 2. The phylogenetic relationships of Y-chromosome Hgs and their distribution in the examined south-east European populations (from* Battaglia et al. 2008*).

eages in the more accessible regions of the island. Y-STR-based analyses demonstrated the close affinity that R1a1 chromosomes from the Lasithi Plateau shared with those from the Balkans, but not with those from lowland eastern Crete. In contrast, Cretan R1b microsatellite-defined haplotypes displayed more resemblance to those from Northeast Italy than to those from Turkey and the Balkans.

An important study of the SEE paternal heritage from a more general aspect was published by Pericic *et al.* (*2005*), extending the number of analyzed populations (7 populations) and sample sizes and setting the obtained data in a wider phylogenetic context. The extent and nature of southeastern Europe (SEE) paternal genetic contribution to the European genetic landscape were explored based on a high-resolution Y chromosome analysis involving 681 males from seven populations in the region. Paternal lineages present in SEE were compared with previously published data from western Eurasian populations. The finding that five major haplogroups (E3b1, I1–P37 (xM26), J2, R1a, and R1b) comprise more than 70% of SEE total genetic variation is consistent with the typical European Y chromosome gene pool. However, the distribution of major Y chromosomal lineages and estimated expansion signals clarify the specific role of this region in structuring European, and particularly Slavic, paternal genetic heritage. The contemporary Slavic paternal gene pool, mostly characterized by the predominance of R1a and I–P37 (xM26) and the scarcity of E3b1 lineages, is a result of several major prehistoric gene flows with different directions: the post-Last Glacial Maximum R1a expansion from east to west, the Younger Dryas- Holocene I-P37(xM26) diffusion out of SEE, in addition to subsequent putative R1a and I–P37(xM26) gene flows between eastern Europe and SEE, and a rather weak diffusion of E3b1 toward regions nowadays occupied by Slavic-speaking populations. To illustrate the proportions of the main components of SEE paternal lineages, Table 1 is presented here.

One more recent study focusing on the topic of SEE paternal heritage was published by Battaglia *et al.* (*2008*). To investigate the possible involvement of indigenous people in the transition to agriculture in the Balkans, patterns of Y-chromosome diversity in 1206 subjects from 17 population samples, mainly from Southeast Europe, were analyzed in the study. The main conclusions from the study are as follows: evidence from three Y-chromosome lineages – I–M 423, E–V13 and J–M241 – makes it possible to distinguish between Holocene Mesolithic forager and subsequent Neolithic range expansions from the eastern Sahara and the Near East. In particular, while the Balkan microsatellite variation associated with J–M241 correlates with the Neolithic period, those related to E–V13 and I–M423 Balkan Y chromosomes are consistent with a late Mesolithic time frame. In addition, the low frequency and variance associated with I–M423 and E–V13 in Anatolia and the Middle East support a European Mesolithic origin of these two clades. The ensuing range expansions of E–V13 and I–M423 parallel the diffusion of Neolithic Impressed Ware in space and time, thereby supporting a case of cultural diffusion. Illustrating the statements of this study, Figure 1 and Table 2 is presented.

Conclusions

The paternal heritage of SEE is consistent with the typical European paternal gene pool, as five major haplogroups E3b1, I1b*, J2, R1a, and R1b comprise over 70% of the genetic variation in SEE. Comprehensive characterization and dating of major paternal lineages suggest that SEE has been both an important source and recipient of gene flow. Estimated expansion signals related to the major Balkan Y-chromosomal lineage I–M423 (earlier known as I–P37) and E–V13 (more common in the Southern Balkans) are consistent with a late Mesolithic time frame. In addition, the low frequency and variance associated with I–M423 and E–V13 in Anatolia and the Middle East support a European Mesolithic origin of these two clades. Thus, these Balkan Mesolithic foragers, with their own autochthonous genetic signatures, became the earliest to adopt farming when it was subsequently introduced by migrating farmers from the Near East. These converted indigenous farmers became the principal agents who spread this economy by using maritime leapfrog colonization strategies in the Adriatic and transmitting the Neolithic cultural package to other adjacent Mesolithic populations. The Neolithic component in the SEE paternal gene pool is most clearly marked by the presence of the J–M241 (more frequent in the Southern Balkans) lineage, and its expansion signals associated with Balkan microsatellite variation correlate with the Neolithic period.

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Early Neolithic pottery dispersals and demic diffusion in Southeastern Europe

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ABSTRACT – *The ^{14}C gradient of pottery dispersal suggests that the sites in the southern Balkans are not significantly older than those in the northern and eastern Balkans. A gradual demic diffusion model from south to north and a millennium time span vector thus find no confirmation in the set of AMS ^{14}C dates and associated contexts that mark pottery dispersal within Southeastern Europe. The first 'demic event' that was hypothesised to reshape significantly European population structure and generate a uniform process of neolithisation of southestern Europe has no confirmation in frequency of Y-chromosome subhaplogroups J2b and E3b1 distribution within modern population in Southeastern Europe.*

IZVLEČEK – *^{14}C datumi prve keramike kažejo, da zgodnje neolitska najdišča na jugu Balkana niso starejša od onih na severu. AMS ^{14}C datumi ne potrjujejo modela postopne demske difuzije od juga proti severu in tisočletni časovni zamik pri širitvi keramike. Prvi 'demski dogodek', ki naj bi domnevno preoblikoval evropsko populacijsko sestavo, v jugovzhodni Evropi pa povzročil proces enovite neolitizacije, ni potrjen s pogostostjo pojavljanja Y-kromosomskih haploskupin J2b in E3b1 pri sedanjih populacijah v jugovzhodni Evropi.*

KEY WORDS – *Southeastern Europe; Early Neolithic; pottery; AMS ^{14}C dates; Y-chromosome haplogroups*

Introduction

Pottery has become archaeologically conceptualized by an interpretative triad suggesting that in the context of human social evolution, 'lower barbarism' (Neolithic) can be distinguished from 'upper savagery' (Mesolithic) by the presence of vessels (*Morgan 1878*), that territorial distributions of pottery types reflect 'sharply defined archaeological cultural provinces' (*Kossina 1911.3*), and that the invention of ceramic technology and pottery making was 'the earliest conscious utilization by man of a chemical change… in the quality of the material… the conversion of mud or dust into stone' in the Neolithic (*Childe 1951.76–77*).

It is worth remembering that pottery distributions became highly ideologized and politicised after *Lex Kossinae* formalized the 'cultural province', an entity defined not from regional geography, but an inductive category deriving from regional distributions of 'Linear' and 'Corded' pottery that 'correspond, unquestionably, with the areas of particular people or tribes'. These people were hypothesised Proto-Indo-Europeans of 'Neolithic Germany' who migrated from the area between the North Sea and Baltic Sea and colonized the rest of Europe (*Kossina 1911; 1936*). Childe agreed that Neolithic pottery was a universal indicator of both, 'cultural identities' and 'distributions of ethnic groups' (*Childe 1929.v–iv*). But he strongly disagreed that its invention and primary distribution can be found within the Europe. He actualized an old Montelius' 'normative principle to prehistorians in Western Europe' that postulates European prehistory as 'a pale reflexion of Oriental culture' (*Childe 1939.10*). There was no room either for technological innovations, or for structural changes in economy and ideology that could have occurred in Europe autonomously and that could have been linked to the Mesolithic-Neolithic cultural transformations at the 'Dawn of European Civilization' (*Childe 1925; 1928*).

Childe (*1939.25–26*) postulated a Neolithic zonal model in which, along with 'true cities and little townships in the Orient', in "*Thessaly, Macedonia and the Morava-Maros region beyond the Balkans, Neolithic villages are permanently occupied by experienced farmers who are content to do without metal... North of the Maros Körös, herdsmen and Bükkian troglodytes are grazing and tilling patches of löss and then moving on; still farther north, Danubian I hoe-cultivators are shifting their hamlets of twenty-odd huts every few years to fresh fields till they reach the confines of the löss... Beyond these, on the North European plain are only scattered bands of food-gatherers hunting, fowling and fishing and collecting nuts or shell-fish...*". Because of interrelated assumptions that all cultural innovations must have originated in those areas where civilizations flourished at the earliest date (Orient), and that they were diffused in the area where cultural continuity was attested (Europe), he denoted this model diffusionist.

However, in the same year (*1939*) Coon introduced the migration model. He postulated the gradual invasion of the 'Danubian agriculturalists of the Early Neolithic' that brought a 'food-producing economy into central Europe from the East'. These people were 'Mediterranean', a new population in Europe that originated in western Asia in a Natufian cultural context. The model was grounded on the metrical and morphological characteristics of skeletal remains of Neolithic 'Danubian immigrants' and on the distribution of 'Danubian painted pottery', that shows 'definite Asiatic similarities'. Both, the invasion of farmers and pottery dispersal were supposed to have occurred from Eastern Mediterranean 'up the Danube Valley' into the Carpathian basin, Central Europe and further to the west, to the Paris basin.

One of his basic interpretative premises relates to interaction between essentially different populations on the agricultural frontier. He relates it to a continuous blending of populations, suggesting that, "*When the food producers entered the territory formerly occupied by Upper Palaeolithic hunters, the former were much more numerous than the latter, who either retired to environmental pockets economically unfavorable to the food producers, or were absorbed into the ethnic corpus of the latter. The adjustment of the earlier population element to the new conditions and their re-emergence through the Mediterranean group made a combination of the two basic racial elements in a genetic sense necessary.*" (*Coon 1939.647*) (Fig. 1a).

It is worth remembering the frontier thesis had been entertained since Herodotus identified it as the agri-

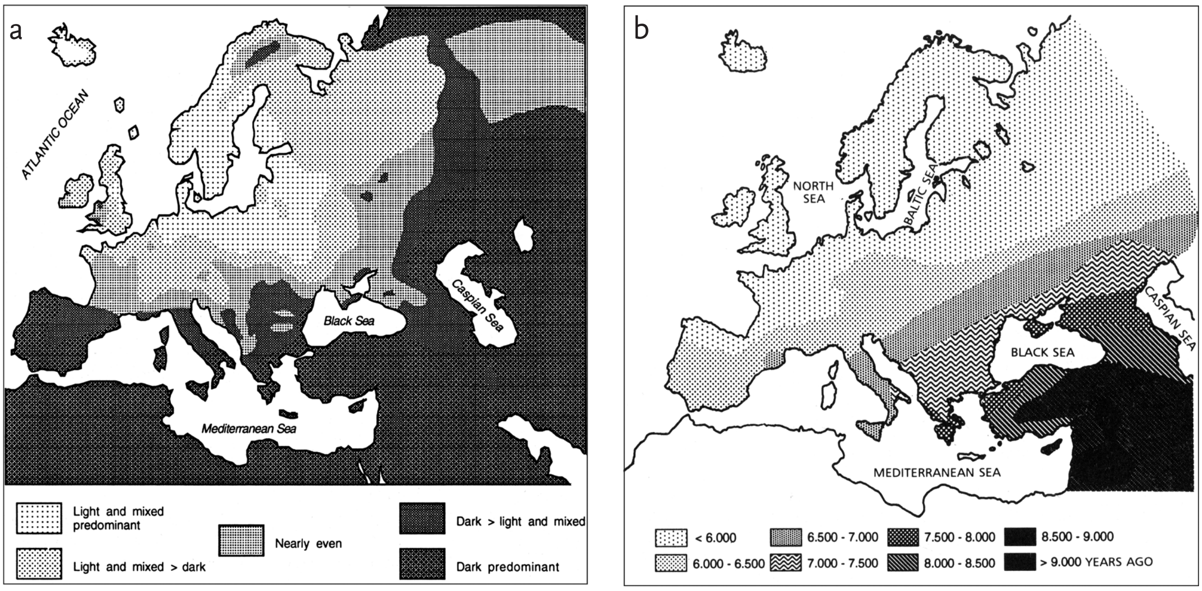


Fig. 1. The map of frequency distribution of morphological and anthropometric characteristics and associated physical types (a) that was hypothesised to corresponds with the Neolithic invasion of Mediterraneans in Europe and with the process of 'Dinaricization' (**Coon 1972.Map 8; Cavalli-Sforza, Menozzi, Piazza 1994.Fig. 5.4.1*****), and the map of genetic landscape (b) of the first principal components that was hypothesised to corresponds with Neolithic 'demic diffusion' (*****Cavalli-Sforza, Menozzi, Piazza 1994.Map 4*****).***

cultural boundary and the meeting point of the civilized and barbarian worlds. Turner (*1893*) introduced a similar notion, referring to the American frontier and colonial conquest of America's Great West thus "*The first ideal of the pioneer was that of conquest. It was his task to fight with nature for the chance to exist... Vast forests blocked the way; mountainous ramparts interposed; desolate, grass-clad prairies, barren oceans of rolling plains, arid deserts, and a fierce race of savages, all had to be met and defeated.*" (*cfr. Klein 1997.81*; see also *Zvelebil and Rowley-Conwy 1986; Zvelebil 2000*).

The interaction between the populations of Mesolithic hunter-gatherers (the Alpines) and Neolithic newcomers (the Mediterraneans), was believed to be determined by a 'dinaricization' process in which the 'Mediterranean type seems to be a brachycephalized by some non-Mediterranean agency'. A new phenotype appeared that can be recognized in modern populations in Europe by its modified craniofacial morphological characteristics: the 'occipital flattening and, the nasal bridge that become prominent'. The process was completed by the end of the Neolithic and, there were remained no other populations than the 'Dinaric' in most of Europe. The 'Mediterraneans' survived on the Iberian Peninsula, and the 'Alpines' in northern Scandinavia (*Coon 1939.647–648*).

The interpretative spiral

Coon's biologically determinate migration model was never recognized in archaeology, although the migration of Mediterraneans, the concept of blending populations, and the cultural and populational frontiers have remained focal points in interpreting the European Neolithic. The repeated waves of migrations from Asia Minor and the establishment of Neolithic diaspora and colonial centres of Neolithization have been hypothesised in rich catchments in the Balkans and central Europe (*Weinberg 1965. 308; Ammerman and Cavalli-Sforza 1984; van Andel and Runnels 1995; Bogucki 1996; Özdoğan 2008*). The colonist's physical remains were suggested to be found in marginal areas of the Danube Gorges, where 'small and gracile male individuals' were buried together with the 'robust indigenous foragers' (*Mikić 1980; Menk and Nemeskeri 1989*; for comments, see *Roksandić 2000*). The Mediterraneans were hypothesised as having married in to the Danube Gorges from 'outside', from agricultural communities (*Chapman 1993*), and the appearance of new burial practices in the gorges, it was suggested, 'can only be explained in terms of either acculturation or immigration' (*Bonsall 2008.271*).

Pinhasi indeed suggests morphological affinities between the Balkan and Anatolian Çatal Höyük populations, but, surprisingly, not with earlier Levantine Pre-Pottery Neolithic populations (*Pinhasi 2003; 2006; Pinhasi and Pluciennik 2004; Pinhasi, Fort, Ammerman 2005*). In a recent interpretation based on a 'null evolutionary model of isolation-by-geographic and temporal distance' and on the correlation of Mesolithic and Neolithic craniometric data with the classic genetic marker dispersal within modern European populations, Pinhasi and von Cramon-Taubadel (*2009*) suggest that crania metric data support the continuous dispersal of people from Southwest Asia to Europe. They found, contrary to Coon, no strong support for a significant admixture of contemporaneous Mesolithic and Neolithic populations in Europe. They suggest that their results 'best fit a model of continuous demic diffusion' into Europe from the south-western Asian, and that the indigenous Mesolithic hunter-gatherers in Europe played almost no role in the Mesolithic-Neolithic transition in Europe.

An excellent illustration, however, of the mixing of 'crania metric characteristics' in a funerary context is shown in the trapezoidal structure 21 at Lepenski Vir (Fig. 2). Apart from the extended inhumation inside the burial pit cut through the floor, there was a disarticulated human skull placed on the left shoulder and facing the deceased. Next to the right side, aurochs and deer skulls with antlers were placed. A sculpted boulder had been placed on the building floor, above the skull. A comparison of human skull morphology reveals that they are very different in terms of size and robustness. While the disarticulated skull is decidedly robust and has been traditionally attributed to a very robust Mesolithic population, the adult man's skeleton in the burial pit was recognized as gracile and has been attributed to a Neolithic population (for a discussion, see *Borić 2005.24*). Both the skeleton and the disarticulated human skull are dated – after a correction for the freshwater reservoir effect – to an overlapping age range from 6216–5884 and 6080–5728 calBC at 2σ – (*Borić and Dimitrijević 2009*). Stable isotope σ^{15}N values indicate that the skulls show differences in dietary practices. While the isotopic signature of the 'robust' one indicates a diet heavily based on riverine resources, the 'gracile' one shows a mixed diet based on terrestrial and riverine resources. These differences, however, cannot be easily interpreted as

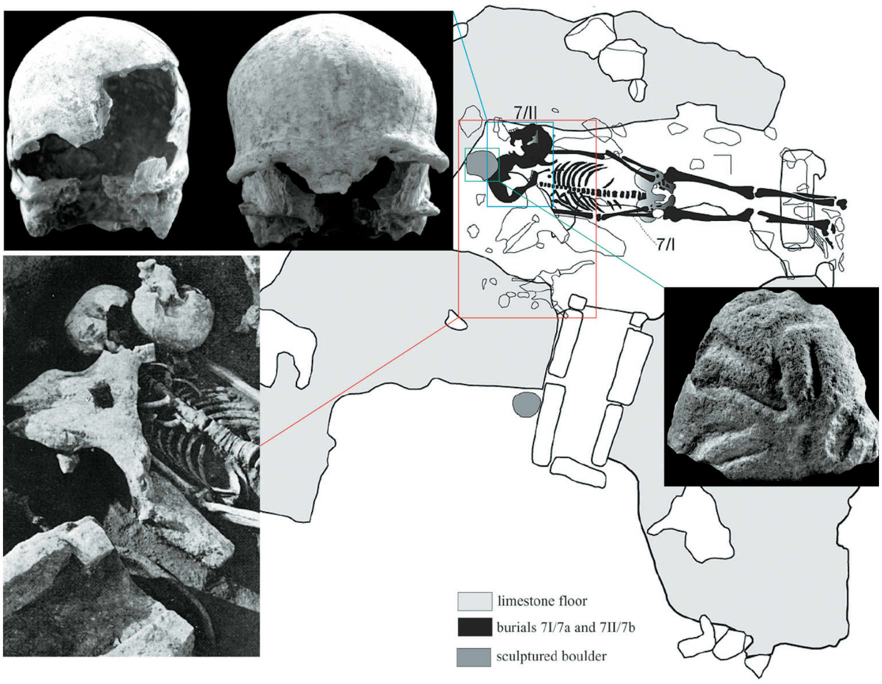


Fig. 2. Lepenski Vir, trapezoidal structure No. 21. An extended inhumation of an adult man, placed in a burial pit cut through the floor ('gracile' skull, left). The disarticulated human skull ('robust' skull, right) was placed on shoulder of the deceased. Aurochs and deer skulls with antlers were placed next to his right side. A sculpted boulder had been placed on the building floor, above the skull (after **Srejović 1969.Fig. 69; Radovanović 1996.Fig. 4.3; Borić 2005.Fig. 3.3; Babović 2006.Figs. 313, 314*).***

marking a clear break between Mesolithic and Neolithic subsistence (*Borić et al. 2004; Borić 2005*). The materiality of this Lepenski Vir burial context suggests that both 'cranial phenotypes' participated in a funeral rite, and that ancestral principle may have played a key role.

Parallel to Coon's[1] racial taxonomy and human phenotype dispersals, the distribution of pottery types and ornaments has been discussed in archaeology in the context of the colonization of southeast Europe in the Early Neolithic. The pottery was recognized 'as the most accessible manifestation of the material culture available, without any breaks, for the comparative study of development' (*Theocharis 1973.39*), and also as 'the most obvious diagnostic element' for tracing 'waves of migrations' from Asia Minor (*Schachermeyr 1976.43–46*).

In the most influential interpretation in the sixties, Southeastern Europe was recognized as a 'western province of the Near Eastern peasant cultures', created by the processes of colonisation and acculturation' (*Piggot 1965.49–50*; see also *Roden 1965*). This assertion was grounded on the identification of 'common traditions in pottery styles' between the regions and in the distribution of 'oriental stamp-seals' and female figurines, and 'sometimes of animals, which may relate to religious cults'. Nandris (*1970.193, 202*) suggested that this dispersal marks Early Neolithic 'cultural unity', which was 'greater than was ever subsequently achieved in this area of southeast Europe, down to the present day'. In this context, Greece was suggested as being the location of the 'foundation' and 'construction of the main features of Neolithic culture' in Europe (*Theocharis 1973.58*). The reconstruction of colonizing and acculturating logic was reduced to identifying the geographical distribution of 'monochrome' and painted pottery. Both achieved paradigmatic status as cultural and ethnic markers of the Neolithic diaspora, in which farming 'oriental' communities dispersed across the Peloponnese and Thessaly on the southern tip of the Balkan Peninsula. By the end of the Aegean Early Neolithic, the diaspora was hypothesised as having spread to northern regions, and farming communities were established in the Balkans and Carpathian basin. A wave of migrations along the Vardar and Morava rivers, marked by the spread of white and red painted pottery, was hypothesied. Differences in decorative motifs and ornamental composition constituted clusters of cultures 'Anzabegovo-Vršnik' 'Starčevo', 'Körös', 'Criş', 'Kremikovci', and 'Karanovo' in neighbouring areas (*Nandris 1970; Garašanin 1979*).

The rate of diffusion was first calculated from the small series of ^{14}C dates available at the time. It was recognized as 'a pure scientific approach in the chronological determination of the expansion of farming culture', based on the 'radiocarbon dating of materials from the actual settlements of the prehistoric

1 The last reprint of his book 'The Races of Europe' was published by Greenwood Publisher, Connecticut in 1972.

cultivators themselves' (*Clark 1965a*). Clark allocated dates to three temporal zones running from Near East to Atlantic Europe: (i) earlier than 5200 BC, (ii) between 5200 and 4000 BC, and (iii) 4000 and 2800 BC. He suggested that decreasing values of these dates be arranged in a southeast-northwest gradient, and that the sequential settlement distribution reflects 'the gradual spread of farming culture and the Neolithic way of life from the Near East over Europe'. The second zone, however, was associated with the 'expansion of Neolithic culture north of the Mediterranean' (*Clark 1965b.66*).

Genetic gradients

A few years later, Ammerman and Cavalli-Sforza (*1971; 1973*; see also *Gkiasta et al. 2003*) gave an average speed of diffusion of about 1 km/y. At the same time, they were the first to emphasize the role of demic diffusion and to point out the strong agreement between the calculated average rate of spread of the Neolithic and that predicted by the demic wave-of-advance model. The model, borrowed from the population biology, proposed that active population growth at the farming frontier, in combination with local migratory activity, would have produced a population expansion that moved outwards in all directions and advanced at a relatively steady rate. They also postulated the mixing of Neolithic and Mesolithic populations on the agricultural frontier that may have led to genetic gradients with extreme gene frequencies in those areas with the oldest Neolithic sites.

The demic 'wave-of-advance' model was first introduced in 1978. The geneticists Menozzi, Piazza and Cavalli-Sforza shifted the focus from phenotype to genotype, from cranial characteristic to classic genetic markers, from races to populations. They linked the first principal component of 38 gene frequencies of 'classic', non-DNA marker dispersal (allele frequencies for blood groups, the tissue antigen HLA system, and some enzymes) in modern European populations with the distribution of Early Neolithic farming settlements in south-western Asia and Europe. A similar 'southeast-northwest gradient or cline' of geographical distribution was suggested to support the spread of early farming in Europe, and that it was 'a demic spread rather than a cultural diffusion of farming technology' (*Menozzi, Piazza and Cavalli-Sforza 1978.786*). Six years later, Ammerman and Cavalli-Sforza (*1984.xv, 137*) postulated, similar to Coone, that 'cultural events in the remote past played a major role in shaping the genetic structure of human populations'. In Europe, they continue, 'the Neolithic transition forms the backbone of the geographic distribution of genes'. Different clines of contour maps of three principal components distributions show, they hypothesised, a sequence of three 'major demic events'. They linked the first to the migration of Neolithic farmers from Near East. The second and third, they guessed, 'can perhaps also be interpreted in terms of population movements other than the spread of early farming', and can be associated with migrations 'of groups of pastoral nomads' in the third millennium BC from central Asia, and with the 'expansion of Indo-European speaking people from the north of the Black Sea'.

The first 'demic event' has become legitimized archaeologically by the definition of the catalogue of artefacts recognized as being brought into Europe by migrating farmers. White and red painted pottery has retained an axiomatic interpretative position (*Renfrew 1987.Fig. 7.9*; see *Budja 2005*).

The new synthetic map of the first principal component in classic genetic markers of 95 gene frequency dispersals across Europe and the Near East appeared in 1993. It has perpetuated the legitimacy of the Neolithic ancestry of modern Europeans, and the question 'Who are the Europeans?' that Alberto Piazza (*1993*) addressed in this context was not at all rhetorical. A more sophisticated interpretation of this synthetic map became available a year later in the monumental volume The History and Geography of Human Genes (*Cavalli-Sforza, Menozzi and Piazza 1994*). In a palimpsest of seven principal components and associated genetic landscapes, the first was linked to the Near East, which was recognized as an ancestral homeland for the current population in Europe. The authors hypothesised that the transition to farming in Europe correlates with a massive movement of population from the Near East, without substantial contact with local Mesolithic populations. The elimination of the European hunter-gatherer population was assumed, despite only a 27% total variation in classical marker frequencies attributed to Neolithic populations across Europe. Only some clear outliers, such as Basques and Lapps were shown to have emerged from this homogeneous Neolithic entity as relic Palaeolithic hunter-gathers.

It is noteworthy that phenotype replacement with genotype, and the concept of race with the concept of population, has been an increasingly significant issue, with serious implications for physical anthropology, population genetics and archaeology. Research into human genetics has highlighted that more genetic variation exists within than between populations, where those groups are defined in terms of linguistic, geographic, and cultural boundaries (*Wierciński and Bielicki 1962; Lewontin 1972; Serre and Pääbo 2004; Rosenberg et al. 2002; 2005; Li et al. 2008*). In 1996, the American Association of Physical Anthropologists issued the political statement that "*Pure races, in the sense of genetically homogenous populations, do not exist in the human species today; nor is there any evidence that they have ever existed in the past*"[2]. After the abolition of the concept of race and in the context of a political and scientific battle between the new physical anthropology and genetics to classifying humans, Coon's approach was labelled as 'scientific' racism and the last gasp of an outdated scientific methodology (*Cavalli-Sforza, Menozzi and Piazza 1994.267*; see also *Barbujani 2002*). The contour maps of classic human genetic marker distribution have replaced the frequency map of the distribution of morphological and anthropometric characteristics. It was suggested recently, however, that the magnitude of the relative regional proportion of human phenotypic variance in crania correlates with the magnitude of regional molecular genetic variance (*Rosseman and Weaver 2007*). This led Pinhasi and von Cramon-Taubadel (*2009*), as noted above, to build a 'hypothetical' interpretative model to update demic diffusion and waves of advance by correlating the Mesolithic and Neolithic craniometric data with the gradient of the first principal component of classic genetic markers within modern European populations.

Since the revolution in the study of the human genome, the debate has shifted from the classic markers of certain genes to the loci in humans – the mitochondrial DNA present in both sexes, but inherited only in the maternal line; and the Y-chromosome present only in males and inherited exclusively through males. Because they are non-recombinant and highly polymorphic, they are seen as ideal for reconstructing human evolution, population history, and ancestral migration patterns. The analyses of uniparentally inherited marker systems allow population geneticists to study the genetic diversity of maternal and paternal lineages in various Eurasian populations, as well as the environmental and cultural processes that might have been involved in the shaping of this variety. Thus different human nuclear DNA polymorphic markers of modern populations have been used to study genomic diversity and to define maternal and paternal lineage clusters – haplogroups – and to trace their (pre)historic genealogical trees, and chronological and spatial trajectories. In human genetics a haplogroup is a group of similar haplotypes that share a common ancestor with a single nucleotide polymorphism (SNP) mutation. These special mutations are extremely rare, and identify a group of people – all the male descendants of the single person who first showed a particular mutation, over a period of tens of thousands of years. The SNP markers allow the construction of intact haplotypes and thus male-mediated migration can be readily recognized.

The phylogenies of the human Y-chromosome as defined by unique event polymorphisms and the geographic distribution of haplogroups have ultimately replaced the classic genetic markers and associated contour maps of principal component distributions.

Semino *et al.* (*2000*) and Rosser *et al.* (*2000*) hypothesised that, because of the southeast-northwest cline of frequencies of the haplogroups Eu4, Eu9, Eu10 and Eu11 (J2, E3b1 and G)[3] within the modern populations in south-western Asia and Europe, and calculated expansion time, they represent the male contribution of a demic diffusion of Levantine farmers to European Neolithic. The authors suggest that the European gene pool was of Palaeolithic origin, as the Neolithic lineages comprise only ~22% of the variation. A reanalysis of the data two years later by the maximum-likelihood admixture estimation method, claimed an average Neolithic contribution of 50% across all samples, 56% for the Mediterranean subset, and 44% in non-Mediterranean samples (*Chikhi et al. 2002*; see also *Dupanloup 2004*). In later studies of the origin, differentiation and diffusion of the Y-chromosomal Neolithic haplogroups E3b and J, it becomes evident that the history of the European population was certainly more complex – and the expansions from the Middle East toward Europe – regardless of whether the coalescence dating calculated for a generation time of 25 or 30 years 'most likely occurred during and after the Neolithic'

2 American Association of Physical Anthropologists. Statement of biological aspects of race. Am. J. Phys. Anthropol. 101: 569–570 (*1996*).

3 The haplogroup's nomenclature was changed after the introduction of the Y-chromosomal binary haplogroup nomenclature system (*Hammer 2002*). For the human Y chromosome haplogroup tree, nomenclature and phylogeography see also Hammer and Zegura (*2002*). For revised phylogenetic relationships and nomenclature see Sengupta *et al.* (*2006*). For the most recent version of haplogroup tree Karafet *et al.* (*2008*).

(*Semino at al. 2004.1032*). The findings of the many biallelic markers which subdivide the haplogroups J and E suggest that the large-scale clinal patterns cannot be read as markers of a uniform and time limited spread of people from a single parental Near Eastern population, but a multi-period process of numerous small-scale, more regional population movements, replacements, and subsequent expansions overlying previous ranges. The consensus on the proportion of these lineages in Europe is at around 20% (*Di Giacomo et al. 2004. 36; Cinnioğlu et al. 2004.133–135; Peričić et al. 2005; 2006; Luca et al. 2007; Novelletto 2007*).

The haplogroup J become archaeologically instrumentalized by correlating the frequency distribution of its genetic marker (M172) within the modern European and Asian populations, and the Early Neolithic distribution of painted pottery and ceramic female figurines within the same area. King and Underhill (*2002.714*) postulated that "*The Eu9 haplogroup is the best genetic predictor of the appearance of Neolithic painted pottery and figurines at various European sites*".

Parallel to this interpretative postulate, ceramic female figurines have been noted as specific markers of an oriental 'expansionist' religion that became a powerful social force in the Levantine Pre-Pottery Neolithic (*Cauvin 2000*). Cauvin postulated an interlinked economic and religious transformation, which explains why hunter-gatherers in villages outside the Levant did not develop subsistence production for themselves: their failure to 'humanise' their art and adopt new deities would have prevented them from making the transition to a new type of economy. Accordingly, Europe could not have become Neolithic until the 'wave of advance' and ceramic female figurines had reached the Balkans.

However, the invention of ceramic and the introduction of ceramic female statuettes and animal figurines was certainly not within the cultural domain of earlier Levantine hunter-gatherer societies, nor did they only appear on the 'eve of the appearance of an agricultural economy', as Cauvin (*2000.25*) suggested.

Knowledge of ceramic technology had been an element of Eurasian hunter-gatherer cultures for many millennia before the appearance of food-producing agricultural societies. We must also note two other facts: first, that the making of ceramic figurines predates the making of pottery, and second, that pottery was not necessarily associated with the emergence of farming, as ceramic vessels had been made before early agriculture appeared in East Asia.

The tradition of making ceramic figurines can be traced back to the Central European Pavlovian cultural context, and then across the Russian Plain into southern Siberia, and ultimately back to the Levant and North Africa. It is now clear that the clay-figurine-tradition was deeply embedded in pre-existing Eurasian hunter-gatherer social and symbolic contexts and that the dates of these figures begin as early as 26 000 years BP (*Verpoorte 2001; Einwögerer and Simon 2008*).

If we look more closely at the contexts in which early hunter-gatherer ceramics were produced, we may assume that they were of social significance. In Central Europe, a total of sixteen thousand ceramic objects – over nine hundred figural ceramics – have been found in Gravettian and Pavlovian hunter-gatherer camps, which indicates that ceramic production, was widespread. At Dolní Věstonice there was an oven-like hearth in the centre of a hut-like structure in which 'two thousand pieces of ceramics, among which about one hundred and seventy-five with traces of modelling' were dispersed. In addition, other ceramic finds had been deposited near a single male burial, around a triple burial, and in the vicinity of a large hearth. The available statistics indicate that almost all the figurines and statuettes were deliberately fragmented, although many of the pellets and balls which comprise a large quantity of the ceramic inventory were found intact (*Soffer et al. 2000; Verpoorte 2001.56, 128*).

Early pottery first occurred in Eastern Eurasia in the context of small-scale sedentary or semi-sedentary communities, in southeast China (Yuchanyan Cave), where it has been dated to as early as 18 300 to 17 500 calBP (*Boaretto et al. 2009*). Later pottery assemblages on the Japanese archipelago and in southern Siberia are dated to the fourteenth and thirteenth millennia calBP (*Kuzmin 2006; Kuzmin and Vetrov 2007*).

We may postulate that the ceramic female figurines are thus as much 'predictors', to paraphrase King and Underhill, of Palaeolithic Gravettian hunter-gatherers' haplogroups, as of Neolithic farmers (*Semino et al. 2000; Budja 2005*).

The postulate that the geographically overlapping distribution of Early Neolithic artefacts and allele frequency clines reflects an individual and time limited demic diffusion of farmers that resulted in the colonization of Europe and the replacement of populations has lost its interpretative, or any other, power. Recent studies of the Neolithic paternal haplogroups E (M78) and J1 (M267) and J2 (M172) strongly suggest continuous Mesolithic, Neolithic and post-Neolithic gene flows within southeast Europe, and between Europe and the Near East in both directions.

The Neolithic haplogroup E (M78) is represented in Europe by its internal lineages E3b1a and E3b1a2 (E–V13 polymorphism). It constitutes about 85% of the European E–M78 chromosomes, with a clinal pattern of frequency distribution from the southern Balkan Peninsula (19.6%) to west Europe (2.5%). This haplogroup reached the southern Balkans after 17 000 calBP and its phylogeny reveals signatures of several demographic population expansions within Europe. Cruciani *et al.* (*2007*), Pompei *et al.* (*2008*) and King *et al.* (*2008*) agree that the earliest expansion was linked to Mesolithic demographic expansion from western Asia into Europe, and that the later series of Neolithic and Bronze Age expansions were restricted regionally within southeast Europe. Thus the first demographic expansion within Europe, from the Peloponnese to Thessaly and Greek Macedonia, was calculated at 8600 calBP (*King et al. 2008.211*). All of the demographic expansion within the Balkans of the later haplogroups, E3b1a and E3b1a2, post-date the transition to farming in the region.

The haplogroup J is subdivided into two major subhaplogroups, J1 (M267) and J2 (M172). The latter was hypothesised as representing an important signature of Neolithic demic diffusion and to have been associated with the appearance of painted pottery and figurines. It became clear recently that it mainly constitutes the signatures of several post Neolithic expansions within Europe, and not demic diffusion into Europe. The J2 subclade frequencies in southeast Europe show two distinct clusters. While the J2a (M410) subclades are frequent in the Peloponnese, Crete and Anatolia, but rare in the Balkans, the J2b (M12) subclades are, conversely, the most frequent in the Balkans and in the Mediterranean (*King et al. 2008; Battaglia et al. 2009*). The expansion time for the J2b (M12) subhaplogroup and associated migration from the southern Balkans toward the Carpathian basin is consistent with the Late Neolithic (*King et al. 2008.209*). The geographical origin of the J2b subclade remains unknown, although it shows a trend of decreasing frequency from the Balkans (7–9%) to Anatolia (1.7%) (*King et al. 2008*). Interestingly, in the region where the PPNA–C sites at Çayönü, Göbekli Tepe and Hallan Çemi are located, the 4.7% clade frequency is significantly lower than those in the Balkans.

Barać *et al.* (*2003*) and Peričić *et al.* (*2005; 2006*) recently observed that a lower frequency of subhaplogroups J2b and E3b1 significantly distinguishes the populations of the western Balkans and the Adriatic (7.9%) from neighbouring populations of the Vardar-Morava river system in the eastern Balkans (21.9%). This corresponds with the recently identified pre-Neolithic I haplogroup and its subclade I1b* (I2a2 –M423 after *Underhill et al. 2005*) with a frequency distribution that reaches a maximum in the western Balkans, the Adriatic (52%–64%), and the central Balkans (<70%). Haplogroup I is the only haplogroup almost entirely restricted to the European continent. It appeared in Europe, probably before the Last Glacial Maximum, with frequency peaks of reached in two distinct regions – in the Nordic populations of Scandinavia, and in the Balkan populations of Southern Europe. Subhaplogroup I1b* expanded from a refuge in southeast Europe before the Neolithic, and a gene flow from the Balkans to Anatolia has also been suggested (*Semino et al. 2000; Barač et al. 2003; Rootsi et al. 2004; 2006; Cinnioğlu et al. 2004; Peričić et al. 2005; 2006; Battaglia 2009*).

Geneticists suggest that the peopling of Europe was a complex process, and that the view of the spread of the Neolithic in Europe as a result of a single, unique and homogeneous process is too simplistic. The paternal heritage of Southeastern Europe reveals that the region was both an important source and recipient of continuous gene flow. In addition, the low frequency and variance associated with I (M423) and E (V13) in Anatolia and the Middle East support the European Mesolithic origin of these two clades. The Neolithic and post Neolithic component in the gene pool is most clearly marked by the presence of the J (M241) lineage and its expansion signals associated with Balkan micro-satellite variation. Its frequency in south-east European populations ranges from 2% to 20%. The remaining genetic variations are associated with pre-Neolithic hunter-gatherer haplogroups E, I, and R.

Pottery distribution gradients

Since Childe (*1929; 1939*) introduced a ceramics diffusion gradient from the Middle East to Europe, pottery has remained a multifunctional, chronological, cultural and ethnic vector in interpretations of the

European Neolithic. Parallel to the gradual spread of pottery from the Near East to Europe – whether based on 'typological comparability and comparative stratigraphy' (*Milojčić 1949; Parzinger 1993*) or standard ^{14}C dating (*Breunig 1987*) – cultural and ethnic distinctions were suggested. While red and white painted pottery was believed to indicate an Anatolian population and culture, coarse pottery was perceived as something so local to the Balkans that "*we do not believe that this primitive pottery was introduced from Asia Minor*" (*Theocharis 1967. 173; cfr. Thissen 2000.163*).

Pottery assemblages with 'impresso' decoration made with the fingernail and shell impressions, or by pinching clay between finger and thumb, and 'barbotine' pottery with the application of a slip in the form of thick patches or trails that comprise the most popular types of pottery in the Balkans were explained simply as showing 'a clear regression in pottery production' (*Milojčić 1960.32*). In Thessaly, this pottery was linked to an interruption in the 'painted ware tradition' (*Nandris 1970.200*). Milojčić, von Zumbusch and Milojčić (*1971.34, 151*) have suggested the interruption was associated with 'barbarian local production' brought into the region by a migrating population from the 'north', and marked by 'burnt layers' and settlement destruction in northern Thessaly at the end of the Early Neolithic.

Meanwhile, it was suggested that white painted pottery marked 'a breakthrough' by Anatolian 'ethnic components' and Early Neolithic culture from Thessaly to the Northern Balkans and the Carpathian Basin (*Garašanin 1979; Pavlu 1989; Garašanin & Radovanović 2001.121–122*). A similar migratory event was hypothesised in a 'leapfrog' or 'salutatory' demographic model that suggests migrations from one suitable environment to another. Van Andel and Runnels (*1995*) hypothesised that Anatolian farmers had moved towards the Danube and Carpathian basin after reaching demographic saturation in Thessaly, which they had settled first. The Larissa plain in Thessaly was believed to be the only region in the southern Balkans that provided a reasonably assured and large enough harvest for the significant population growth that led to the next migratory move north. It was calculated that farmers needed 1500 years to reach saturation point and to migrate to the northern Balkans.

The interpretative paradigm constructed around the dichotomy 'civilized/barbarian' continued to be highly significant in the context of academic controversy over the Neolithisation process in southeast Europe. It was embedded in both interpretative models – the 'Balkan-Anatolian cultural complex' and the 'frontier model' – determining differences between European and Oriental materiality and potential, and postulating a frontier between indigenous Mesolithic societies and the incoming farmers from surrounding areas. Both models maintain a perception of an allochthonous Anatolian population in association with a well-developed farming economy and pottery technology, and an autochthonous Balkan population able to produce only simple and coarse pottery that selectively adopts crop production and animal husbandry (*Benac, Garašanin, Srejović 1979; Todorova 1998.; Garašanin & Radovanović 2001; Perić 2002; Tringham 2000; Zvelebil and Lillie 2000; Lichardus-Itten and Lichardus 2003; Borić and Miracle 2004; Sanev 2004; Boroneanț and Dinu 2006*).

The distributions of material items, such as female figurines, sometimes exaggerated in form, stamp seals, anthropomorphic, zoomorphic and polypod vessels, which indeed connect south-east Europe and west Anatolia, continue to support the perception of migrating farmers and the gradual distribution of the Near Eastern Neolithic package (*Lichter 2005; Özdoğan 2008*). We cannot ignore, however, different regional patterns in the use of cereals within these areas. Cyprus is believed to relate culturally to the Levant, but their archaeobotanical assemblages have much less in common. The differences between the varieties of Neolithic wheat compositions recovered on mainland Greece and those on Crete are well known. The Karanovo, Starčevo and Körös cultures in the Balkans and the southern Carpathian Basin are recognized as forming a homogenous Neolithic cultural complex, but the composition of the plant suites found in the Balkan regions could hardly be more different (*Perlès 2001.62; Colledge et al. 2004; Kreuz et al. 2005; Coward et al. 2008*).

It is worth remembering that the beginning of the Neolithic in Southeastern Europe was marked neither by ceramic female figurine nor painted pottery dispersal. When the figurines appeared in the Balkans, they remained highly schematised, sometimes to the extent that their identification as anthropomorphic is debatable (*Vajsov 1998; Perlès 2001*; for a general overview, see *Hansen 2007*).

Unpainted vessels were clearly the first to appear in Europe. Since coloured ornaments were attached to the pots in northern Balkans and Carpathians at approximately 6000 calBC at 1σ, a dichotomy of colour and motif perception in the European Early Neolithic becomes evident. Red and brown geometric and floral motifs were limited to the Peloponnese and the southern Balkans; white painted dots and spiral motifs were distributed across the northern and eastern Balkans and southern Carpathians. None of them appeared in the Early Neolithic on the eastern Adriatic (*Schubert 1999; 2005; Müller 1994; Budja 2001*).

We mentioned above that the standard ^{14}C dating model postulates a gradual spread of farmers and pottery, and suggests an interval of a millennium between the initial pottery distributions in the Aegean and Danube regions, respectively. A similar time span vector has been integrated into the demographic model of the Neolithic transition and population dynamics (*Pinhasi et al. 2005*).

The earliest pottery in Thessaly is chronologically contextualized within a 1σ range of 6500–6200 calBC, with a high peak at about 6400, and one slightly less high at *c.* 6200 calBC. In general terms, the Early Neolithic (EN I) settlements and associated pottery assemblages with monochrome pottery, and 'a very limited use of painting' at Argissa, Sesklo, Achilleion and Nea Nikemedeia, were founded at about 6400–6300 calBC (*Perlès 2001; Thissen 2005; 2009; Reingruber and Thissen 2009*).

As already pointed out by several authors, there is now abundant evidence from AMS ^{14}C dating to show that pottery distribution in the northern Balkans and south-western Carpathian basin can be traced from *c.* 6200 calBC at the latest (*Whittle et al. 2002; Tasić 2003; Borić and Miracle 2004; Biagi and Spataro 2005; Biagi et al. 2005; Reingruber and Thissen 2005; Bonsall 2008; Luca et al. 2008; Luca, Suciu 2008; Borić and Dimitrijević 2009; Thissen 2009*). The earliest pottery assemblages from the northern Balkans "*... differ in important aspects from these NW Anatolian potteries, and foremost in their categorical structure, as well as in essential details, signifying differences in manipulation and positioning of the vessels. NW Anatolian features such as flat bases and two differing handle sets do not occur in the Danube sites, nor are the large dishes with roughened exteriors, so typical for the SE European sites, part of the Anatolian repertoire...*" (*Thissen 2009.10*).

Pottery from Lepenski Vir and Padina in the northern Balkans was contextualized within trapezoidal structures having lime-plastered floors, while some were associated with pairs of stone sculptures and neonatal and infant burials. The context is traditionally interpreted as Late Mesolithic, and associated with hunter-gatherers' symbolic behavioural and funeral practices. Recently, it was recognized as Early Neolithic (*Borić and Dimitrijević 2009*). The trapezoidal structures 4, 24 and 36, and at Lepenski Vir, and 17 at Padina are dated within 6213–6093 (6226–6068), 6213–6092 (6231–6060), 6394–6072 (6411–6022) and 6228–6099 (6353- 6054) calBC at 68,2% (95,4%) probability (Tabs. 1 and 2).

At Grivac, a well stratified Early Neolithic settlement in central Serbia, the monochrome pottery was contextualized in a pit dwelling dated to 6219–6031 (6368–5979) calBC at 68,2% (95,4%) probability.

An even earlier context, with monochrome pottery ranging from 6441–5989 (6462–5923) calBC at 68,2% (95,4%) probability, is the well known Poljanica-Platoto Early Neolithic settlement in north-eastern Bulgaria. The pottery assemblages consist of 'monochrome' and impressed pottery. The pottery is associated with 'typical trapezes' and only two (einkorn and lentil) of the ten crop species cultivated in Neolithic Bulgaria (*Todorova 1989.11–12; 2003; Kreuz et al. 2005.243; Weninger et al. 2006.415*).

In a contemporary context at Poljna (Blagotin) settlement in the West Morava valley in Serbia, pottery analysis shows that 91% of the total quantity of ceramics is undecorated. Of the remaining 9% of the decorated pottery, the impressed ware is predominant, at 43% of all decorated pieces. Barbotine ornaments comprise 5%, and painted pottery, 0.2% (*Vuković 2004*). The assemblage is chronologically embedded in time span 6400–6030 (6430–6018) calBC at 68,2% (95,4%) probability. The dates relate to ritual contexts, marked by a red deer skull deposited in the pit, and to a new born infant skeleton buried in an ashy layer within the same building context (*Nikolić and Zečević 2001.6; Whittle et al. 2002.66*).

The later pottery assemblage at Lepenski Vir continues to be associated with funeral practices and symbolic behaviour. A globular vessel with a pair of plastic spirals on opposite sides was deposited in the 'ash-place' in a centrally positioned trapezoidal built structure No. 54 (*Garašanin and Radovanović 2001. 119*). It was associated with newborn and infant burials at the rear of the structure, the secondary burial of the mandible of a mature woman within the rectangular hearth, with a mortar and a pair of coloured stone sculptures behind it. The context is dated to 6015–5811 (6085–5720) calBC at 68,2% (95,4%) probability.

Within this chronological horizon, white painted pottery was embedded for the first time in settlement contexts at Divostin (6090–5809 [6241–5713]) in the northern Balkans, at Donja Branjevina (6062–5635 [6100–5571]) and Magareći Mlin (6060–5926 [6203–5880]) in the southern Pannonain Plain, and at Gura Baciului in the Southern Carpathians (6054–5988 [6084–5911]) calBC at 68,2% [95,4%] probabi-

Lab code	Context	Conventional radiocarbon age (BP)	Cal BC age range 68,2% probability	Cal BC age range 95,4% probability	Summed probability distributions cal BC	Pottery	
	Poljanica-Platoto				*68.2% probability* 6441 (14.2%) 6372 BC 6251 (53.2%) 5989 BC *95.4% probability* 6462 (92.9%) 5979 BC	'monochrome'	*Weninger et al. 2006. Tab. 11.*
Bln-1571	horizon I, Qu. 49	7535±60	6461-6274	6476-6248			
Bln-1613	horizon I, Qu. 153	7380±60	6371-6123	6392-6093			
Bln-1613A	horizon I, Qu. 153	7275±60	6213-6076	6242-6019			
Bln-1521	horizon I, Qu. 153	7140±60	6066-5927	6205-5889			
	Lepenski Vir				*68.2% probability* 6349 (9.5%) 6311 BC 6262 (58.7%) 6072 BC *95.4% probability* 6411 (95.4%) 6022 BC	'monochrome'	*Tissen 2009. Tab. 4.*
Bln-740a	trapezoidal structure 36,	7310±100	6331-6059	6392-6011			
Bln-740b	floor	7360±100	6366-6101	6428-6054			
OxA-16084	**Lepenski Vir** trapezoidal structure 4, floor	7285±37	6213-6093	6226-6068	*68.2% probability* 6213 (53.3%) 6133 BC 6117 (14.9%) 6093 BC *95.4% probability* 6226 (95.4%) 6068 BC	'monochrome'	*Borić and Dimitrijević 2009. 36. Tab. 1.*
OxAX-2176-18	**Lepenski Vir** trapezoidal structure 24, floor	7285±45	6213-6132	6231-6060	*68.2% probability* 6213 (50.6%) 6132 BC 6121 (17.6%) 6091 BC *95.4% probability* 6231 (95.4%) 6060 BC	'monochrome'	*Borić and Dimitrijević 2009. 35. Tab. 1.*
	Lepenski Vir				*68.2% probability* 6230 (38.7%) 6008 BC 5986 (29.5%) 5893 BC *95.4% probability* 6380 (95.4%) 5746 BC	'monochrome'	*Garašanin and Radovanović 2001. 119.*
Bln–653	trapezoidal structure 54	7040±100	6015-5811	6085-5720			
Z–143	hearth	7300±124	6339-6031	6427-5930			
KN–407	hearth	7280±160	6354-6006	6452-5846			
Bln–738	hearth	7225±100	6212-6016	6355-5899			
Z–115	hearth	6984±94	5981-5771	6031-5676			
OxA-11103	**Padina** trapezoidal structure 17, hearth	7315±55	6228-6099	6353-6054	*68.2% probability* 6228 (68.2%) 6099 BC *95.4% probability* 6353 (4.6%) 6309 BC 6265 (90.8%) 6054 BC	'monochrome'	*Borić and Miracle 2004. Tab. 4.*
Bln-869	**Grivac** pit dwelling I	7250±100	6219-6031	6368-5924	*68.2% probability* 6219 (68.2%) 6031 BC *95.4% probability* 6368 (93.8%) 5979 BC	'monochrome'	*Bogdanović 2004. 497.*
	Poljna (Blagotin)				*68.2% probability* 6090 (68.2%) 5809 BC *95.4% probability* 6246 (95.4%) 5713 BC	'monochrome' 'white' and 'red' painted	*Whittle et al. 2002. 113. Fig. 9.*
OxA-8608	dwelling 7, pit	7480±55	6421-6262	6437-6239			
OxA-8609	dwelling 7, burial	7270±50	6212-6074	6231-6032			
OxA-8760	dwelling 7	7230±50	6206-6028	6205-5889			
	Donja Branjevina				*68.2% probability* 6062 (22.1%) 5974 BC 5951 (7.0%) 5917 BC 5798 (39.1%) 5635 BC *95.4% probability* 6100 (94.9%) 5616 BC	'monochrome' 'white' and 'red' painted	*Whittle et al. 2002. 114. Fig. 9.; Tasić 203.184; Karmanski 2005. 71.*
GrN–15974	trench V/86-87, pit dwellig, hearth	7155±50	6062-5992	6204-5911			
GrN–15976	trench V/86-87, outside pit dwelling	7140±90	6089-5901	6221-5841			
GrN–15975	trench V/86-87, outside pit dwelling	6955±50	5891-5767	5978-5732			
OxA–8557	trench II/87, under house remains	7080±55	6014-5902	6055-5845			
OxA–8556	trench II/87, under house remains	6775±60	5717-5636	5778-5563			
OxA–8555	trench II/87, hearth	6845±55	5775-5666	5843-5636			
GrN–24609	trench XXX/96, pit 7	6810±80	5762-5630	5883-5564			
GrN–15973	**Magareći Mlin** house no.3, hearth	7130±60	6060-5926	6203-5880	*68.2% probability* 6060 (58.5%) 5981 BC *95.4% probability* 6105 (93.8%) 5880 BC	'white painted'	*Tasić 203.184h*
	Divostin				*68.2% probability* 6090 (68.2%) 5809 BC *95.4% probability* 6246 (95.4%) 5713 BC	'white painted'	*Tissen 2009. Table 4; Tasić 203.183.*
Bln–823	feature 15(earth-cabin 5)	7080±180	6096-5743	6355-5637			
Bln–866	house 14, beneath floor	7060±100	6031-5838	6202-5726			
Bln–866a	house 14, beneath floor	7200±100	6211-5992	6343-5849			
Bln–931	house 14, beneath floor	7050±100	6021-5814	6098-5721			
GrA–24137	**Gura Baciului** pit dwelling B1BG	7140±45	6054-5988	6084-5911	*68.2% probability* 6054 (68.2%) 5988 BC *95.4% probability* 6084 (84.2%) 5971 BC 5954 (11.2%) 5911 BC	'white painted'	*Biagi et al. 2005. 46-47; Luca and Sicu 2008.44.*
GrN-28114	**Seusa** dwelling L1, stone floor foundation	7070±60	6009-5897	6061-5811	*68.2% probability* 6009 (68.2%) 5897 BC *95.4% probability* 6061 (94.2%) 5836 BC	'white painted'	*Biagi et al. 2005. 49; Luca and Sicu 2008.44.*
	Petriş-Miercurea Sibiului				*68.2% probability* 5984 (63.4%) 5876 BC *95.4% probability* 6020 (95.4%) 5778 BC	'white painted'	*Luca et al. 2008. 328, Fig. 19.*
GrN-28520	pit dwelling B10	7050±70	6006-5849	6052-5775			
Poz-24697	pit dwelling B17	7030±50	5986-5879	6011-5795			
GrN29954	pit G26	7010±40	5978-5846	5990-5794			
OxA–9336	**Pitvaros** pit 3/B	7060±45	5994-5901	6019-5845	*68.2% probability* 5994 (68.2%) 5901 BC *95.4% probability* 6019 (95.4%) 5845 BC	'white painted'	*Whittle et al. 2002: 115. Fig. 9.*

Tab. 1. All available ^{14}C-ages for the initial Neolithic in the northern and north-eastern Balkans, the southern Pannonian Plain, and Carpathians. All calculations are carried out with OxCal v4.1.3 (*Bronk Ramsey 2009*).

lity. This age range set is followed by later ranges at Seusa (6009–5897 [6061–5811]) and Petriş-Miercurea Sibiului (5984–5848 [6020–5778]) in Transylvania, and Pitvaros in the Tisza River catchment (5994–5901 [6019–5845]) calBC at 68,2% [95,4%] probability (Tab. 1 and Tab. 2).

Fig. 3. Early Neolithic pottery from Anzabegovo (Anza) and Donja Branjevina.

The appearance of white painted pottery in the northern Balkans and the southern Pannonian Plain chronologically corresponds with its appearance at Anzabegovo (Anza) in Macedonia in the southern Balkans. The ^{14}C series embedded the Anzabegovo assemblage within 6097–5561 (6453–5322) calBC at 68,2% (95,4%) probability. We have already mentioned that the white-painted motifs differ significantly between these regions. While white floral motifs and stepped triangles comprise the main ornamental motifs in the south, patterns of white dots and grids predominate in the north (see *Schubert 1999; 2005; Budja 2001*) (Fig. 3).

It is worth remembering that there is no evidence of painted ware on the Eastern Adriatic before 5539–5480 calBC. However, the dates of the earliest pottery production in northern Ionia (Sidari) sum at 6641–6119 (6801–5897) calBC at 68,2% (95,4%) probability. In the Eastern Adriatic catchment, the dates range between 6228–5811 (6391–5716) in Vela Spila, 6076–5741 (6208–5728) in Gudnja Cave, 6004–5232 (6203–4844) at Tinj, 5988–5808 (6046–5726) in Gospodska pećina, 5987–5847 (6017–5772) in Grapčeva spila and at Vižula 5877–4960 (6050–4851) calBC at 68,2% (95,4%) probability (calculated with OxCal v4.1.3; for data set see *Forenbaher and Miracle 2006.Tab. 13.2 and 13.3*). The ornamental system is based exclusively on incised, impressed and cardium-impressed ornaments. The old question of why painted pottery and female figurines were not distributed throughout the eastern Adriatic catchment in the Early Neolithic remains to be answered.

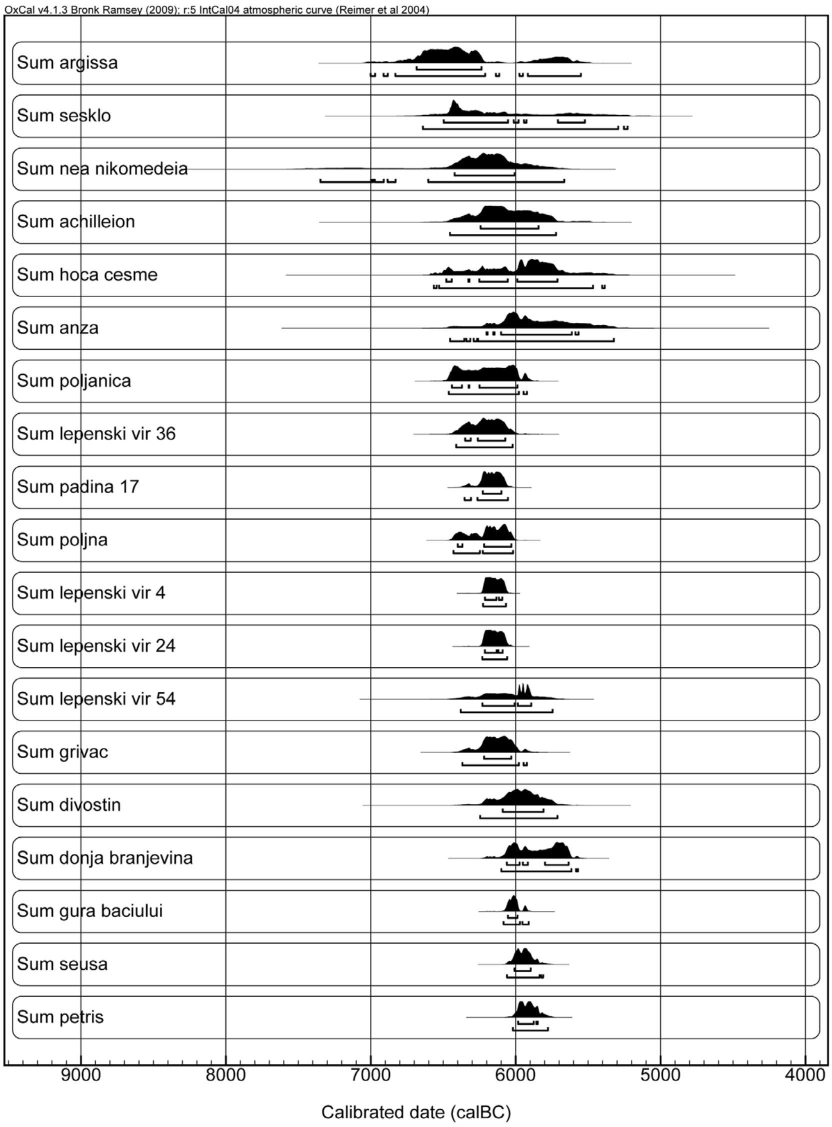
The ^{14}C gradient of pottery dispersal suggests that the sites in the southern Balkans are not significantly older than those in the northern and eastern Balkans (Tabs. 1 and 2). A gradual demic diffusion model from south to north and a millennium time span vector thus find no confirmation in the set of AMS ^{14}C dates and associated contexts that mark pottery dispersal within Southeastern Europe (Fig. 4). We may postulate a widespread, contemporary adoption and adaptation of pottery manufacturing techniques by local populations which not necessarily coincide with the adoption of farming. In this context, we have to examine the various ornamental patterns and techniques and colour application as much as the above-mentioned heterogeneity of Early Neolithic wheat and plant compositions within the region.

Concluding remarks

A critical reflection on the demic diffusion model and hypothesised population replacement during the initial European Neolithic in population genetics and archaeology shows that two basic assumptions – the continuously moving boundary between savagery and civilization and population replacement at the onset of the Neolithic – remain speculative. The hypothesis of gradual pottery distribution and the suggested time span vector believed to mark migration and acculturation – the absorption of hunter-gather groups by farmers in an interaction which took place through culture contact and emulation between two groups – are unrealistic.

Geneticists suggest that the peopling of Europe is a complex process and that the view of the spread of the Neolithic in Europe being the result of a unique and homogeneous process is too simplistic. Y-chromosomal paternal lineages reveal the signatures of several demographic population expansions within Europe, and between Europe and western Asia in both directions. This continuous gene flow and demographic expansion have been calculated for the Mesolithic, Neolithic and Chalcolithic periods, and seem to be more visible in the frequency of Y-chromosome markers in modern populations in the Balkans and Mediterranean than in other regions.

Recent phylogenetic analyses of ancient maternally inherited mitochondrial DNA have yielded contradictory results. Thus the phylogeographic analysis of the Iberian Peninsula suggests a long period of genetic continuity between the Neolithic population and modern populations in Spain, but not with the Middle East group (*Sampietro et al. 2007*). The comparison of the ancient mitochondrial DNA sequences from late hunter-gatherer skeletons with those from Neolithic farmers and with modern populations in Central and North Europe show that modern European sample are 'significantly different from the early farmer and from the hunter-gatherer' (*Bramanti et al. 2009.2*). The characteristic mtDNA type N1a with a frequency distribution of 25% among Neolithic LBK farmers in Central Europe shows in contrast low frequency of 0.2% in modern mtDNA samples in the same area (*Haak et al. 2005*). The N1a type was not observed in hunter-gatherer samples from western and northern Europe and this led Bramanti *et al.* (*2009.3*) to reject a direct continuity between hunter-gatherers and early farmers, and between hunter gatherers and modern Europeans, but assume 'continuity between early farmers and modern Europeans'. The assumption is supported by coalescent simulations which were performed to test if the genetic differences between the population samples could be explained by the null-hypothesis of genetic drift over time in a continuous population. They suggest a 'substantial influx of people' from the Pannonian Plain in Central and North Europe who did not mix significantly with the resident female hunter-gatherers. Shennan and Edinborough proposed, however, an alternative scenario in which the lost of N1a type relates to 'a population crash of enormous magnitude' after 5000 BC. They recognized the latter in a marked decrease in occupation intensity at the end of the LBK by applying the analysis of summed probability distributions of radiocarbon dates of settlement contexts in the region (*Shennan and Edinborough 2007; Shennan 2007*).



Tab. 2. Sum probability distributions plot of initial Neolithic pottery distribution based on available ^{14}C- data from Argissa, Sesklo, Nea Nikomedeia, Achilleion, Anzabegovov (Anza) and Hoca Çeşme (**Reingruber and Thissen 2005*****); Poljanica (*****Weninger et al. 2006.Tab. 11*****), Lepenski Vir, Padina, Poljna, Divostin, Donja Branjevina, Magareći Mlin and Pitvaros (*****Borić and Dimitrijević 2009.Tab. 1; Tissen 2009.Tab. 4; Whittle et al. 2002. 115, Fig. 9*****); Grivac (*****Bogdanović 2004.497*****); Gura Baciului, Seusa and Petriş (*****Biagi et al. 2005.46–47; Luca and Sicu 2008.44; Luca et al. 2008.328, Fig. 19*****). All calculations are carried out with OxCal v4.1.3 (*****Bronk Ramsey 2009; Reimer et al. 2004*****).***

Initial pottery distribution in southeast Europe shows the wide-spread and contemporary appearance of pottery making techniques. The various structures, ornamental patterns and differences in colour application reflect Balkan cultural complexity and local knowledge and not the hypothesized axial transfer of the Near Eastern artefact and nutrition package along the gradual Neolithic frontier displacements across the Balkans. This pottery predates artefact assemblage consist-

Fig. 4. Frequency distributions of the Mesolithic and Neolithic Y-chromosome haplogroups I (M423), E (V13) and J (M241) (after* Battaglia et al. 2009.Fig. 4*), and the sites with pottery assemblages and ^{14}C ranges and sum probability distributions listed on Table 1 and Table 2.

ing of female figurines, stamp seals, anthropomorphic and zoomorphic vessels, and polypod vessels and tripods, with distribution in both regions, the Balkans and Anatolia, and was traditionally assumed to be associated with either demic diffusion or the leap-frog colonization of Europe. It is worth remembering that neither this assemblage nor painted pottery was distributed in the Dinaric region or the eastern Adriatic coast.

We suggest that interpretations of the transformation process and transition to farming cannot be marginalized neither to contacts in frontier zones nor to the gradual axial dispersal of Early Neolithic material culture and Y-chromosome markers and associated paternal lineages from western Asia to Southeastern Europe. The paternal heritage of Southeastern Europe reveals continuous Mesolithic, Neolithic and post-Neolithic gene flows within southeastern Europe, and between Europe and the Near East in both directions. The ^{14}C gradient of pottery dispersal suggests that the sites in the southern Balkans are not significantly older than those in the northern and eastern Balkans. The earliest pottery assemblages differ morphologically and ornamentally between the Anatolia and the Balkans and between southern and northern Balkan regions. The first 'demic event' that was hypothesised to reshape significantly European population structure and generate a uniform process of neolithisation of Southestern Europe has no confirmation in frequency of Y-chromosome subhaplogroups J2b and E3b1 distribution and in initial Neolithic pottery dispersal.

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Demographic model of the Neolithic transition in Central Europe

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ABSTRACT – *Several recent lines of evidence indicate more intensive contact between LBK farmers and indigenous foragers in Central Europe (5600–5400 calBC). Strong continuity has been identified between Mesolithic and Neolithic material cultures; faunal assemblages, and isotopic analyses of diet have revealed a greater role of hunting in LBK communities; genetic analyses have suggested that the modern Central European gene pool is mainly of Palaeolithic origin. Surprisingly little attention has been paid to demographic aspects of the Neolithic transition. In our study, demographic simulations were performed to assess the demographic conditions that would allow LBK farmers to spread across central Europe without any admixture with Mesolithic foragers. We constructed a stochastic demographic model of changes in farming population size. Model parameters were constrained by data from human demography, archaeology, and human ecology. Our results indicate that the establishment of farming communities in Central Europe without an admixture with foragers was highly improbable. The demographic conditions necessary for colonization were beyond the potential of the Neolithic population. Our study supports the integrationists' view of the Neolithic transition in Central Europe.*

IZVLEČEK – *Več novih dokaznih linij kaže na intenzivnejše stike med LKB poljedelci in prvotnimi nabiralci v srednji Evropi (5700–5500 calBC). Dognana je bila možna kontinuiteta med mezolitskimi in neolitskimi materialnimi kulturami; favnistični zbiri in izotopske analize prehrane kažejo večjo vlogo lova v LBK skupnostih; genetske analize kažejo, da je moderni srednje evropski genetski fond pretežno paleolitskega izvora. Presenetljivo malo pozornosti je bilo posvečene demografskim aspektom neolitizacije. V naši študiji uporabljamo demografske simulacije, da bi ocenili demografske pogoje, ki bi omočili LKB poljedelcem širitev preko srednje Evrope brez kakršnegakoli mešanja z mezolitskimi nabiralci. Oblikovali smo stohastični demografski model sprememb v velikosti poljedelske populacije. Parametri modela so bili izvedeni iz podatkov o humani demografiji, arheologiji in humani ekologiji. Naši rezultati kažejo, da je bila ustanovitev poljedelskih skupnosti brez mešanja z nabiralci malo verjetna. Demografski pogoji potrebni za kolonizacijo so presegali potencial neolitske populacije. Naša študija podpira integracionistični pogled na neolitizacijo v srednji Evropi.*

KEY WORDS – *demographic simulations; Neolithic transition; Central Europe; colonization; fertility; population growth*

Introduction

The pattern of the introduction of domesticated plants and animals into Europe has been a subject of major interest for more than one hundred years (*Gronenborn 2007*). Although it is generally accepted that farming spread into Europe from the Near East, disagreements prevail about the relative contribution of Near Eastern farmers and indigenous foragers to the establishment of farming communities. Three alternative explanations of the spread of agriculture across Europe have been proposed, which were summarized by Zvelebil (*2000*) as the migrationist, indigenist, and integrationist positions. Migrationists favor the spread of farmers, with the genetic replacement of Mesolithic foragers; indigenists prefer the spread of farming with no genetic contribution from the Near East; and integrationists emphasize both people and ideas, and presume a genetic admixture of foragers and farmers.

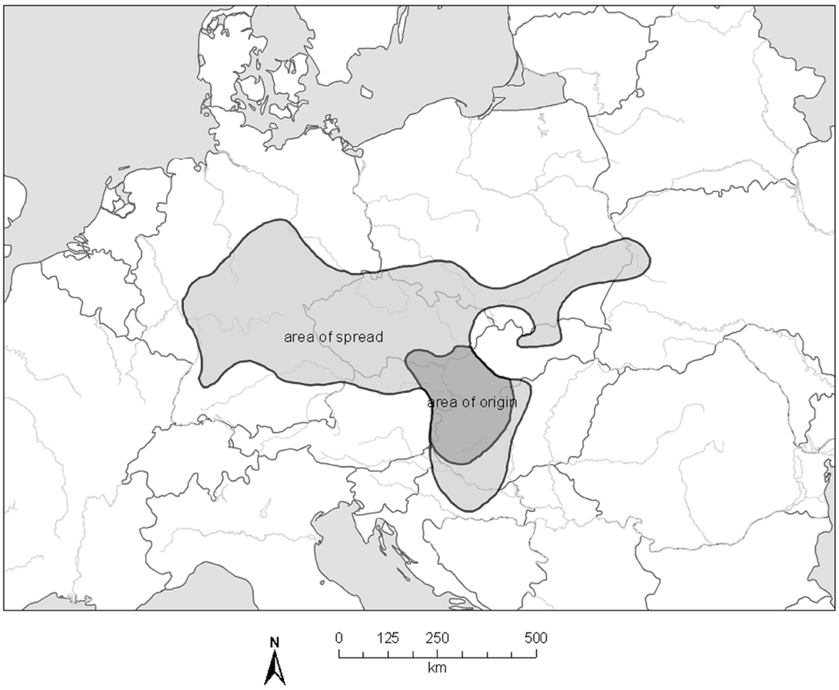

Fig. 1. Map of the LBK origin area in Western Hungary (dark grey) and the area settled after the Earliest LBK expansion over Central Europe from 5600 to 5400 calBC (light grey). Adapted from Zvelebil (*2001.Fig. 2*).

Recently, it has become clear that the spread of agriculture across Europe cannot be modeled monocausally. The spread involved a variety of mechanisms that were shaped by regional conditions. On the one hand, local Mesolithic groups played a significant role in the spread of agriculture throughout much of Northern Europe, the Alps, the Atlantic fringe of France and Central Iberia. On the other hand, the Eastern Mediterranean and South-Eastern Europe are regions that probably experienced farmer migration (*Zvelebil 2000; Robb and Miracle 2007*). Similarly, the spread of farming across Central Europe has traditionally been accepted as an example of agricultural colonization by farmers of Linear Pottery Culture (LBK) (*Childe 1925; Piggott 1965; Vencl 1986; Lüning 1988; Price et al. 1995; Bogucki 2001; Neustupný 2004*). It is believed, that LBK farmers spread within 4–6 generations from its origin in Western Hungary over the broad area extending from Western Ukraine to the Rhine River in Germany (Fig. 1). Recently, the migrationist view that the LBK spread across Central Europe has been challenged and, today, the integrationist view is accepted by the majority of scholars from continental Europe concerned with the Central Early Neolithic (*Gronenborn 2007*).

The integrationist position is supported by a number of indicators of contact between foragers and farmers. Typological and technological analyses of lithic assemblages show a continuity in stone tool production from the Mesolithic to the Earliest LBK (*Gronenborn 1998; Kind 1998*). Some Earliest LBK sites yield relatively high amounts of game, which might be interpreted as an interaction between Earliest LBK and Mesolithic groups (*Gronenborn 1999*). Also, stable isotope analyses of LBK skeletons from Southern German have demonstrated relatively high stable nitrogen ratio values, traditionally interpreted as a reliance on animal protein (*Dürrwächter et al. 2006*). Several authors have suggested that late Mesolithic foragers practiced some kind of small-scale farming (*Erny-Rodmann et al. 1997; Tinner et al. 2007*). Strontium isotope analyses of human skeletons from LBK cemeteries in South-Western Germany have revealed a significant amount of non-locals, which would indicate that foragers had joined LBK communities (*Price et al. 2001; Bentley 2007*). Genetic studies of the classical markers, mtDNA, and Y-chromosome, have indicated a significant contribution from Mesolithic foragers to the gene pool of modern Europeans (*Richards 2003*). The admixture view has been strengthened by the direct extraction of mtDNA from skeletons buried at LBK cemeteries in Germany and Austria (*Haak et al. 2005*).

Given the fact that many different disciplines have been involved in explaining the mechanism of Neolithic dispersal, it is surprising how little has been done in the field of demography. Authors have only generally presumed that the prerequisite of the colonization would have been a high rate of population growth (*Crubézy et al. 2002*), and LBK farmers would have had to reproduce at the rate approaching the theoretical maximum for human population. A growth rate of from 2.0% to 3.5% per year has been universally used as the input value in models of population dynamics, such as the wave of advance model (*Ammerman and Cavalli-Sforza 1973*) and its various generalizations (*Fort and Mendéz 1999; Pinhasi et al. 2005; Davison et al. 2006; Davison et al. 2007*).

So far, there have been only a few attempts to estimate the growth and/or fertility rates of the LBK population directly from the archaeological evidence. Neustupný (*1983*) produced abridged life tables from LBK skeleton samples from eastern Germany and estimated the growth rate at 1–2%. A similar value was calculated by Petrasch (*2001*). His analysis was based on the function of exponential growth, and input variables were derived from the distribution of LBK settlements and radiocarbon data. Unfortunately, both estimates are deterministic, and do not account for the uncertainty associated with adopting input parameters from archaeological sources.

In this study, we built a stochastic demographic model that describes the demographic conditions of Neolithic transition in Central Europe. Demographic simulations were performed to directly test the colonization hypothesis. In particular, our question is whether the growth and fertility rates of Earliest LBK population could have been high enough to allow the farmers to colonize Central Europe without mixing with the local Mesolithic foragers.

Demographic model

Our model is a demographic projection of the size of the LBK population during the expansion across Central Europe. To avoid estimations of many parameters, we applied a simple mathematical solution. We modified the basic exponential equation $P_t = P_0 e^{rt}$ (*Newell 1988.182*), where P_0 and P_t are population size at the beginning and end of the expansion; t is the duration of the process in years, and r is the growth rate. The exponential curve is presented in Fig. 2. It may be seen that population size (Y axis) is a function of only two parameters: time (X axis) and growth rate (the slope of the curve).

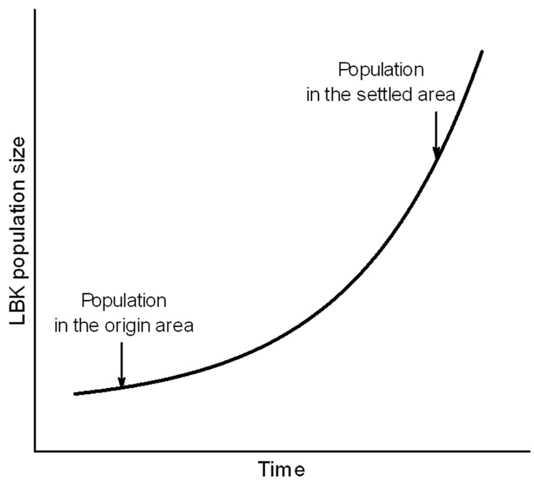

Fig. 2. Exponential growth. The function describes how changes in population size (Y axis) depended on time (X axis). Growth rate is reflected by the steepness of the curve.

We rearranged the basic equation describing exponential growth to obtain the growth rate $r = \ln(P_t/P_0)/t$. Because we were not able to estimate the LBK population size with sufficient accuracy, we replaced it with the product of area size and population density. The last equation was then rewritten as $r = \ln(A_t \cdot d/A_0)/t$, where A_0 and A_t are the size of the origin area and settled area respectively, and d is the ratio of population density at the end to density at the beginning of the expansion ($d = d_t/d_0$).

We then used the estimate of growth rate to measure LBK fertility. Total fertility rate (TFR), which is the number of children born to average woman, was calculated according to the equation: $TFR = e^{r \cdot g}/S \cdot l_g$ (*Hinde 2002.25*), where g is the generation length, l_g is the proportion of females surviving to g years of age, and S is the proportion of females at birth.

Values of input parameters

The values of input and output parameters of the model were obtained from archaeological, ethnographic and demographic sources. The list of input and output parameters along with their values that were entered in the simulations is presented in Table 1. In the following paragraphs we will explain in detail the determination of these values.

The size of the LBK area of origin (A_0) was computed in GIS software from four maps produced by archaeologists (*Kalicz 1993; Petrasch 2001; Zvelebil 2001; Bánffy 2004*). Similarly, the size of the area settled during the expansion (A_t) was derived from five maps of Earliest LBK site distribution (*Lüning et al. 1989; Gronenborn 1998; Bogucki 2000; Jochim 2000; Zvelebil and Lillie 2000*). To avoid regions in high altitudes we consider only part of the landscape up to 350m above sea level. This level was suggested as an upper limit of LBK settlement activity. Only a small proportion of LBK settlements have been discovered above the 350m contour (*Rulf 1983; Květina 2001*). Fig. 3 shows an example of the area restricted by the 350m contour made for a map of the settled area suggested by Zvelebil (*2001*). Similar maps were produced for each of the four maps of the origin area and each of the five maps of the settled area. The final input parameter estimated from archaeological data is the duration of the initial spread of Earliest LBK (*t*). Although the absolute data differ from author to author (5600–5400 calBC, *Gronenborn 1999*; 5400–5200 calBC, *Zvelebil 2004*), most agree that the spread occurred within an interval of 100–200 years.

symbol	description	n	min	max
A_o	Origin area limited by 350 m a.s.l. contour [km²]	4	32.714	51.446
A_t	Settled area limited by 350 m a.s.l. contour [km²]	5	181,978	232.45
t	Time of spread [years]	12	100	200
g	Generation length [years]	8	27.5	27.5
S	Proportion of females at birth	5	0.4878	0.4878
l_g	Proportion of females survived to the g years of age	1	0.24	0.43
d	Density ratio	1	100	100
TFR*	Total fertility rate [children per woman]	11		6.92

n: Number of estimates

Tab. 1. List of the input parameters and the output variable (*) of the demographic model.

The next three input parameters were acquired from demographic sources. The relative proportion of females at birth (*S*) and mean age at childbearing (*g*) have been assumed to be relatively stable among human populations with natural reproduction (*Hinde 2002*). So we were able to find reliable point estimates of both parameters. In all simulations, the proportion of females at birth was set to 0.4878 (100 females per 105 males) and mean age at childbearing to 27.5 years of age. Also, density ratio (*d*) was fixed in basic simulations to the single value of 100%, which means that density was assumed to remain constant during the spread of LBK.

Estimating female mortality was not straightforward. Women's survival to the mean age at childbearing (l_g) was obtained from life tables. We did not rely on the life tables of real prehistoric populations because the skeletal data that the tables stem from were considered unreliable. Instead, we estimated mortality from simulated life tables which we generated using the Brass two-parametric relational system of model life tables (*Brass 1971*). The Brass logit system is based on a generic survival function which is transformed by a logit transformation into a new survival curve. By varying either of two parameters, we generated 1000 model life tables with a life expectancy at birth of between 18 and 25 years, which is assumed to be the mortality level of the prehistoric population (*Gage 2005*). Finally, women's survival to the mean age at childbearing, the input parameter of our model, was obtained from this set of simulated life tables.

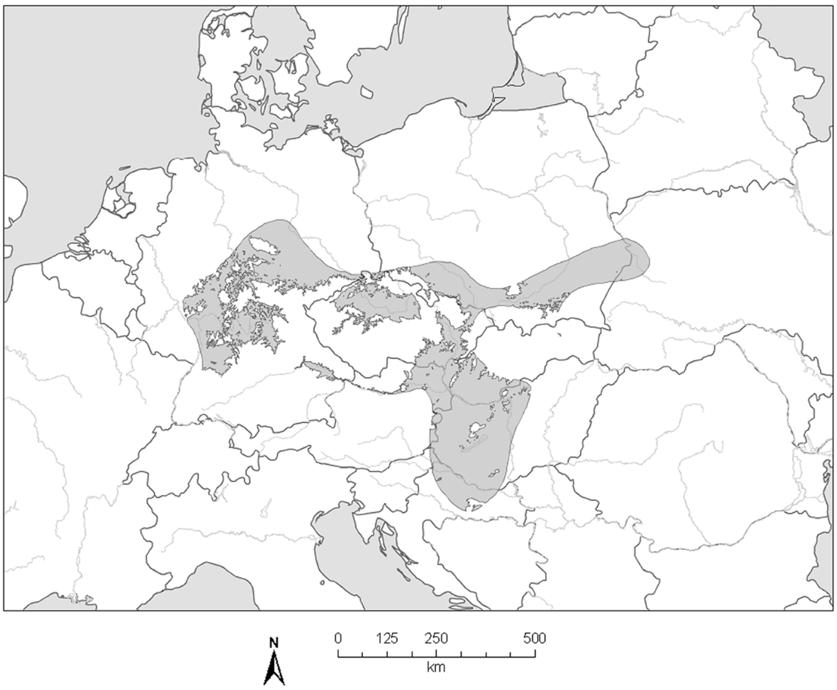

Fig. 3. Map showing the area settled by the Earliest LBK around 5400 calBC up to 350m above sea level. Base map adapted from Zvelebil (2001. Fig. 2).

Output variable and comparative sample of fertility

The only output parameter of our demographic model is a measure of the fertility of the LBK population, namely its total fertility rate (TFR). To assess the level of fertility obtained in simulations, we created the comparative sample of TFR. The comparative sample comprises TFRs of eleven recent populations with natural reproduction. Populations included in the sample are horticulturalists (extensive agriculturalist) who cultivate cereals and are sedentary. These characteristics have traditionally been attributed to the LBK population (*Gregg 1988*), although some authors have assumed that LBK cultivators were familiar with some intensive gardening techniques (*Halstead 1989; Bogaard 2004*).

TFR data were gathered from two studies concerned with the relationship between fertility and subsistence (*Bentley et al. 1993; Sellen and Mace 1997*). The histogram of TFR in the comparative sample is shown in Fig. 4. The distribution of TFR is highly skewed to larger values. Populations with TFR greater than 6 prevail in the sample. The sample maximum is 6.7 children, but to obtain the parametric maximum in the population (population in the statistical sense), we used an unbiased standard bootstrap method of confidence limits calculation (*Manly 2007*). This parametric maximum we entitle here as the critical value of TFR, and its value was calculated at 6.92 children born to the average woman. We assumed that the critical value of TFR represents the upper limit of fertility that could be attained by LBK women during the Neolithic transition.

Randomization step

Table 1 demonstrates that four out of seven input variables are defined in range. Because we did not want to reduce the interval estimates of input parameters only to a point estimate (*e.g.* average value), we inserted a randomization step into the model. The randomization step is a stochastic component of the simulations and is motivated by the complexity associated with the input parameters. The principle of the randomization step is described in Figure 5. First, a single value of each input parameter was drawn at random from the interval shown in Table 1. These values were used to calculate the output variable, *i.e.* TFR. Then, a process of random sampling of input parameters and calculation of output variable was run 10 000 times. In the end, we obtained 10 000 estimates of TFR. Each of the 10 000 iterations of the model represented one possible demographic scenario of the Neolithic transition in Central Europe.

Statistical and graphic analyses (descriptive statistics, multivariate regression, randomization analysis) were performed in MS Excel 2003 (© Microsoft Corporation, 1985–2003) and STATISTICA 6.1 (© StatSoft, 1984–2003). 3D surface charts were made in R software (*Ihaka and Gentleman 1996*), version 2.8.0 (© 2008 The R Foundation for Statistical Computing). Geographical data were analyzed in ArcMap 9.0 (© ESRI, 1999–2004).

Results

The descriptive statistics of 10 000 estimates of TFR and growth rate obtained in the simulations are shown in Table 2. The growth rate of the farming population ranges from 0.64% to 1.96% per year. The estimates of total fertility rates oscillate from around 6 to 13 children per woman. The distribution of TFR is skewed (Fig. 6); lower values (up to 9 children) are more frequent in the simulations than larger values. From both Table 2 and Fig. 6 it is evident that the majority of iterations give an estimate of TFR greater than the critical value of fertility. In fact, only 7.89% of TFR estimates are lower than the

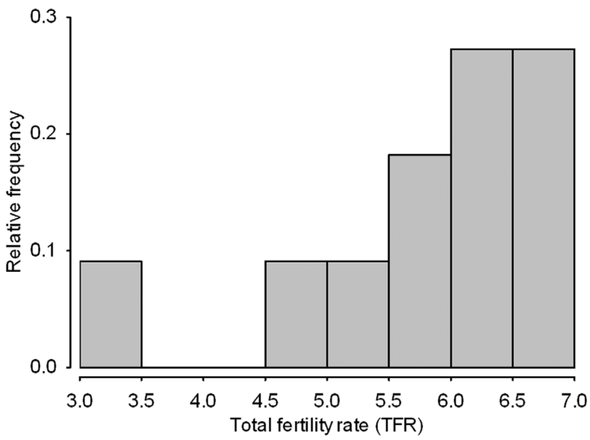

Fig. 4. The distribution of total fertility rate (TFR) in the comparative sample (n = 11 horticulture societies).

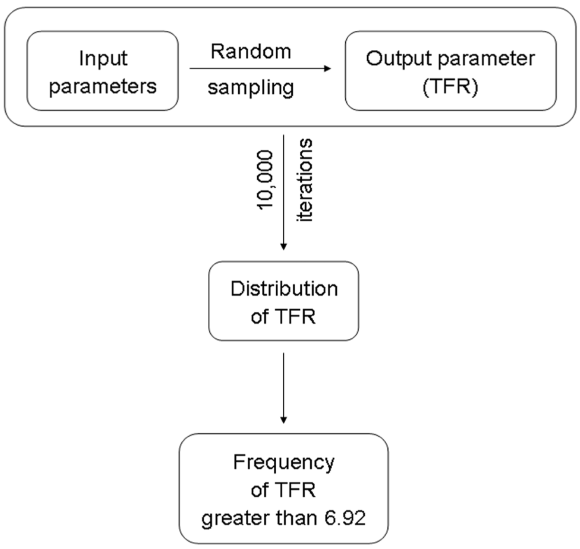

Fig. 5. The principle of the demographic model with a randomization component (see text for the explanation).

critical value of 6.92 children. In other words, around 92% of the demographic scenarios of the Neolithic transition in Central Europe contradict the hypothesis of colonization.

To assess the effect of input parameters, we performed a multiple regression analysis of data obtained in 10 000 iterations. As independent variables, we selected only four input parameters that are defined in range: origin area, settled area, time and survival of females (see Tab. 1). The remaining input parameters were excluded from the regression analysis because they were estimated by single values and have, therefore, the same effect on TFR in each iteration. The analysis of residuals suggested that the regression trend in raw data is non-linear. To achieve linearity, we transformed the raw data by natural logarithm. The results of multivariate regression analysis and basic statistics of ln transformed inputs parameters are given in Table 3. Multivariate regression is highly significant ($P < 10^{-5}$). The high value of the coefficient of determination (0.996) indicates that the regression provides a good fit to the data. In fact, 99.6% of the variability of TFR is explained by the model. The standardized coefficients shown in Table 3 indicate that the greatest effects on TFR came from the duration of spread and the survival of females. On the other hand, variation in the size of the origin and settled area has minimal impact on fertility estimate.

The relationship among total fertility rate and three input parameters in the model is shown in Figure 7. The isolines in contour graphs connect points of equal value of TFR. The ratio of population density in the settled area to population density in the origin area is displayed on the X axis, and the proportion of females surviving to 27.5 years of age on the Y axis. The contour graph on the left shows the duration of LBK initial spread through Central Europe fixed to the value of 100 years, and to 200 years in the graph on the right. Both contour graphs were computed with average size of the origin and settled area. The isoline at 6.92 children represents the critical value of the total fertility rate of horticultural societies. The white parts of the graphs correspond to the fertility estimates that match the colonization hypothesis. The grey segments represent demographic conditions that lead us to reject the colonization hypothesis. For example, the combination of 100% density, 40% survival and duration of 100 years (left contour graph) gives a TFR estimate of almost 8 children.

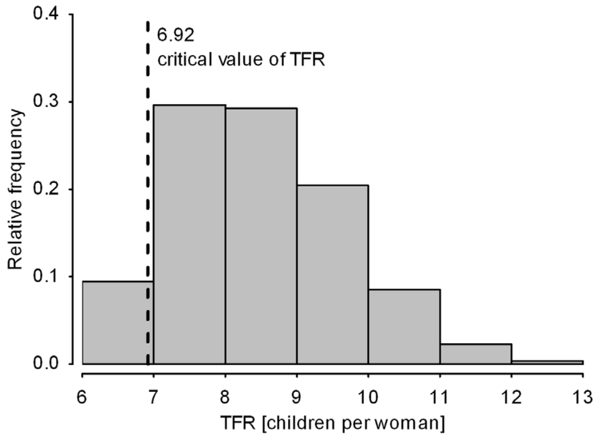

Fig. 6. The distribution of the output variable. Histogram comprises 10 000 estimates of TFR obtained in the simulations. Dashed line indicates the position of the critical value of fertility for horticultural societies (6.92 children, see text for explanation).

	min	max	95% of values	TFR < 6.92 [%]
growth rate [%]	0.64	1.96	0.77–1.58	
TFR	5.93	13.03	6.75–10.60	7.89

Tab. 2. Descriptive statistics of 10 000 estimates of growth rate and total fertility rate obtained in the simulations.

Discussion

In this study, we estimated the level of fertility and growth rate of the LBK population via demographic modelling. The objective was to assess whether such a level of fertility and growth rate could be high enough to allow the LBK farmers to spread across Central Europe within less than 200 years without admixture with indigenous foragers. Although both fertility and mortality levels can be estimated from skeletal remains (*Buikstra et al. 1986; Paine and Harpending 1996; Bocquet-Appel 2002*), the low number of Earliest LBK cemeteries with well preserved human remains and their non-random spatial distribution restrict such attempts. In situations where few empirical data are available, demographic simulations are a powerful tool for answering similar questions (*cf. Steele et al. 1998; Alroy 2001; Surovell 2003*).

In this study, we estimated the growth rate range of the LBK population at 0.64 to 1.96% per year (Tab. 2). Comparison with the estimates proposed by other authors suggests that such values seem to be rather high for the LBK population. Bocquet-Appel (*2002*) has even estimated that the population undergoing Neolithic transition in Europe was

	mean	V [%]	*beta*	SE_{beta}
origin area	10.6	1.2	–0.18	0.0006
settled area	12.2	0.6	0.10	0.0006
time	5.0	4.0	–0.46	0.0006
survival of females	–1.1	10.8	–0.87	0.0006

V: Coefficient of variation
beta: Standardized regression coefficient
SE_{beta}: Standard error of coefficient

Tab. 3. Effect of input parameters to output variable (TFR). Regression analysis computed after ln transformation. Coefficient of determination R^2 = 99.6%.

stationary, *i.e.* with zero growth. Carneiro and Hilse (*1966*) and Barringer (*1966*) have assumed that a reasonable estimate of growth rate in the Neolithic would be as high as 0.12% and 0.25% per year respectively. Hassan and Sengel (*1973*) have estimated that the average annual growth rate during the Neolithic was about 0.1%. They suspected, however, that growth rate would be uniform and it could, in fact, attain values of 0.5–1.0% in a period of rapid population increase. Van Bakel (*1981*) has given a growth rate of 0.4 to 0.7% per annum for the period of Neolithization, and similar values have been suggested by Polgar (*1972*). Bandy (*2001*) has calculated that the Neolithic population of the Basin of Mexico in the Formative period grew at approximately 0.74% per annum, and assumes that such a value is a very high rate for an agricultural population with no access to antibiotics or modern medicine. Neustupný (*1983*) have assumed that a growth rate greater than 1% per annum for the Earliest LBK is highly unlikely. Although some authors have shown that a human population could have grown at a rate of around 3% in the past (*Birdsell 1957*), others have argued that the development of agriculture negatively affected human health, led to poorer nutrition, and that higher population density increased the probability of transmission of infectious disease from livestock to humans (*Gage 2005*).

Similar results were obtained in the analysis of total fertility rate, which is the final parameter of the demographic model. TFR vary approximately from 6 to 13 children (Tab. 2). Slightly more than 92% simulations gave estimates of TFR greater than the maximum level of fertility observed in the horticulture populations (Tab. 2). Thus, it is more likely, that LBK fertility was not high enough to allow farmers to spread over Central Europe without admixture with local foragers. Our demographic simulations thus provide a strong argument against the hypothesis of colonization.

Moreover, in our demographic projection, we assume that LBK population enjoyed the most favorable conditions for population growth, because the exponential function (Fig. 2) describes growth that is unbounded by any factor. However, under more realistic conditions, population growth is limited by the carrying capacity of the environment, and the growth rate gradually decreases to zero. Furthermore, we have presumed that stable and maximum rate of growth was maintained during the entire transition period and in the entire area settled at the time. However, several authors argue that popula-

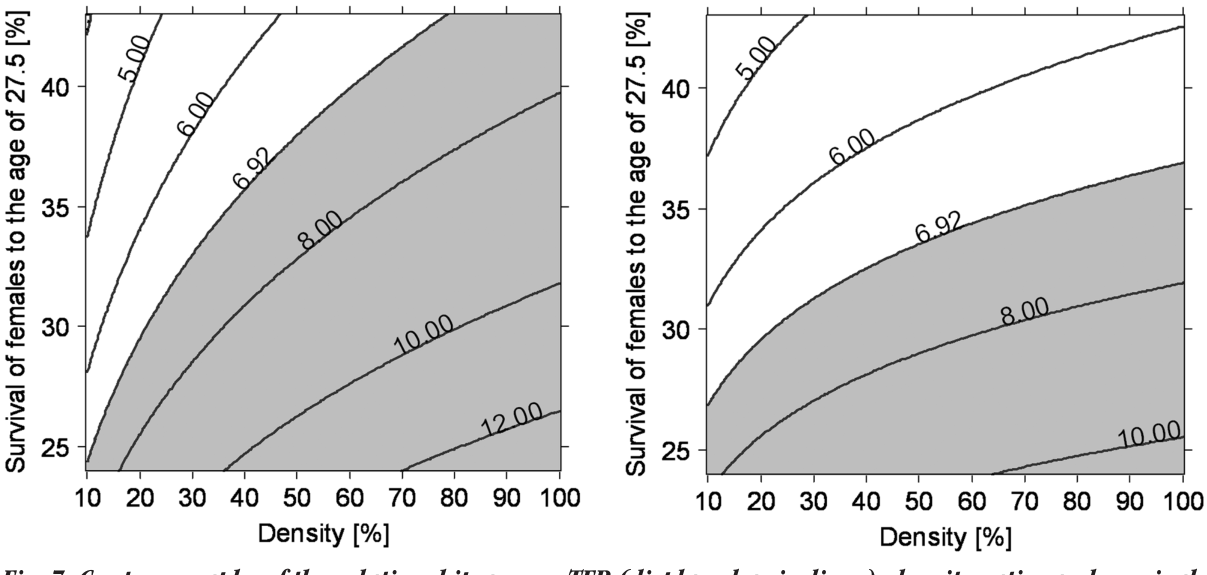

Fig. 7. Contour graphs of the relationship among TFR (displayed as isolines), density ratio, and survival of females for two temporal scenarios of the Earliest LBK expansion. For an explanation of the figures, see text.

tion increase occurred only at the wave front, *i.e.* in the relatively small contact zone between the expanding farmers and indigenous foragers. In the area remaining, which is located behind the front, population growth slows down (*van Andel and Runnels 1995; Pinhasi 2003*). Therefore, the actual level of LBK fertility would have to be greater than we estimated in the simulations. Thus, the colonization hypothesis may be rejected with greater confidence.

The reliability of results of any demographic simulation is directly dependent on the reliability of input parameters. Thus, our motivation was to use only sufficiently reliable parameters. Two of these (generation length and proportion of females at birth) are assumed to be very stable across human populations with natural reproduction (*Hammel 1996*). There is no reason to speculate that they attained different values in the population of LBK farmers. The duration of the spread of LBK has been estimated by numerous independent analyses of radiocarbon data. There is a general agreement among scholars that LBK spread from Transdanubia to the Rhine River during 100–200 years. To achieve satisfactory confidence of the survival of females, we collected a large numbers of estimates (1000) gathered from model life tables with widely ranging mortality levels. On the other hand, the size of the origin and settled area respectively we consider to be the input parameters most prone to bias. Fortunately, the analysis of the effect of the input parameters has revealed (Tab. 3) that the sizes of the origin and settled area have relatively low impact on the results of simulations.

Although the majority of simulations gave unrealistically high estimates of TFR for the LBK population, approximately 8% of them were concordant with the hypothesis of colonization. The demographic conditions of colonization can be inferred from the contour graphs in Figure 7. First, we suppose that population density was maintained at a constant level during the expansion. That is to say, that the population density after LBK expansion was as high as the density in the origin area in Transdanubia. Previously, this assumption would have seemed unlikely, because population pressure was traditionally viewed as the main trigger for the spread of the Neolithic (*Childe 1925*). However, recent authors agree that there is no solid evidence for population pressure in Transdanubia that would encourage the first farmers to migrate (*Willis et al. 1998; Pavúk 2004*), and that even Transdanubia was sparsely populated by people of the Earliest LBK (*Whittle 1996*). Therefore, a density value of 100% might be a reasonable assumption in the simulations. It can be seen in Figure 7 that there are some TFR estimates below the threshold value of 6.92 children at the density level of 100%. However, they can be found only in simulations where the duration of spread was fixed at 200 years (right contour graph), and where approximately 37% or more females survive to the mean age at childbearing. In contrast, if the spread of the LBK took place within 100 years (left contour graph) it may be ruled out that it was the consequence only of the migratory activity of farmers originating in Transdanubia, because all TFR estimates at the 100% density level are greater than the critical value of fertility.

Another important interpretation may be derived from Figure 7. If we want to obtain acceptable estimates of TFR (white parts of contour graphs), we would have to assume that the population density of farmers who spread from Transdanubia decreased during the transition. To maintain the overall population density in the settled area at 100%, a contribution from local foragers to the establishment of farming communities would have been necessary. What the admixture proportion was is a matter of debate. If we assume the modal level of female survival (around 33%), then the proportion might be 10–30% of farmers to 90–70% of foragers if LBK expanded during 100 years, or 10–50% of farmers to 90–50% of foragers if LBK expanded during 200 years. Such values of admixture proportion correspond well to the results of genetic analyses that have also implied a minor overall contribution from Transdanubian farmers. Studies based on mtDNA have suggested that the contribution of farmers was between 13–20% (*Richards and Macaulay 2000*). According to Y-chromosome evidence, the genetic contribution of Neolithic people may be as low as 22% (*Semino et al. 2000*).

In our model, it is a priori assumed that the age and sex structure of both admixing populations (immigrating foragers and expanding farmers) was identical. However, from the purely demographic view, a fertility level is dependent only on the proportion of females, not males. To keep the overall fertility level of LBK population below the critical value of 6.92 children, immigration from forager communities could have been sex-specific and limited only to females. This consequence inferred from the demographic model is well supported by other evidence. Bentley (*2007*), based on strontium isotope analysis of tooth enamel, has shown that female skeletons were more common among non-locals in LBK cemeteries. Similarly, Pavlů (*2004*) interpreted a minimum quantity of decorated fineware in Earliest LBK pottery assemblages in Bohemia as the result of the lack of potters' – hunter-gatherer women's – experience. It is argued that females could have joined farming communities through marriage, as has been shown in ethnographic examples (*Kelly 1995*).

Although our demographic simulations clearly support an integrationist view of the Neolithic transition in Central Europe, the model alone does not provide a basis for a more detailed evaluation of an exact mechanism of the process. Several mechanisms which were summarized by Zvelebil (*2000*), *i.e.* demic diffusion, elite dominance, infiltration, leapfrog colonization, and frontier mobility, are possible. To distinguish among these alternatives, restricting ourselves to demographic modeling, several more parameters would enter the model. However, as we have argued above, we preferred to keep the model robust and reliable rather than to speculate with many unreliable parameters.

Conclusion

In this paper we try to show that demographic simulations might be another independent line of evidence in the study of the spread of agriculture in Central Europe. We have demonstrated that the hypothesis of colonization proposed as the mechanism of Neolithic transition in Central Europe may be rejected in 92% of simulations. Colonization would have been possible only if (1) the LBK population was growing in the whole area throughout the transition; (2) the mortality of LBK females was low; and (3) the transition lasted at least 200 years. We have argued that according to ethnographic, demographic, and radiocarbon evidence, these assumptions are unlikely. To allow the farmers to spread over Central Europe, the population density of Transdanubian farmers would have had to decrease. We have suggested that in order to restore the original population density in western Hungary, the contribution of local foragers to the establishment of the Earliest LBK communities would have been necessary. The admixture proportion we have roughly estimated to 10–50% of Transdanubian farmers to 90–50% of local foragers.

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The Mesolithic background for the Neolithisation process

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ABSTRACT – *Most researchers today agree that the Early Neolithic is clearly related to the late Mesolithic and cannot be understood without its Mesolithic predecessors. Immigration is thus hardly an issue in the question of Neolithisation any longer.*

IZVLEČEK – *Večina znanstvenikov danes soglaša, da je zgodnji neolitik očitno povezan s poznim mezolitikom in ga ne moremo razumeti brez njegovih mezolitskih predhodnikov. Migracija v kontekstu neolitizacije je težko še naprej predmet razprave.*

KEY WORDS – *Mesolithic; Early Neolithic; Neolithisation; Switzerland; far distance contacts; palynology; fauna*

The transition from the Early to the Late Mesolithic

The transition from the early to the late Mesolithic seems to be one of the clearest breaks in the Stone Age of Central Europe. Only little evidence of continuity can be established. Although the radiocarbon evidence is rather scarce, the beginning of the late Mesolithic must be dated to around 6800 calBC, though (*Nielsen 2009*). According to assemblages containing early as well as late Mesolithic artefacts, it is hard do decide whether they are contemporary, or if more periods are represented. In the Abri Freymond (*Pignat and Winiger 1998*) in western Switzerland, layer 4d1 has delivered an early Mesolithic assemblage which can be dated by two radiocarbon dates to around 7200 calBC. Apart from the typical microliths of the late part of the early Mesolithic, a few atypical trapezes and notched blades are present. These trapezes are not comparable to the narrow trapezes of the older early Mesolithic, which anyway not are found in western Switzerland at all. It is, of course, not possible to exclude a late Mesolithic intrusion, but as the trapezes are not really comparable to the late Mesolithic forms, an early Mediterranean influence could be possible.

Layer 7 in the south-west German 'Jägerhaushöhle' cave delivered a late Mesolithic assemblage, including an antler harpoon, and was dated by one radiocarbon dating to around 6800 calBC. Further dating of the early Mesolithic of south-western Germany seems to be no younger than 6900 calBC (*Nielsen 2009*).

The conclusion must be that there was a remarkably swift transition from the early to the late Mesolithic. The notched blades found in the Swiss late Mesolithic shows connections with the area south of the Alps, although trapezes of Mediterranean type are lacking in the area. No artefacts made of chert of southern origin could so far be established. We are thus evidently facing an intense cultural influence, but see no evidence of immigration.

The Late Mesolithic

On the shore of the former lake of Wauwil – today, a mire intensively used for agriculture purposes – more than a hundred pre-Neolithic sites have been found. Some 38 sites could be dated to the early, and 25 to the late, Mesolithic (*Nielsen 2009*). Thus there is no evidence of a rising population through the Mesolithic period.

The well-known Schötz 7 site (*Wyss 1979; Nielsen 2009*) was excavated 1965, and delivered a large number of animal bones. As the excavation technique was rather rough, the value of the assemblage must be considered rather limited. Radiocarbon analysis suggests a dating shortly after 6000 calBC, but this might be a bit too young. Important finds are adzes, axes, and a harpoon made of antler and bone. More than 90% of the bones are from red deer; no evidence of domesticated animals was found. Interestingly, the size of the red deer population was remarkably small. This could indicate that they were intensely hunted during the late Mesolithic.

A typologically later assemblage excavated in 1970 is the Abri of Liesbergmühle VI. Apart from the typical late Mesolithic notched blades and trapezes, microliths with the so-called 'retouche inverse plate', including points which can be considered as a development of the trapezes, were found (*Nielsen 2009*). There is a remarkable number of antler harpoons. The fauna is dominated by red deer and wild boar. No domesticated animals were present in the assemblage. Fish bones constitute approximately 20% of the animal bones, which explains the high number of harpoons at the site.

As there are only a few well-excavated sites with good conditions for the preservation of animal bones, it is hard to tell if a change in the economy took place up to Neolithisation. However, the small size of the red deer found in Schötz and the tendency to intensify the hunting of small animals and fishing in the late Mesolithic might indicate a certain change.

Of great importance to late Mesolithic research and understanding Neolithisation in southern central Europe is the ongoing excavation of the rock shelter at Arconciel-La Souche in western Switzerland conducted by Michel Mauvilly (*Mauvilly 2008*).

A sequence containing the Late Mesolithic and probably the earliest Neolithic is being excavated. As the excavation and the analysis still are incomplete, no final conclusions can be drawn. At the moment, the most interesting object is a so-called 'Pintadera', a small stamp made of clay. Due to its stratigraphic position, the piece can be dated to around 6200 calBC, and thus to the middle of the late Mesolithic period. As such objects can normally be found in south-east Europe, Mauvilly's find from western Switzerland shows unexpected and extremely important evidence of long-range contacts during the late Mesolithic.

Early Neolithic

This period is not very well established in the Swiss area. In the Jurassic mountains, there are a number of sites with Danubian (Bandkeramik) finds, and also such which can be attributed to the so called La Hoguette-Group. Asymmetric arrow-points, 'Bavans-points', and closely related artefacts, are found in more or less the entire area north of the Alps (*Stöckli 1995; Nielsen 2009*). We thus anticipate that the whole area was settled by Neolithic communities at around 5500 to 5400 calBC. This anticipation is supported by the palyonological off-site evidence from numerous analyses made in recent years. The cave of Le Locle Col-des-Roches in western Switzerland was excavated between 1927 and 1933 (*Cupillard 1984*). Layer III yielded an assemblage with trapezes, triangular points ('Bavans-points') and notched blades. Apart from game, the fauna included cattle, pig and goat and/or sheep.

Comparable material was excavated in the already mentioned cave of Baulmes Abri de la Cure in the 1960ies. In the upper part of the layer, potsherds of La-Hoguette type were found. As this important site remains unpublished, it is still unclear if animal bones were preserved.

Comparable assemblages can be found across most of the entire Swiss plateau, but only as surface finds, regrettably (*Nielsen 2009*).

Palyonological research

Switzerland has been subject to intense palyonological and palaeoclimatic research over several decades. The chronological framework is thus undisputed (*Ammann 1989; Lotter 1988*).

In the last few years, a discussion concerning the evidence for early agriculture in southern central Europe between 'believers' and 'non-believers' has been rather lively (*Erny-Rodmann et al. 1997; Tinner et al. 2007 and 2008; Behre 2008*). The main argument of the latter – primarily German botanists – is that, although hundreds of late Mesolithic sites are known, there are no on-site finds of cereals. The first group of researchers, mainly Swiss botanists, ar-

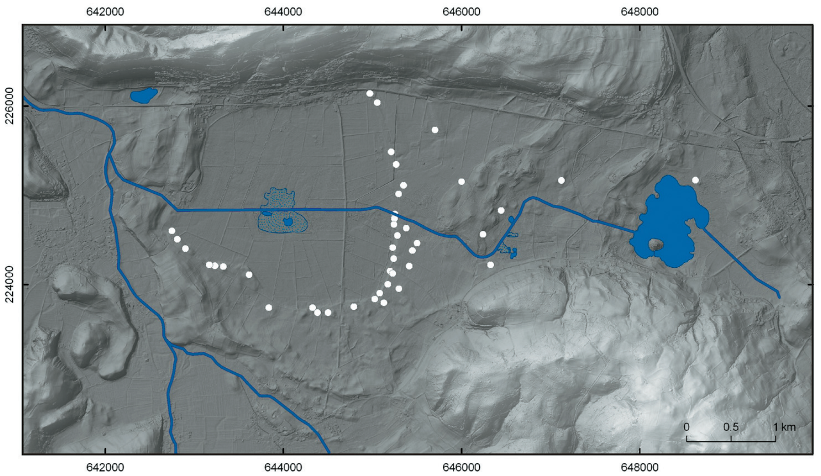

Fig. 3. Wauwilermoos (CH). Early Mesolithic sites distribution.

gue that the evidence from the off-site cores is consistent. Further, we hardly have well excavated sites with good conditions for the preservation of botanical material, anyway.

Abri de la Cure in western Switzerland is so far the only on-site find of Mesolithic evidence for early agriculture (*Egoff 1967; Leroi-Gourhan and Girare 1971*). Beneath a layer containing finds from the early Neolithic La Hoguette-group, a late Mesolithic layer could be established. Regrettably, only some early Neolithic artefacts, as well as the palyonological results have been published. The values of cereals in the late Mesolithic layer exceeded 1% (*Tinner et al. 2007*), which must be considered rather good evidence for agriculture.

The well-dated core from Wallisellen-Langachermoos in eastern Switzerland yielded pollen of Triticum (combined with Plantago lanceolata) at around 6400 and 5800 calBC (*Haas 1996; Tinner et al. 2007*). Very important is one seed (!) of Linum usitatissimum at 6500 calBC. As there is no further evidence of pollution of this part of the core with younger material, the find has to be recognized.

The cores from the Lake Soppensee in central Switzerland are dated by a large number of radiocarbon datings, as well as laminated sediments (*Lotter 1999*). Evidence of several episodes of agriculture during the late Mesolithic could be established. Most of the cereal pollen could be identified as Triticum and Avena. If the thesis of early agriculture is accepted, it must have occurred on a very modest scale, as forest clearences was not confirmed by palaeobotany. It is remarkable that the occurrence of cereals is very clear during the earlier part of the Neolithic (*c.* 5400–4800 calBC), a period only known in the central Swiss plain from a few stray finds ('Bavans-points') (*Nielsen 2009*).

Conclusions

The question is – as hardly anybody believes in the immigration thesis any more – whether Neolithisation came as a package, or whether Mesolithic societies slowly adjusted to the new way of life. Some researchers even consider the Mesolithic of the area as a kind of pre-pottery Neolithic (*Stöckli 2009*). However, as there is no evidence of stock breeding, of a sedentary way of life, or of the production of ceramics – as seen in the Ertebølle Culture of southern Scandinavia – this definition seem slightly exaggerated. Still, we probably have to abandon the clear boundary between the late Mesolithic and the early Neolithic.

To prove the thesis of Mesolithic agriculture once and for all, grains of cereals in Mesolithic cultural layers need to be found. The off-site find of a late Mesolithic Linum seed in Wallisellen has to be born in mind. Although several late Mesolithic sites have been excavated, there are almost none with good

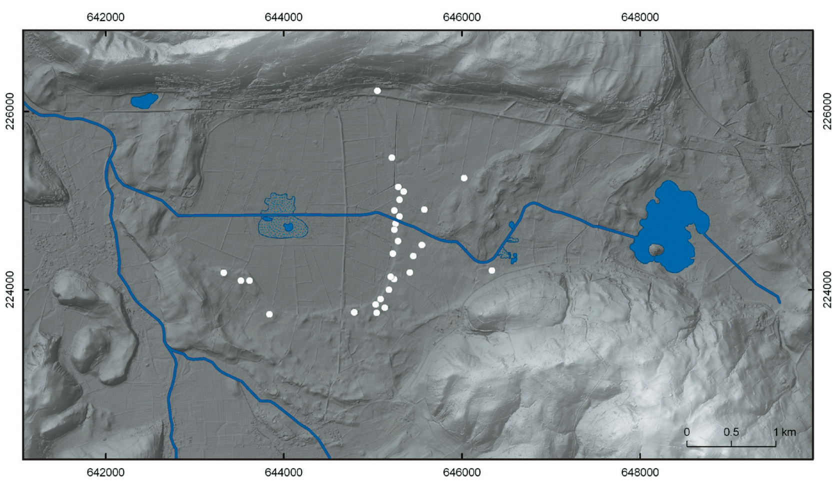

Fig. 4. Wauwilermoos (CH). Late Mesolithic sites distribution.

conditions for the preservation of botanical material. In terms of technology, it would of course have been no problem for the local population to have exercised a simple kind of agriculture or horticulture during the Mesolithic.

During the Preneolithic and the Neolithic of southern central Europe, contact with Mediterranean cultures has been established through finds of shells used as pendants. Contacts with the Mediterranean and other parts of central Europe throughout the Mesolithic have been known for a long period, due to finds of Columbella rustica and various fossil shells (*Rähle 1978; Jagher 1989*). Thus, the import of cereals during the Mesolithic is theoretically possible. A number of field projects conducted by the universities of Berne and Basel are at present focussed on this possibility, and new evidence – positive or negative – can thus be expected in the years to come. Typologically, the late Mesolithic of Switzerland is closely related to adjoining parts of eastern France and shows clear differences from neighbouring southern Germany (*Nielsen 2009*). This can also be established for the earliest part of the Neolithic, as the Danubian Culture only reaches the north eastern fringe of Switzerland. It thus seems that the already established late Mesolithic cultural groups still existed in the earliest Neolithic. This also indicates continuity between the last hunter-gather cultures and the first farmers.

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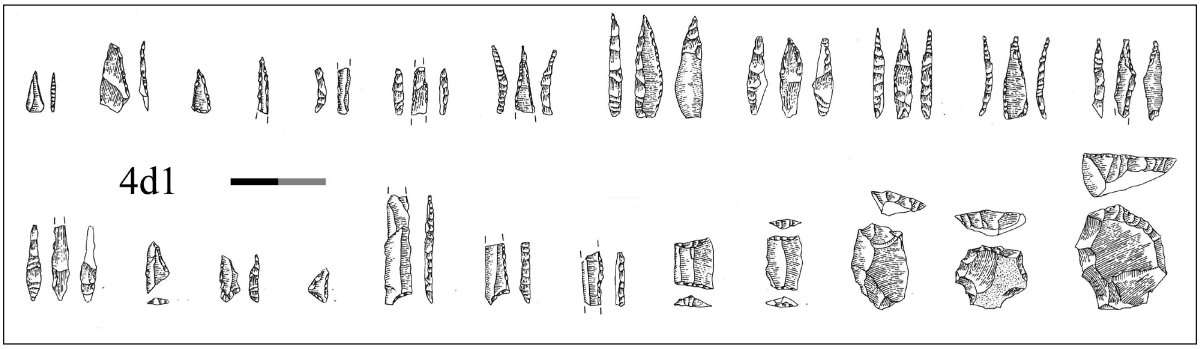

Fig. 1. Mollendruz (CH), Abri Freymond layer 4d1. Early Mesolithic assemblage (from* Pignat and Winiger 1998*).

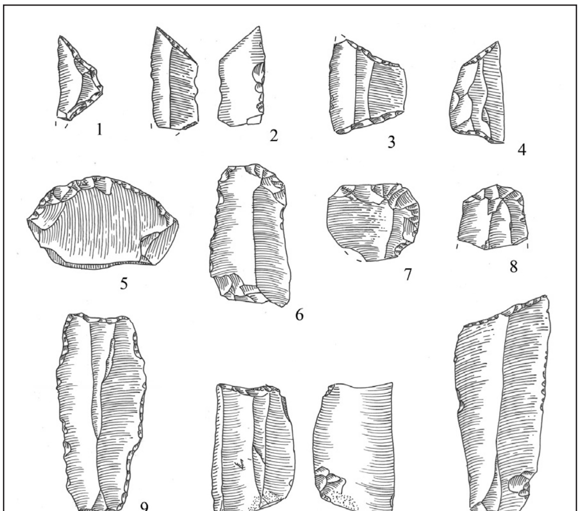

Fig. 2. Jägerhaushöhle (D), layer 7. Late Mesolithic assemblage (from* Nielsen 2009*).

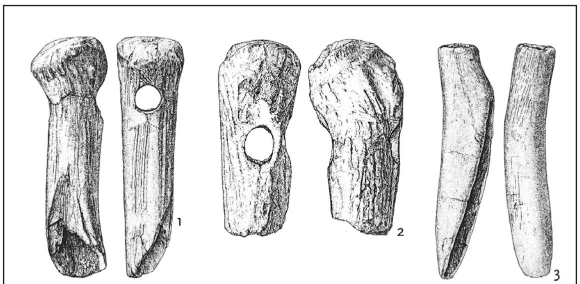

Fig. 5. Schötz (CH), Rorbelmoos site 7. Late Mesolithic antler and bone tools (from* Wyss 1979*).

Schötz "Rorbelmoos" site 7. Fauna		
Deer	2198	92% (without antler)
Roe deer	72	3%
Elk	3	<1%
Wild boar	50	2%
Auerochs	36	2%
Bear	1	<1%
Wolf	3	<1%
Badger	3	<1%
Marten	1	<1%
Beaver	4	<1%
Birds	3	<1%
Frogs	12	<1%
	2386	
Deer antler	774	

Fig. 6. Schötz (CH), Rorbelmoos site 7. Late Mesolithic fauna.

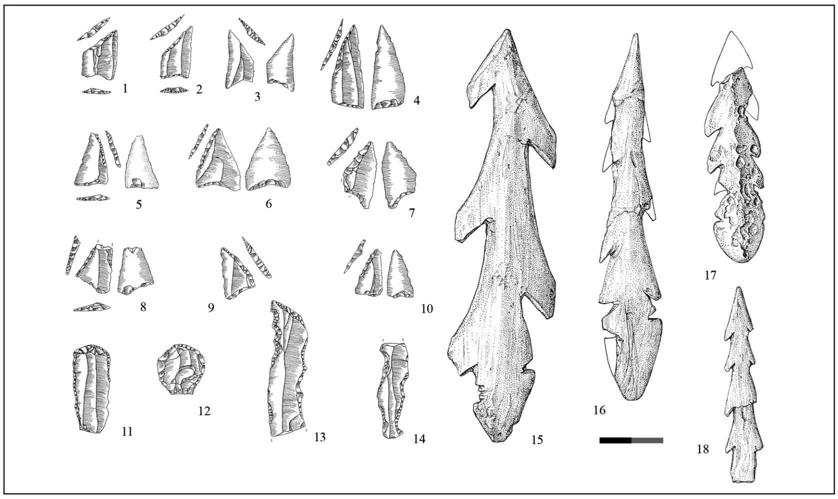

Fig. 7. Liesberg (CH), Liesbergmühle site VI. Late Mesolithic artefacts assemblage (from* Nielsen 2009; Wyss 1979*).

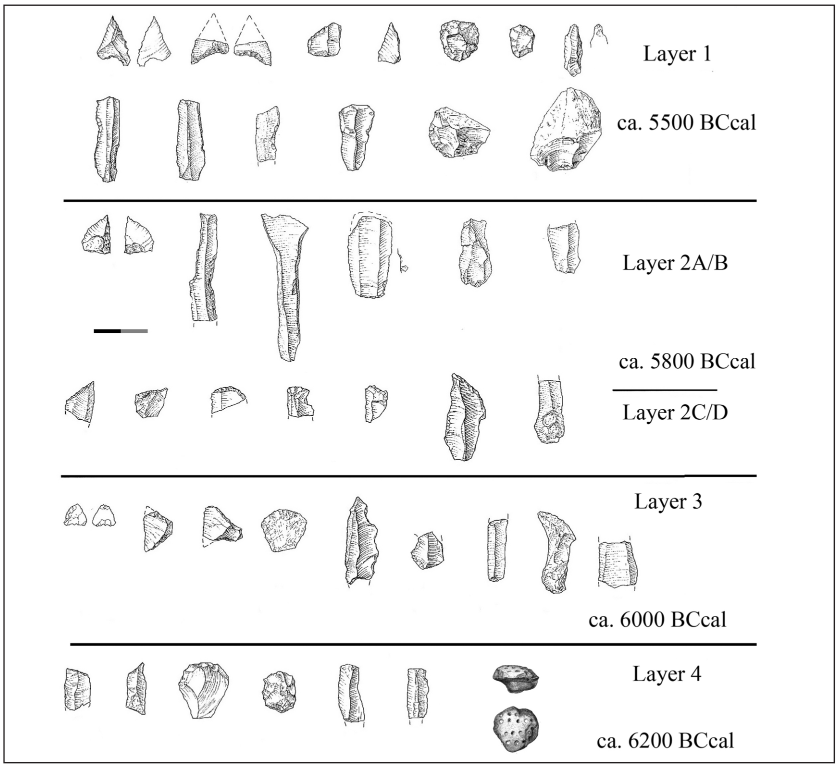

Fig. 8. Arconciel (CH), La Souche. Late Mesolithic sequence (from* Mauvilly 2008*).

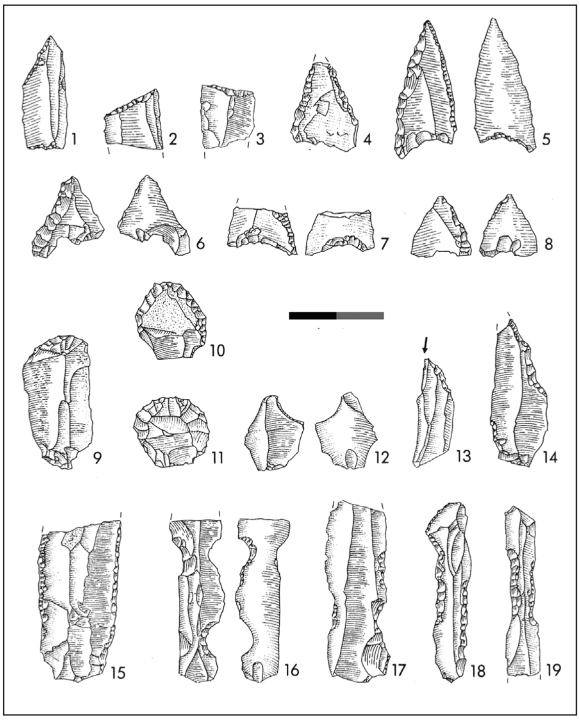

Fig. 9. Le Locle (CH), Col des Roches. Early Neolithic stone tool assemblage. (from Cuppilard 1994*).*

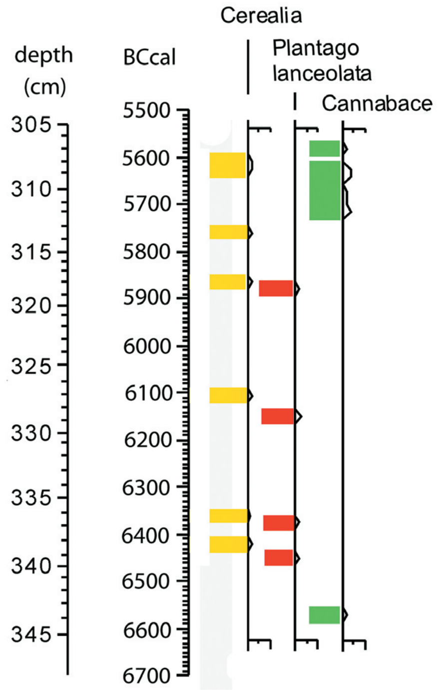

Fig. 13. Soppensee (CH). Pollen profile 6700–5500 calBC with human impact (from Tinner et al. 2007*).*

Cattle	8	3%
Sheep/goat	11	4%
Domest. pig	34	13%
Deer	145	53%
Elk	1	<1%
Wildpig	2	1%
Bear	17	6%
Wolf	1	<1%
Fox	2	1%
Badger	1	<1%
Frog	50	18%
	272	

Fig. 10. Le Locle (CH), Col des Roches. Early Neolithic fauna.

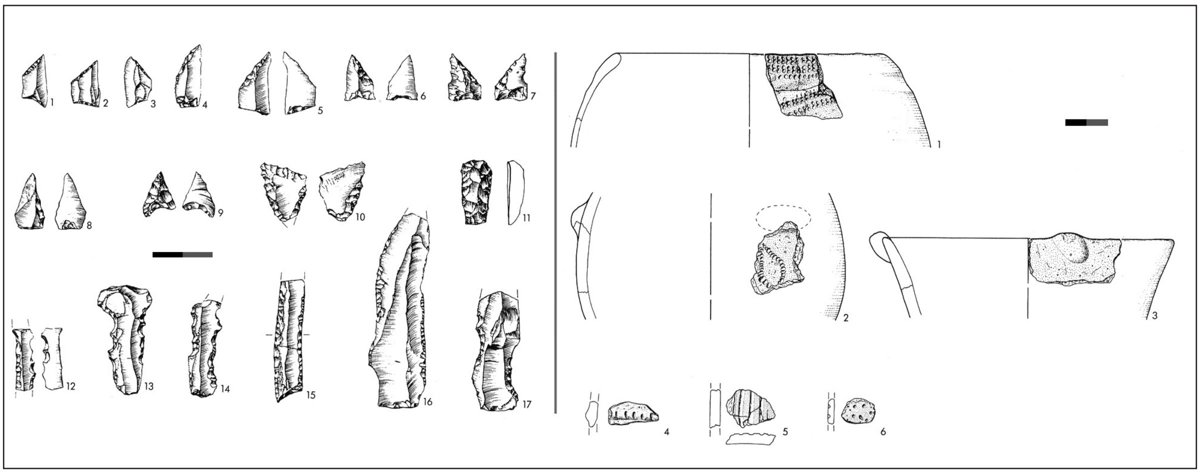

Fig. 11. Baulmes (CH), Abri de la Cure. Early Neolithic stone tools and pottery (from Egloff 1967*).*

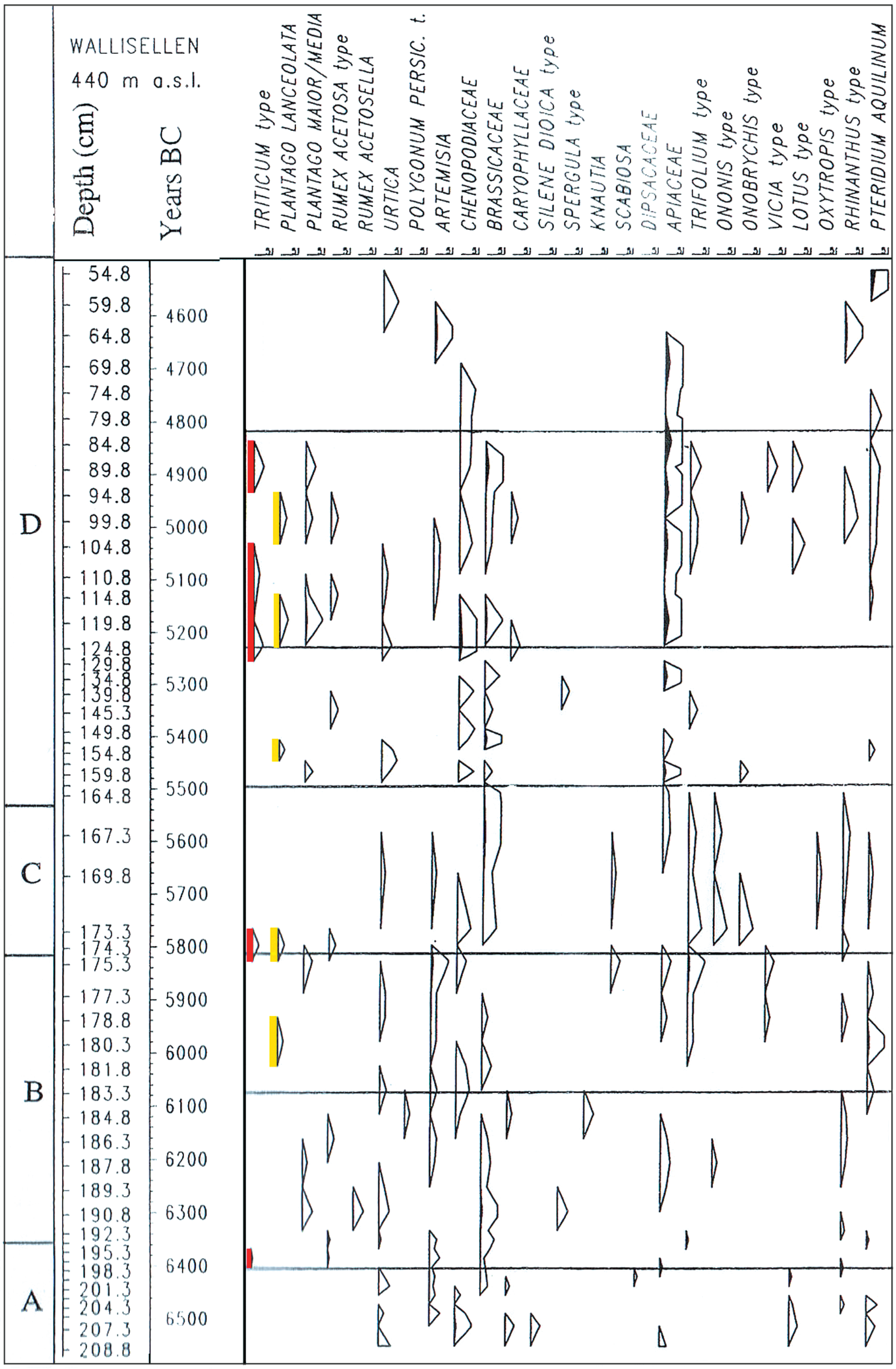

Fig. 12. Wallisellen (CH) Langachermoos. Pollen profile 6500–4600 calBC with human impact (from Erny-Rodmann et al. 1997*).*

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The Neolithization of Northern Black Sea area in the context of climate changes

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ABSTRACT – *The neolithisation of the Pontic steppe was a long process, with four stages which were associated with climate changes. It began* c. *7500 calBC, with early animal husbandry in the western Azov Sea area. The beginning of the second stage was connected with an arid climate (7000–6900 calBC) and the origin of the Rakushechny Yar culture in the Lower Don region. The third stage (6500–6300 calBC) occurred during a humid period. Besides animal husbandry, the steppe population borrowed the first pottery from the Rakushechny Yar culture. The fourth phase (6300–6000 calBC) was connected with extreme aridity and the neolithisation of the modern forest-steppe and forest zones of Ukraine and Russia.*

IZVLEČEK – *Neolitizacija Pontske stepe je bila dolgotrajen proces, ki ga sestavljajo štiri stopnje, povezane s klimatskimi spremembami. Začela se je z zgodnjo živinorejo na področju Azovskega morja okoli 7500 calBC. Začetek druge stopnje je bil povezan s sušnim podnebjem (7000-6900 calBC) in začetkom kulture Rakushechny Yar na področju spodnjega Dona. Tretja stopnja (6500-6300 calBC) se je pojavila v vlažnem obdobju. Stepsko prebivalstvo je poleg živinoreje od omenjene kulture prevzelo tudi lončenino. Četrta faza (6300-6000 calBC) je bila povezana s skrajno suhim podnebjem in neolitizacijo sodobne gozdne stepe in gozdnih predelov Ukrajine in Rusije.*

KEY WORDS – *Pontic steppe; climate changes; neolithisation; first pottery; early animal husbandry*

Basic concepts of the Early Neolithic in Ukraine

At the end of the 60s, V. N. Danilenko assumed that the beginning of the Neolithic in Ukraine was connected with an eastern cultural impulse (*Danilenko 1969*). He supposed that a progressive aridity in East Europe had resulted in a crisis of hunting economies, and in the VII millennium BC the ancient population of this region shifted to cattle breeding, and borrowed pottery. In search of new pasture, it began to move west, up to the Dnieper and the Southern Bug. Danilenko confirmed this migration with the similarity of the ceramics, with point bottom, drawn and pit ornamentation, which were found at Early Neolithic sites in the south of Eastern Europe. Apart from the first ceramics, the newcomers brought early animal husbandry to Ukraine. Under their influence, the local Mesolithic population shifted to the Neolithic, and the Azov, Surskaya and Bug-Dniestr cultures appeared. Danilenko dated the first appearance of ceramics in Ukraine to the end of the VII millennium BC, based on its similarity to the pottery of the most ancient ceramic layer of Dzhebel in the Caspian Sea area. In turn, he synchronized this Dzhebel layer with the layers of Hacilar in Western Anatolia, which contained monochrome ceramics similar to the Dzhebel pottery (*Danilenko 1969.186*).

Danilenko supposed that cattle were domesticated in the Northern Caucasus and predominated in animal husbandry of Eastern Europe (*Danilenko 1969. 180*). He connected the dissemination of agriculture in Ukraine with the influence of the Criş-Körös cultures, owing to which it appeared among the population of the Bug-Dniestr culture. The latter, in its turn, had played the main role in the neolithisation of the forest-steppe and the forest zones of Ukraine. The Bug-Dniestr migration into the southeast woodlands and the Dnieper River basin caused the formation of the Dnieper-Donets culture. At the end of the VII millennium BC, the Mesolithic population of these areas borrowed the first ceramics and early agriculture from the newcomers.

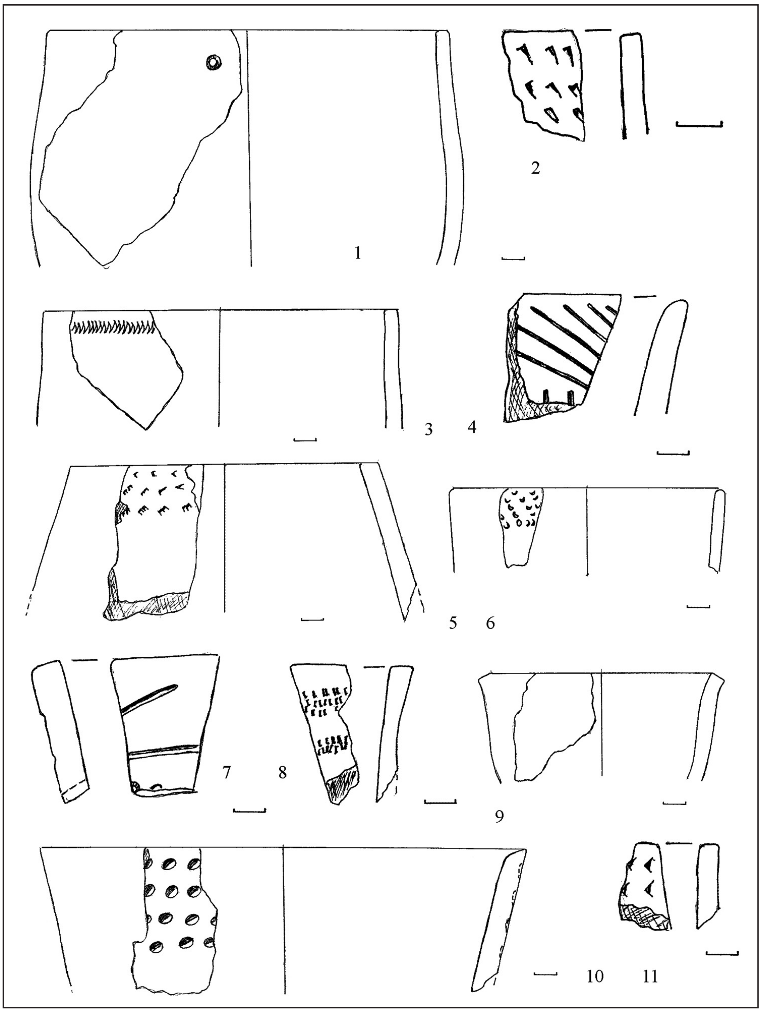

Fig. 1. Pottery of the Rakushechny Yar culture from the Rakushechny Yar site: 1–3 layer 23; 4, 5 layer 22; 6–11 layer 21.

Danilenko divided the sites of the Bug-Dniestr culture into seven phases (*Danilenko 1969*). The first phase (Pre-Ceramics) was dated to the second half of the 7th millennium BC. At the same time, according to his opinion, the Sursko-Dnieper culture also appeared. The second phase (Skibentsy) of the Bug-Dniestr culture was characterized by the appearance of ceramics, analogies for which he found in the Caspian Sea area and in the East Mediterranean. He synchronized the sites of this phase with a lower layer of Nea Nikomedeia, the fifth layer of Dzhebel, and the lower layers of Mersin. This phase, together with the Kizlevskaya phase of the Sursko-Dnieper culture, was dated to the end of the 7th – first half of the 6th millennium BC. Danilenko supposed that, at that time under the influence of the Bug-Dniestr culture, the earliest monuments of the Dnieper-Donets culture were also formed on the basis of the Mesolithic traditions of the forest-steppe Dnieper zone.

The third phase of the Bug-Dniestr culture (Sokoltsy), according to the researcher's opinion, kept the features of the relationship with the cattle breeding cultures of eastern regions. It was dated to the second half of the 6th, and the beginning of the 5th millennium BC. Danilenko assumed that the fourth phase (Pechera) was a result of the influence of the Criş-Körös cultures, with the distribution of painted pottery and ceramics with ornamentation in the form of finger prints, bowls on pallets as well as, burnished vessels. However, painted pots have been absent in all the Bug-Dniestr sites, whereas pottery with finger prints, pallets and burnished surface is known in the collections of the sites attributed by the researcher to the previous phases, where their appearance was explained by the Mediterranean-Balkan interactions. Danilenko connected the completion of the fourth phase with the end of the spread of the Linear Pottery culture over the territory of Poland, Romania and Western Ukraine.

Danilenko considered the fifth (Samchinsty) phase to be short, and dated it to the last quarter of the 5th millennium BC. He connected the formation of its traditions with the influence of the population of the Dnieper-Donets culture. The sixth phase of the Bug-Dniestr culture (Savran) was characterized by the restoration of Pre-Samchinkaya traditions. The final phase of the Bug-Dniestr culture referred to the Pre-Tripolye period.

The problem of the appearance of the first domestic animals in Eastern Europe was considered by Tsalkin in detail (*Tsalkin 1970*). He admitted the fact of local domestication of horse, cattle and pig, supposing that further study of the most ancient Neolithic sites would clarify this problem.

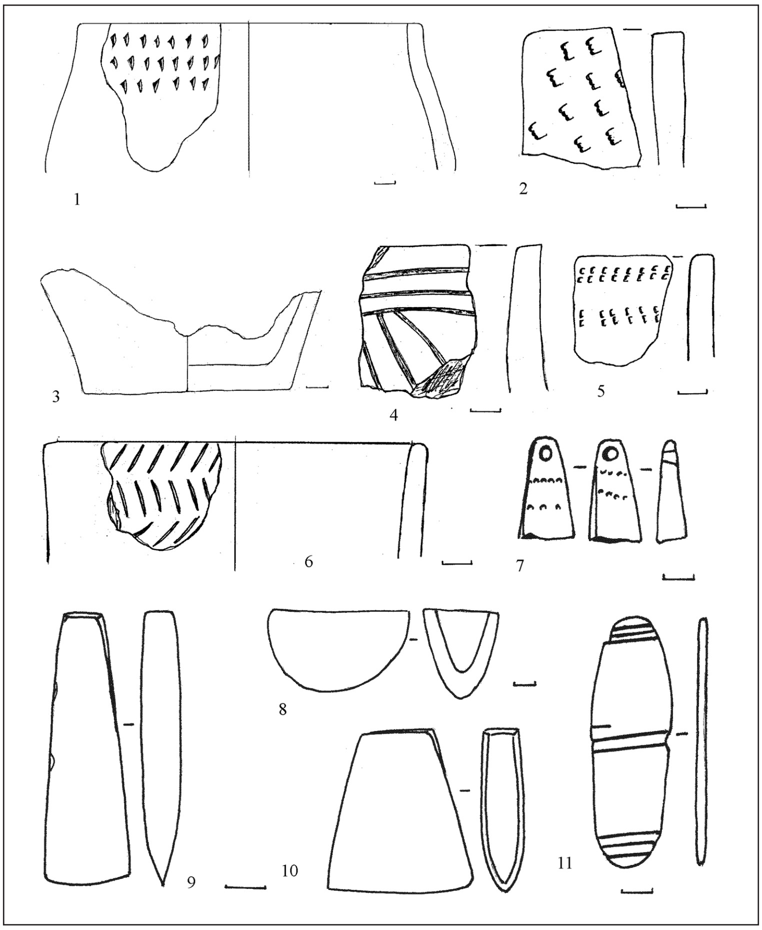

Fig. 2. Materials of the Rakushechny Yar culture from the Rakushechny Yar site: 1, 2 layer 19; 3 layer 20; 4, 5 layer 17; 6 layer 16; 7 layer 8; 8 layer 9; 10 layer 7; 11 layer 10; 7–10 stone; 11 bone.

Telegin suggested recently a renewed periodization of the Neolithic in Ukraine based on the ^{14}C dates (*Telegin 1992; Telegin et al 2000*). He dated the Neolithic period to 6500–5500 calBC, and connected it with the appearance of the Bug-Dniestr culture in the north-west Black Sea area, and the Surskaya culture – in the lower Dnieper River basin, the oldest Dnieper-Donets cemeteries (Vasilievsky 2 and Marievsky) – in the northern steppe of the Dnieper River basin. In his opinion, these cultures developed on the local Mesolithic basis under the influence of other cultures. He considered the Criş-Starčevo cultures as having influenced the Bug-Dniestr culture; and the Surskaya culture as being influenced by the Neolithic of Asia Minor. The similarity of the Surskaya vessels to stone and burnished vessels from Asia Minor having an impurity of sand in the clay testifies to this. He also marked the similarity of ornamentation, consisting of smooth 'walking' prints and drawn lines in combination with pits.

Telegin considered the formation of agriculture and animal husbandry in Ukraine repeatedly (*Telegin 1968; 1977; 1990; etc.*). He assumed that domestic pig and bull had appeared in the South of the European part of the former USSR in the Mesolithic; domestic horse – in the Neolithic; and their appearance was the result of local domestication. Ovicaprids were disseminated in Ukraine together with the Linear Pottery culture. He connected the distribution of agriculture in Ukraine with the influence of this culture, as well as the Tripolye culture.

Shnirelman considered the development of the food-producing economy in the Neolithic, including Ukraine (*Shnirelman 1980; 1986; 1989*). In his opinion, only the horse could have been domesticated in the Northern Black Sea area (*Shnirelman 1986.293*). According to his assumption, the first domestic animals appeared among the population of Moldova and Ukraine as a result of borrowing: pig from the bearers of the Lepensky Vir culture, and cattle from the Criş population. Shnirelman supposed that the absence of ovicaprids at sites of the Dniestrovskiy variant of the Bug-Dniestr culture and the fact of finding their bones on sites of the Bugskiy variant and at settlements of the Matveev Kurgan type in the Azov Sea area proves that domestic goat and sheep were borrowed from the East – from the population of the Northern Azov Sea area and the Northern Caucasus. In his opinion, the existence of early animal husbandry is hardly possible given the absence of agriculture (*Shnirelman 1980.216*) and, as a whole; the early food-producing economy had most favorable conditions for the complex development. In this connection, he considered that the existence of agriculture in the steppe Black Sea area is possible, as through this region *Triticum spelta* and *Panicum miliaceum* was distributed in the Dniestr River basin and further to the west (*Shnirelman 1989.178*).

Shnirelman writes that in the Early Neolithic cultures of the Northern Black Sea area and the Azov Sea area, the food-producing economy had little importance. In the course of time, its role grew gradually, and it penetrated to the North to the territory of the Dnieper-Donets culture, where domestic animals appeared and barley cultivation began. The researcher marked the significant role of the Bug-Dniestr culture in the distribution of the food-producing economy in Ukraine, stressing that its microcenter had developed in the area between the Dnieper and the Southern Bug rivers. It was a unit of the secondary Balkan centre of a food-producing economy. In spite of the fact that the Bug-Dniestr culture and its agriculture was similar to the Balkan cultures, this microcenter differed in its originality, which was the result of the penetration of hexaploid wheat, millet and ovicaprids through the steppe corridor (*Shnirelman 1989.384*).

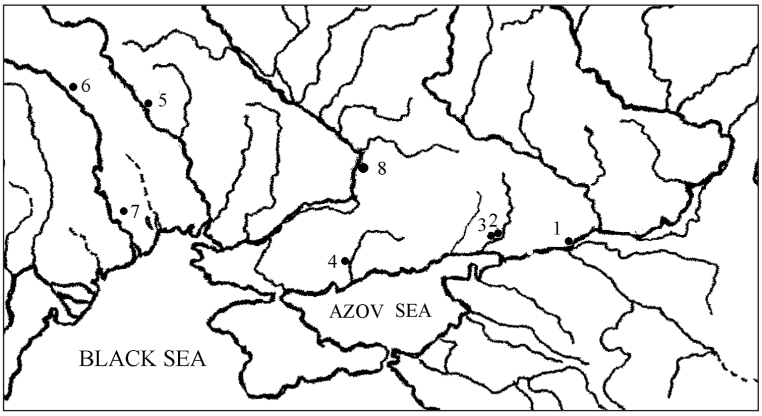

Fig. 3. The map of the sites of the 6500–6300 BC. 1 Rakushechny Yar; 2 Matveev Kurgan 1 and 2; 3 Gruntovsky 1 and 2; 4 Kamennja Mogila 3; 5 Zankovtsy; 6 Soroki 2; 7 Girzhevo; 8 Vasilievsky 2 and Marievsky cemeteries.

Krizhevskaya raised questions connected with the formation of animal husbandry in the Azov Sea area regarding materials of the Matveev Kurgan type, where the bones of domestic pig, cattle, ovicaprids and, probably, horses have been found in Early Neolithic layers (*Krizhevskaya 1992.105*). In her opinion, the local domestication of bulls and pigs was possible, owing to the specialized hunting of wild boar, while ovicaprids were borrowed from inhabitants of the Caspian Sea area. She considered the steppe areas to the East from the Dnieper as a place of horse domestication.

The neolithisation in Ukraine is discussed by Zaliznyak (*1998; 2006*). He connects the dissemination of the food-producing economy in the Balkan-Carpathian region and in Ukraine with migration from Greece. Zaliznyak assumes that the neolithisation of the steppe Ukraine began with the migration of the Grebeniki population about 7600 uncalBP. The flint tools of this culture do not connect with local Paleolithic and Mesolithic sites and are very similar to the Pre-Pottery complexes of the Balkan region (*Zaliznyak 2006.8–9*). The late migration of the Criş population in the 6 millennium BC resulted in the formation of the Bug-Dniestr culture and its economy, with cattle, ovicaprids and pig. Wechler has the same opinion, according to which the spread of cattle-breeding and agriculture in southern Ukraine was connected with the influence of Criş culture (*Wechler 2001*).

Following Danilenko, Zaliznyak considers that in the middle of the 5th millennium BC, the migration of the Bug-Dniestr population north up to the woodlands resulted in the formation of the Dnieper-Donets culture. In the steppe areas of Ukraine, a cattle breeding was disseminated as a result of aridity in the 4 millennium BC only among the population of the Sredny Stog culture.

Environment and climate in the Northern Black Sea area

The Northern Black Sea region is a vast steppe area extending from the Danube in the west to the Northern Caucasus in the east, from the Black Sea and the Sea of Azov in the south, to the forest-steppe zone in the north. It includes four big rivers and the basins of some smaller rivers.

The Ukrainian steppe is characterized by constantly low humidity. The dryness in the southern areas of the steppe is six times greater than that in northern areas. The vegetative cover, being determined by climatic conditions, is also varied. The stock of phytomass increases from the northern limits of the steppe to the centre from 28 tons up to 48 tons per hectare, falling to 9 tons at its southern limits. The centre of the steppe zone is optimal, with a combination of heat and sufficient amount of precipitation (*Mordkovich 1982*).

Summer drought connected with a fall in the basic amount of precipitation in spring and autumn is a feature of the steppes from the Dniestr to the Don. Here, in comparison with more eastern areas, there are many mesophytes, but fewer xerophytes having a large underground phytomass. This makes the Northern Black Sea steppe more vulnerable and susceptible to climatic change. The small amount of xerophytes with advanced root systems cannot prevent

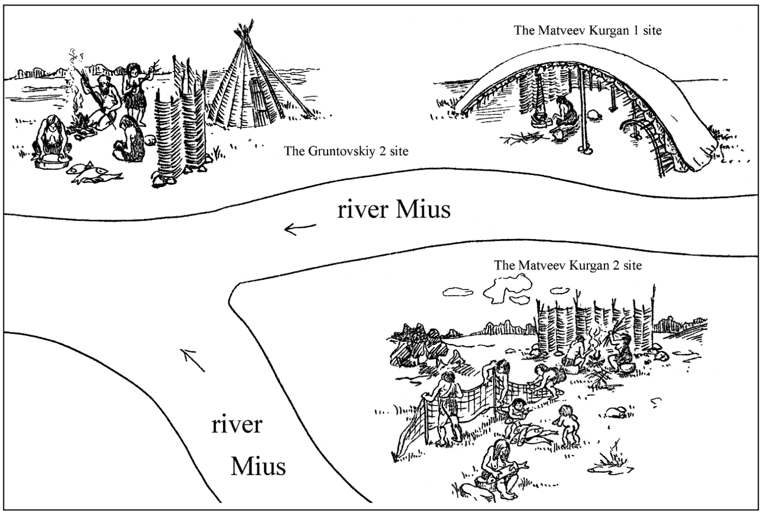

Fig. 4. The reconstruction of sites the Matveev Kurgan group (after* Krizhevskaja 1992*).

the rooting of woody vegetation. With increasing of humidity, this promotes easy access for trees to the steppe territories and to the southward expansion of the forest-steppe zone (*Mordkovich 1982.56*).

The steppes from the Don to the Urals are characterized by greater dryness in comparison with the Ukrainian steppe. During periods of aridity, the landscapes of their southern areas become similar to deserts. There are numerous xerophytes in this eastern steppe. During periods of humidity, they stop the southward expansion of the forest-steppe zone. The drier character of the eastern steppe region as compared to the Black Sea area is very important for understanding cultural processes in the prehistory of Eurasia.

The ancient climate and landscapes of the Pontic steppe have been reconstructed on the basis of the palynological analyses of samples from bogs and Neolithic settlements: Matveev Kurgan, Chapaevka, Kamennaja Mogila 1, and Razdolnoe (*Levkovskaja 1992; Bezus'ko et al. 2000*). These materials have added to the detailed scheme of the climate and landscape changes for the Holocene of Eastern Europe developed by E. A. Spiridonova (*Spiridonova and Lavrushin 1997*).

According to this scheme, the Atlantic period included several sub-periods of climatic fluctuation. During the wet sub-periods, the forests spread into the river valleys in the southern area of the steppe, and the amount of motley grass in the structure of the grassy vegetation increased. During the dry sub-periods, the forests in the South of the steppe zone disappeared, the role of motley grass decreased, and the quantity of wormwood in the structure of the grassy vegetation increased.

However, all the wet sub-periods during the Atlantic period were drier than the current climate, and the northern border of the steppe was on the territory of the modern forest-steppe zone. Such a situation continued until the beginning of the Sub-Boreal period, when the border became similar to the modern one.

Neolithisation in the Pontic steppe

The beginning of neolithisation in the Pontic steppe was probably connected with the Pre-pottery Neolithic layer of the multilayer settlement at Kamennaya Mogila 1 in the Azov Sea area (*Danilenko 1986; Kotova 2003*). Kamennaya Mogila is a natural stone accumulation with caves, near the village of Terpenie in Melitopol District, Zaporozhye Region. Near this stone hill, three multilayer settlements are located. All of them include Neolithic layers, but a Pre-Pottery Neolithic layer was discovered only at the first site. It is dated from 7500 to 6900 calBC and contains cattle, horse, sheep and goat bones. Unfortunately, the bones of the oldest domestic animals from Kamennaya Mogila 1 were studied by only one archaeozoologist, and more than 70 years ago (*Pi-*

Site and context	Material	Index	BP	calBC (2σ) *	Reference
Rakushechny Yar, layer 20^{th}	pots-snuff	Ki–6476	7930±140	7246–6472	*Telegin et al. 2000*
Rakushechny Yar, layer 20^{th}	pots-snuff	Ki–6477	7860±130	7062–6466	*Telegin et al. 2000*
Rakushechny Yar, layer 20^{th}	pots-snuff	Ki–6476a	7690±110	6901–6260	*Telegin et al. 2000*
Rakushechny Yar, layers $14–15^{th}$	pots-snuff	Ki–6480	7040±100	6085–5720	*Telegin et al. 2000*
Rakushechny Yar, layers $14–15^{th}$	pots-snuff	Ki–6478	6930±100	5999–5646	*Telegin et al. 2000*
Rakushechny Yar, layers $14–15^{th}$	pots-snuff	Ki–6479	6825±100	5974–5558	*Telegin et al. 2000*

Tab. 1. Radiocarbon dates of the Rakushechny Yar culture (* calibrated by OxCal v.4., after* Bronk Ramsey 2009*).

doplichko 1956). Now we have no the opportunity to test these bone determinations, but we may offer two hypotheses about their origin.

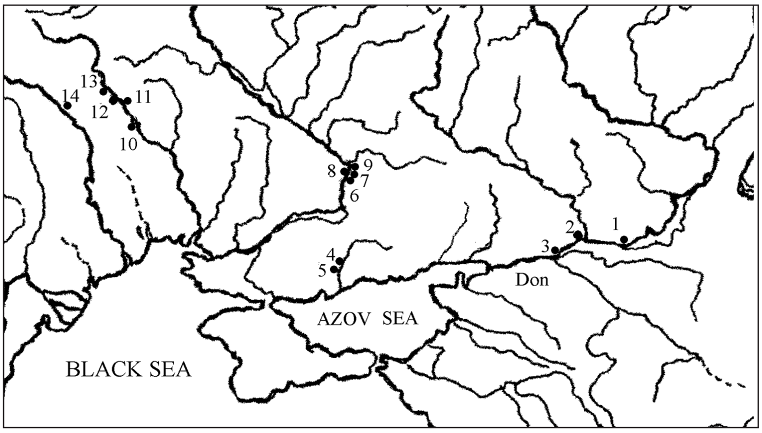

Fig. 5. The map of the monuments about 6300–6000 BC. 1 Tzimljanskoe; 2 Samsonovka; 3 Rakushechny Yar and Razdolnoe 1; 4 Kamennaja Mogila 1; 5 Semenovka 1; 6 Vinogradny; 7 Vasilievskiy and Marievskiy cemeteries; 8 Kodachok; 9 Surskoy Island 1 and 2; 10 Mitkov and Bazkov Islands; 11 Sokoltsy; 12 Glinskoe; 13 Pechera; 14 Soroki.

The first hypothesis is that the animals were locally domesticated. It cannot be doubted that horse was domesticated in the Pontic steppe. The analysis of this problem by Kuzmina has been the most convincing up to now (*Kuzmina 1997*). She has proved that the origin of the domestic horse was connected with *Equus latipes Gromova*, which survived in the south of Russian steppe up to the 5th millennium BC. A study of East European Neolithic sites demonstrates the absence of domesticated horse and the presence of *Equus gmelini Antonius* and *Equus latipes Gromova* in the South of forest-steppe area of the Don basin in the 7–6 millennia BC (*Kuzmina and Kasparov 1987*). Horse, similar to *Equus uralensis Kuzmina*, was found at the Neolithic sites of Lower Volga basin (*Kuzmina 1988. 178*). Around 6200 calBC, domestic horses were known in the basin of the Southern Bug and in the Northern Azov Sea area (*Kotova 2003*). The most ancient finds of domestic horse are connected with the territory of the Western Azov Sea area, which was probably just the centre of its domestication, no later than at the beginning of 8th millennium BC.

The Pontic steppe was a habitat of the Auroch – an ancestor of cattle. Local domestication of this species was also possible (*Tsalkin 1970.266*). The ancestry of ovicaprids could lie in wild sheep, the Mouflon and a wild goat-pasan, which lived in the Northern Caucasus (*Amirkhanov 1987.174*).

However, the second hypothesis, regarding the borrowing of cattle, sheep and goat from the Ancient East, is also tenable. These domesticates are known from Pre-Pottery Neolithic sites in Eastern Turkey around 8000 calBC (*Özdoğan 1999*). It is possible to assume that they were borrowed by the population of the Pontic steppe around 7500 calBC. But without genetic analysis, this problem cannot be resolved.

The second phase of neolithisation (6900–6500 calBC) was connected with the Rakushechny Yar culture, whose sites are located in the Low Don region, and date from 6900 to 5600 calBC (Tab. 1). The most famous site of this culture is a multilayer settlement at Rakushechny Yar, which has 23 layers (*Belanovskaya 1995*). Seventeen of these are of the Rakushechny Yar culture (layers 23–7). This culture has the complete Neolithic package: pottery, polished stone tools, a productive economy. Rectangular houses were constructed with wooden posts, and clay coated floors and, possibly walls. Flat-bottomed pots, with an organic admixture in the clay, with linear, comb and impression ornamentation are typical of this culture (Figs. 1 and 2). The point-bottom pots appeared only *c.* 6700 calBC. Cattle, ovicaprids and pigs were known from 6900 calBC. At around 5900 calBC, the bones of hypothetical domestic horses appeared. The presence of querns suggests the existence of agriculture.

Some traits of Rakushechny Yar culture are similar to Neolithic sites in Eastern Anatolia: rectangular houses with daub, flat-bottomed pots, clay figurines, polished tools, animal husbandry with domestic cattle, ovicaprids and pigs, but no horses. This similarity, together with close radiocarbon dates, allows me to assume a borrowing of some attainments, or even a penetration of small groups of population from Eastern Anatolia to the Azov Sea area around 6900 calBC.

This migration could be the result of aridity, which has been fixed at *c.* 7000 calBC in the Azov Sea steppe (*Bezus'ko et al. 2000.105*). It was not a short arid period, nor a local event. The transition from the Pre-Pottery to the Ceramic Neolithic has been recorded for this period in southeastern Anatolia. It was accompanied by a collapse of the Pre-Pottery Neolithic cultures. Many sites were deserted. Turkish

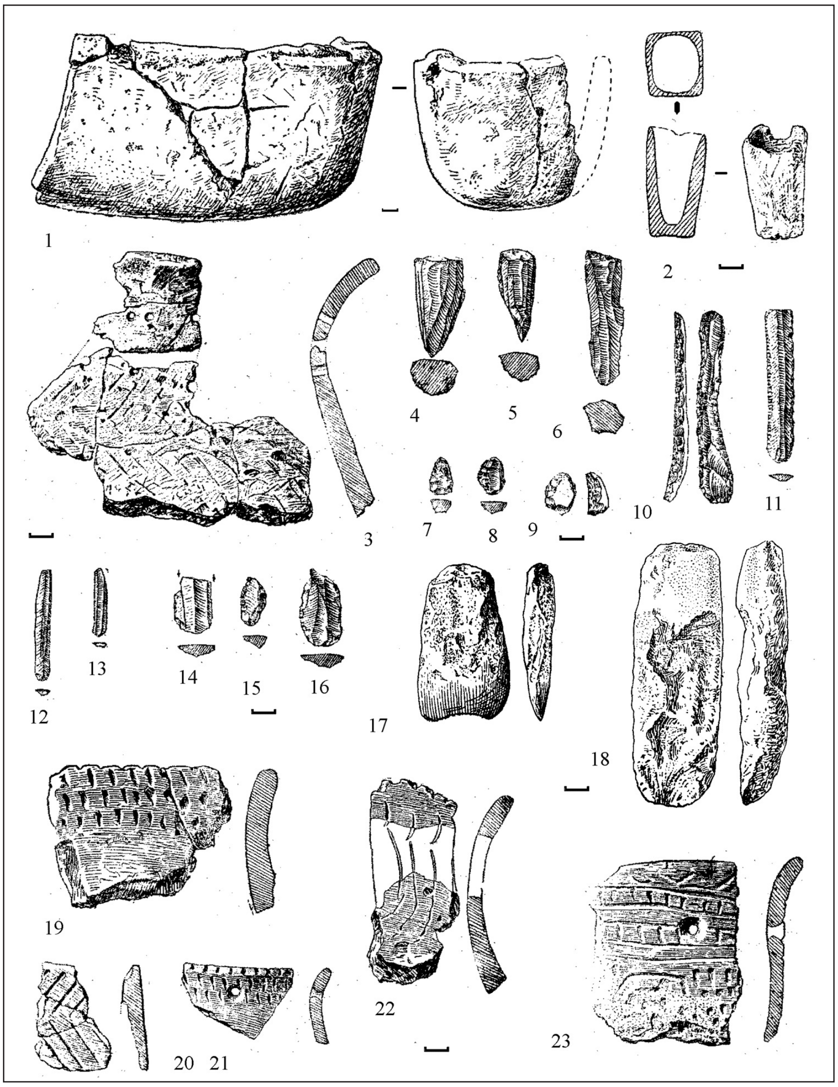

Fig. 6. Materials of the Surskaja culture from the site 1 (1–18) and 2 (19–23) on the Surskoy Island.

archaeologists have connected these events with climatic changes and overexploitation of the land (*Özdoğan 1999.232*). The migration from Northern Mesopotamia to the north and west and formation of the lowest layers at Yumuktepe were suggested as well (*Caneva 1999.113*).

The migration of some small groups of the Anatolian population along the eastern shore of the Black Sea was also possible. The similarity of the pottery found at the Chokh site in the Northern Caucasus to pottery in Northern Mesopotamia, as recorded by Shnirelman (*Shnirelman 1989.85*), has confirmed this migration. *Triticum dicoccon*, *Triticum monococcum*, *Hordeum vulgare* and *Hordeum vulgare var. Coeleste*; the bones of cattle and ovicaprids were found at this site, which is dated to *c.* 6900 calBC (*Amirkhanov 1987*).

Penetrations of some groups of ancient populations from the South to Northern Caucasus during dry periods are well known for prehistory and ancient history. For example, the origin of the Maikop culture was connected with such migration after the most extreme drought *c.* 5200–5000 uncalBP (*Korenevskiy 2001*). We may assume that the origin of Rakushechny Yar culture was related to that Early Neolithic migration.

Thus, for the second stage, two secondary centers of neolithisation are known in the south of Eastern Europe: eastern (in the Northern Caucasus) and western (in the Low Don region). They mainly coincide with two variants of the Neolithic tradition as distinguished by Shnirelman, *i.e.*, western, to which – in my opinion – the Rakushechny Yar culture is close, and eastern, represented by Chokh (*Shnirelman 1989.85*). The influence of traditions of the eastern variant has been not traced in the steppes of Eastern Europe, probably because their

Site and context	Material	Index	BP	calBC (2σ) *	Reference
Matveev Kurgan 1	charcoal	GrN–7199	7505±210	6424–6381	*Krizhevskaya 1992*
Zankovtsy 2, lower layer	animal bone	Ki–6694	7540±65	6439–6404	*Telegin et al. 2000*
Soroki 2, third layer	charcoal	Bln–588	7515±120	6428–6392	*Markevich 1974*
Soroki 2, second layer	charcoal	Bln–587	7420±80	6363–6239	*Markevich 1974*
Girzhevo	animal bone	Ki–11240	7390±100	6343–6226	*Man'ko 2006*

Tab. 2. Radiocarbon dates of the Grebeniki type settlements (* calibrated by OxCal v.4., after* Bronk Ramsey 2009*).

bearers occupied mountain areas. The steppe population of the Northern Azov Sea area appeared to have been more interactive. It is probable that the Early Neolithic of eastern Europe was formed solely under its influence.

The third phase of the neolithisation of the east European steppe was connected with a period of damp climate from *c.* 6500–6300 calBC. The forest spread along the river valleys and there were favorable conditions for life in the steppe. The main areas of steppe were covered by meadows, typical now of the more northern part of the steppe zone (*Levkovskaja 1992.176*). Flood-land woods consisting of birch, elms, lindens, oaks, hornbeams, and maples expanded. Hazel, buckhorn, cornelian-cherry-tree, guelder rose, elder-grove were represented in undergrowth. It should be stressed that the majority of these plants form the bush component of the ravine woods of the steppe zone. Alder and willow grew in moist places; pines was widespread on sandy terraces.

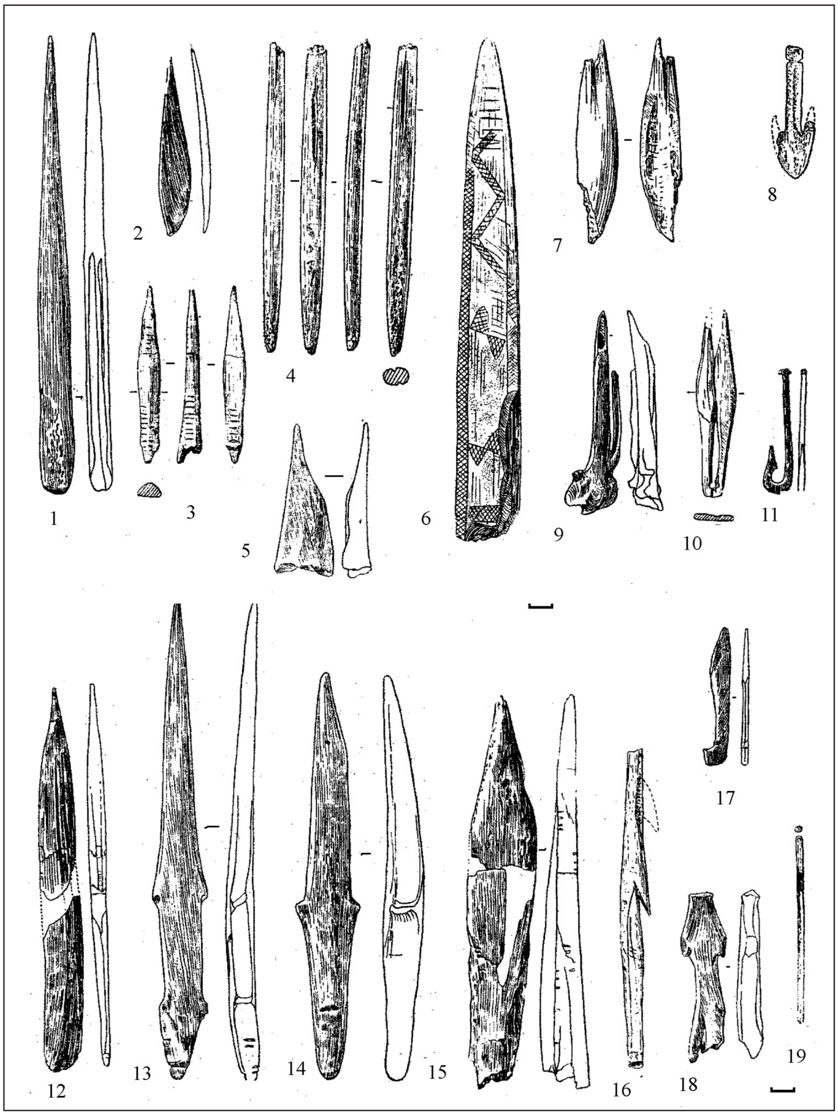

Fig. 7. Materials of the Surskaja culture from the site 1 (1–10) and 2 (11–19) on the Surskoy Island.

This was the period of the sites of the Late Grebeniki type in the steppe between the Dniestr and Don rivers. The center of this cultural group was the Grebeniki culture, located in the western part of this region (*Stanko 1997.118*), but a few sites have been

Site and context	Index	BP	calBC (2σ) *	Reference
Vasilievka 2 cemetery	OxA–3806	8020±90	7051–6838	*Telegin et al.* 2000
Vasilievka 2 cemetery	OxA–3804	7920±85	6824–6693	*Telegin et al.* 2000
Vasilievka 2 cemetery	OxA–3805	7620±80	6471–6443	*Telegin et al.* 2000
Marievka cemetery, grave 4	OxA–6199	7955±50	7029–6773	*Telegin et al.* 2000
Marievka cemetery, grave 4	Ki–6782	7680±90	6568–6468	*Telegin et al.* 2000
Marievka cemetery, grave 14	OxA–6269	7630±110	6477–6448	*Telegin et al.* 2000
Marievka cemetery, grave 14	Ki–7600	7650±100	6496–6460	*Telegin et al.* 2000
Marievka cemetery, grave 10	OxA–6200	7620±100	6471–6443	*Telegin et al.* 2000
Marievka cemetery, grave 10	Ki–6781	7585±80	6459–6432	*Telegin et al.* 2000
Marievka cemetery, grave 10	Ki–6779	7550±80	6443–6413	*Telegin et al.* 2000

Tab. 3. ^{14}C dates obtained of human bone samples from Vasilievka 2 and Marievka cemeteries (* calibrated by OxCal v.4., after* Bronk Ramsey 2009*).

found in the Azov Sea region (Fig. 3). During the previous drought, only a few Kukrek culture inhabitants lived in the territory near the Sea of Azov. In the steppe near the Black Sea, a region more humid than the Azov Sea area, the population of the Grebeniki culture was preserved during the first half of the VII millenium BC. When the climate became more humid, the Grebeniki population started to penetrate to the steppe near the Azov Sea. The most interesting sites are known at the periphery of the Grebeniki group: the Matveev Kurgan and Kamennaya Mogila 3, near the Sea of Azov, and the Aceramic layers of Soroki in the forest-steppe zone of the Dniestr.

These settlements have given some evidence of a productive economy and ceramics. Domestic cattle and pig bones were found at the Soroki sites in the Middle Dniestr (*Markevich 1982*). The bones of cattle and a few shards without ornamentation were discovered at the Kamennaya Mogila

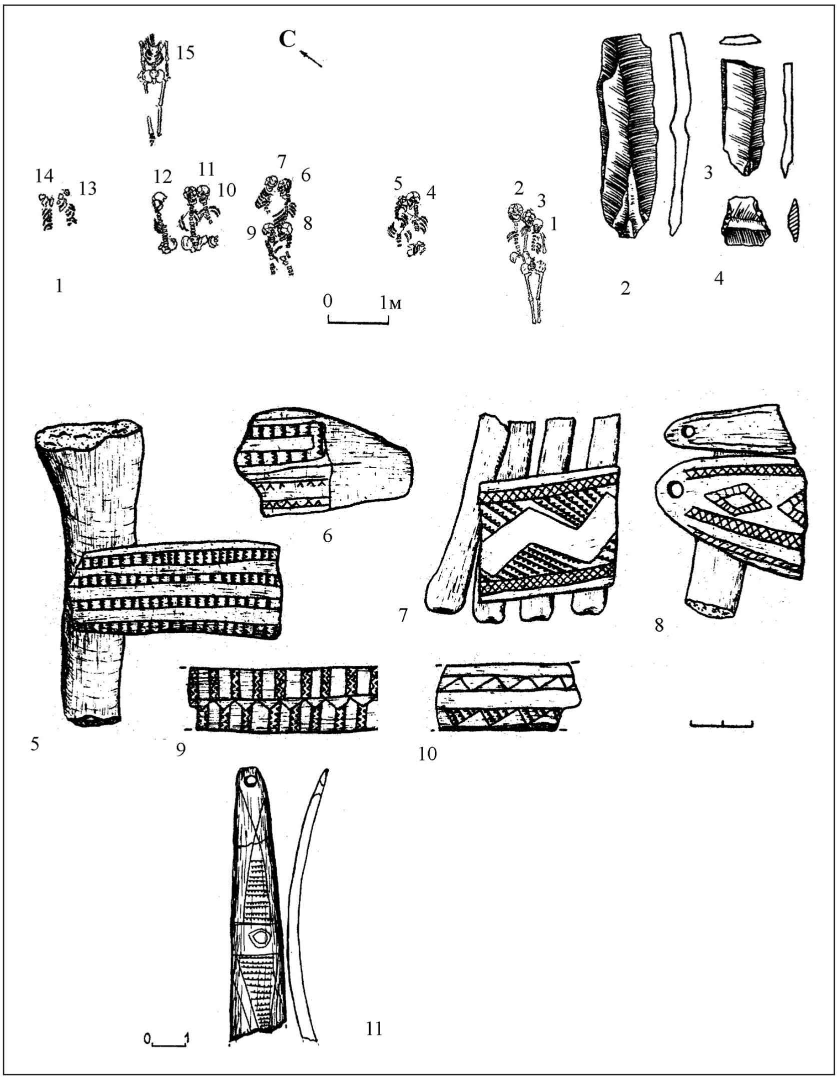

Fig. 8. Plan and grave goods of the Marievsky cemetery (1–4) (after* Bodjansky 1956*); grave goods of Vasilievsky 2 cemetery (5–10) (after* Telegin 1991*); the Kizlevy 5 site (11).

Site and context	Index	BP	calBC (2σ) *	Reference
		The first period		
Surskoy Ostrov 2, lower layer	Ki–6691	7245±60	6227–6015	*Kovaliukh and Tuboltsev 1998*
Surskoy Ostrov 2, lower layer	Ki–6690	7195±55	6213–5988	*Kovaliukh and Tuboltsev 1998*
		The second period		
Semenovka 1, lower layer	Ki–7679	7285±70	6351–6012	*Kotova 2003*
Semenovka 1, lower layer	Ki–6689	7125±60	6199–5847	*Kovaliukh and Tuboltsev 1998*
Semenovka 1, lower layer	Ki–6688	6980±65	5988–5737	*Kovaliukh and Tuboltsev 1998*
Semenovka 1, lower layer	Ki–7678	6850±70	5886–5630	*Kotova 2003*
Kamennaya Mogila 1, layer of the Surskaya culture	Ki–4022	7250±95	6362–5926	*Telegin et al 2000*
Kamennaya Mogila 1, layer of the Surskaya culture	Ki–4226	7170±70	6217–5911	*Telegin et al 2000*
Kamennaya Mogila 1, layer of the Surskaya culture	Ki–7667	7055±60	6049–5797	*Kotova 2003*

Tab. 4. ^{14}C dates obtained from animal bone samples of the Early Surskaya culture (* calibrated by OxCal v.4., after* Bronk Ramsey 2009*).

3 site (*Tuboltsev 1995*). Domestic cattle, pig, horse, sheep and goat are known from the sites of the Matveev Kurgan group. The pollen of cereals and associated weeds were defined for the cultural layer of Matveev Kurgan 1 (*Krizhevskaya 1992*). Oval wattle-and-daub houses were also discovered there (Fig. 4). Hunting played an important role in the economy: wild boar, red deer, and roe deer inhabited the forests near rivers. Wild horses (Tarpan and Kulan), and wild donkey lived on the steppe between river valleys. All of them were hunted, supplementing the products of cattle husbandry.

The population of the Matveev Kurgan group were probably in contact with the bearers of the Rakushechny Yar culture. These contacts can explain the first ceramics and more advanced character of the economy of the Matveev Kurgan group in comparison with the economy of other synchronous sites. In that period, the East European type of animal husbandry was formed in the Azov Sea area. It was characterized by the complete absence – or insignificant numbers – of pigs, and a preponderance of horse, cattle, sheep and goat (*Kotova 2003*).

When the bearers of the Grebeniki culture occupied the south region of the steppe near the Azov Sea, there was a Mesolithic Kukrek population on the central and northern part of the steppe along the Dnieper River. Perhaps the Vasilievka 2 and Marievka cemeteries belonged to that Late Mesolithic population. According to the radiocarbon dates, these cemeteries functioned *c.* 6900–6300 calBC. But it is possible that they are earlier, taking into account a reservoir effect.

The fourth phase of neolithisation is dated around 6300–6000 calBC. It was connected with the greatest aridity of the Atlantic period (*Spiridonova and Lavrushin 1997*), which was not a local phenomenon. It has been fixed in Anatolia and various parts of Europe, and connected with the dissemination of the farming and, with it, the onset of neolithisation in Europe (*Todorova 1998.68; Weninger et al. 2005; Budja 2007*).

Living conditions deteriorated in the steppe zone during the arid period: the forest in the river valleys disappeared, along with the forest animals. Steppe animals also suffered from the drought. As zoologists emphasize, extended aridity can reduce the food value, including vitamins, of forage. Poor nutrition reduces fertility in herbivores, sharply reducing herd sizes. In addition, mortality become considerably higher due to starvation and plague, and because of natural disasters and predators activity (*Ognev 1951. 215*). Therefore, long-term drought seriously reduces the available hunting resources of steppe regions and could be precisely the impulse that resulted in the wide distribution of domesticated animals and the adoption of pottery.

	Surskoy Ostrov 1	Surskoy Ostrov 2
Bos taurus L.	4–2*	114–23
Capra and Ovis	–	1–1
Sus domestica Gray	2–1	3–2
Equus caballus L.	–	30–7
Canis familiaris L.	1–1	6–5
In total domestic animals	**7 – 4–12%**	**154 – 38–49%**
Cervus elaphus L.	84–17	124–27
Bos primigenius Bojanus	79–11	1–1
Capreolus capreolus L.	–	2–1
Sus scrofa L.	15–4	1–1
Canis lupus L.	–	7–3
Lepus europaeus Pallas	20–10	4–3
Vulpes vulpes L.	20–8	5–3
Meles meles L.	2–1	–
Spalax mycrophtalmus Nordm	1–1	–
Castor fiber L.	–	2–1
In total wild animals	**221 – 60–88%**	**146 – 40–51%**
In total animals	**228 – 64**	**300 – 78**

Tab. 5. Faunal remains of the Surskaya culture (*The first figure is the number of the bones; the second figure – the minimum quantity of the species; the third figure – the percentage of the species from the total number of the animals listed here and in other tables).

At the beginning of this arid period, the steppe population began to move to more humid regions: the basins of such big rivers as the Dnieper, Dniestr and Don, the northern part of steppe and to the forest-steppe zone. In these regions the Early Neolithic population retained old type of economy, with hunting playing a prominent role. But these migrations changed the cultural situation in the south of Eastern Europe.

At the beginning of this arid period, around 6300 calBC, two new Neolithic cultures appeared. The first was the Surskaya culture in the Middle Dnieper region (Fig. 5). The migration of the Grebeniki population from the Azov Sea steppe area to the Dnieper valley, where the big river mitigated the dry conditions, resulted in their coexistence with local Kukrek inhabitants and the formation a new culture on the bases of their respective traditions. It was probably at that time that pottery with line and pit ornamentation, polished tools and domestic pigs were borrowed from the Rakushechny Yar culture. The point-bottom pots and complicated band composition of ornamentation may be considered as the local innovations (Figs. 6.3, 19–23). Stone pots were also typical of the Surskaya culture (Figs. 6.1, 6.2).

The oldest site of the Surskaya culture is Surskoy Island 1 in the northern part of the steppe zone in the Dnieper valley (Figs. 6.1–18; 7.1–10). This site probably dates to the beginning of the drought, when forest with numerous wild animals (red deer, roe, wild boar and Bos primigenius) persisted in that region. This is why their bones are predominant in this collection, with the presence of only cattle and domestic pig –

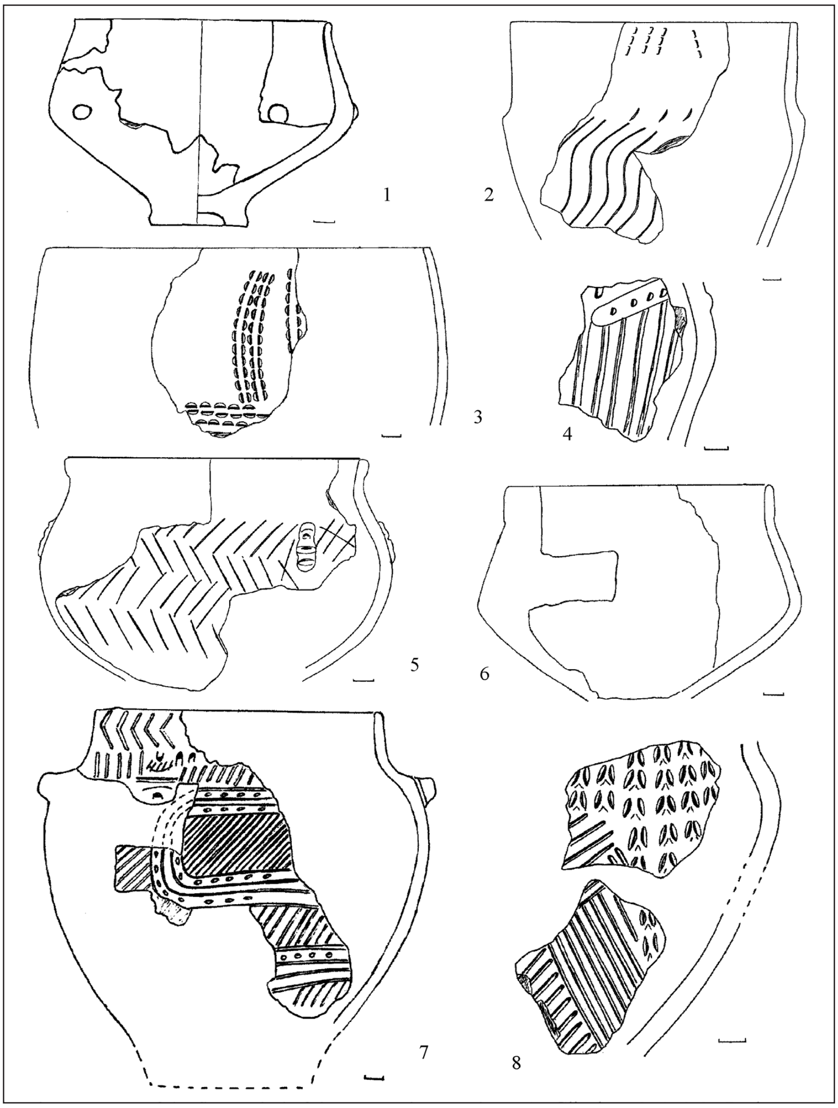

Fig. 9. Pottery of the first period of the Bug-Dniester culture: 1 Glinskoe; 2, 4, 6, 8 Pechera; 3, 5 Sokoltsy 6; 7 Sokoltsy 1.

Site and context	Index	BP	calBC (2σ) *	Reference
Sokoltsy 2, lower layer	Ki–6697	7440±60	6439–6213	*Telegin et al. 2000*
Sokoltsy 2, lower layer	Ki–6698	7405±55	6416–6101	*Telegin et al. 2000*
Mitkov Ostrov, lower layer	Ki–6695	7375±60	6388–6090	*Telegin et al. 2000*
Bazkov Ostrov, lower layer	Ki–8166	7410+65	6426–6099	*Kotova 2003*
Bazkov Ostrov, lower layer	Ki–8167	7270+70	6336–6004	*Kotova 2003*
Bazkov Ostrov, lower layer	Ki–6651	7235+60	6225–6009	*Telegin et al. 2000*
Bazkov Ostrov, lower layer	Ki–6696	7215±55	6217–6002	*Telegin et al. 2000*
Bazkov Ostrov, lower layer	Ki–6652	7160+55	6208–5913	*Telegin et al. 2000*
Pechera, lower layer	Ki–6692	7260±65	6241–6008	*Telegin et al. 2000*
Pechera, lower layer	Ki–6693	7305±50	6329–6054	*Telegin et al. 2000*
Pechera, lower layer	Ki–8164	7205+70	6227–5929	*Kotova 2003*
Sokoltsy 1, lower layer	Ki–8165	7260+80	6351–5988	*Kotova 2003*
Dobrjanka 3	Ki–11105	7400±130	6356–6228	*Man'ko 2006*
Dobrjanka 3	Ki–11104	7320±130	6230–6095	*Man'ko 2006*

Tab. 6. ^{14}C dates obtained from animal bone samples of the first period of the Bug-Dniestr culture (* calibrated by OxCal v.4., after **Bronk Ramsey 2009*).***

the forest in the Dnieper valley was a favorable area for pasturing only these types of domestic animal.

It is possible that the Vasilievka 2 and Marievka cemeteries date to the first period of the Surskaya culture, too (Fig. 8.1–11). Their burial rites are very similar to other Surskaya cemeteries – Vilno, Vovnigi 1 (*Kotova 2003*). The common features are extended skeletons with the south-north orientation, and grave goods that include bone points, middle flint blades and, fish and red deer teeth. Tuboltzev has noted the common types of ornamented bone goods at Surskaya settlements and from the Vasilievsky 2 cemetery (*Tuboltsev 2003.40*) (Figs. 7.6; 8.5–11).

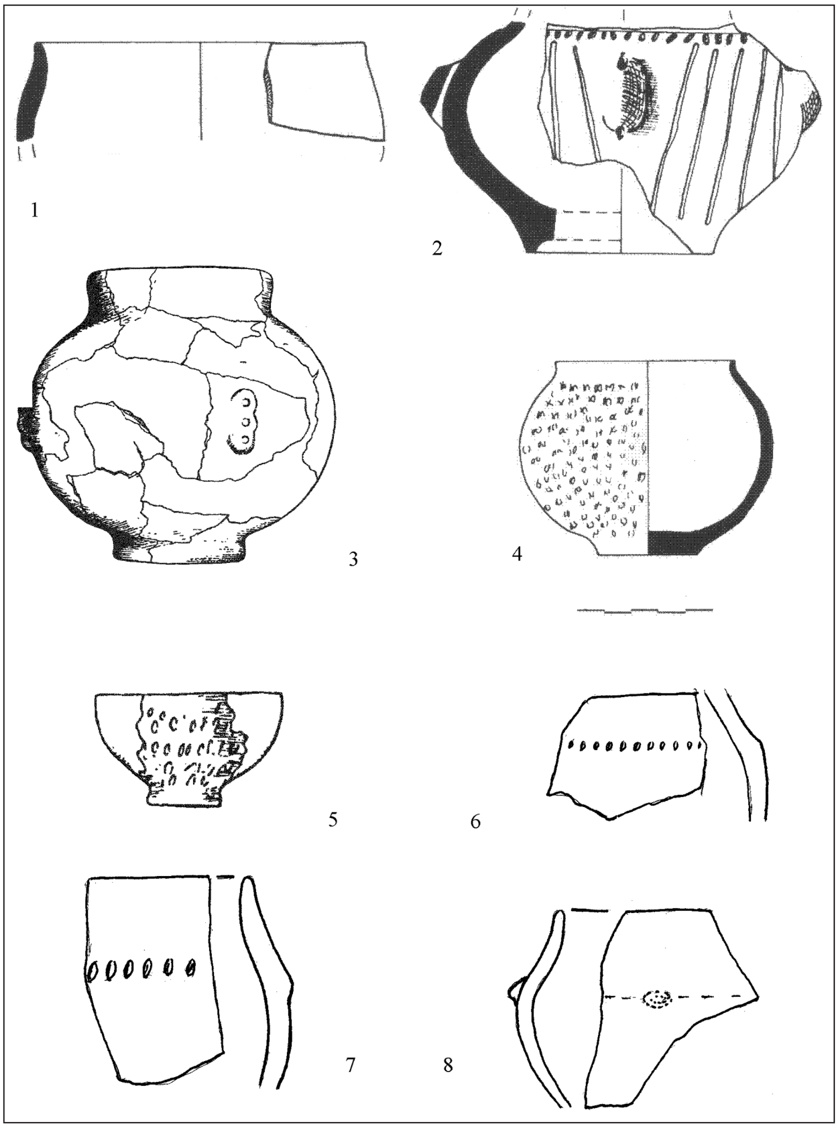

Fig. 10. Pottery of the Early Neolithic sites of the Balkan region: 1, 2 Koprivec; 3 Poljanitsa (after **Stefanova 1996*****); 4, 5 Donja Branjevina, layer 2–3 (after*** **Titov 1996*****); 6–8 Grivac (after*** **Bogdanović 2006*****).***

At around 6300 calBC, a new, Bug-Dniestr culture originated in the South of modern forest-steppe between the Bug and Dniestr. Its formation was very complicated and included local components (Grebeniki and Kukrek cultures) and two cultural impulses (from west and east). The flint tools were the heritage of local cultures. Most of the pottery was connected with a western cultural impulse (Fig. 9). It has an organic or sometimes invisible admixture. The pottery consisted of cups on pedestals and flat-bottomed pots with low necks and globular bodies. This pottery was ornamented with finger pinches, plastic bands, knobs on the ribs, and handles. All these features have analogies in the Early Neolithic of the Balkan region (Fig. 10).

The Bug-Dniestr ceramics are similar to the Monochrome pottery of the Balkan region, with the closest to the Ukrainian sites with Monochrome pottery being found in Bulgaria and Serbia (*Stefanova 1996; Karmanski 1989; Bogdanović 2006*). The oldest of these have been dated to *c.* 6500–6400 calBC (*Weninger et al. 2005*).

The sites of the first period of the Bug-Dniestr culture probably constitute the most easterly group in Europe having the Monochrome pottery. Western elements in the Bug-Dniestr culture have two explanations. They can be a result of the separate migration of the Early Neolithic population from the Balkan region to the Middle Dniestr basin at *c.* 6300 calBC. However, I do not reject the idea that pottery and some elements of productive economy were borrowed from the western population.

It is interesting that similar sites have not been discovered in Romania, although it is understandable, because sites with Monochrome pottery are not numerous everywhere, and may perhaps be found in Romania, as well.

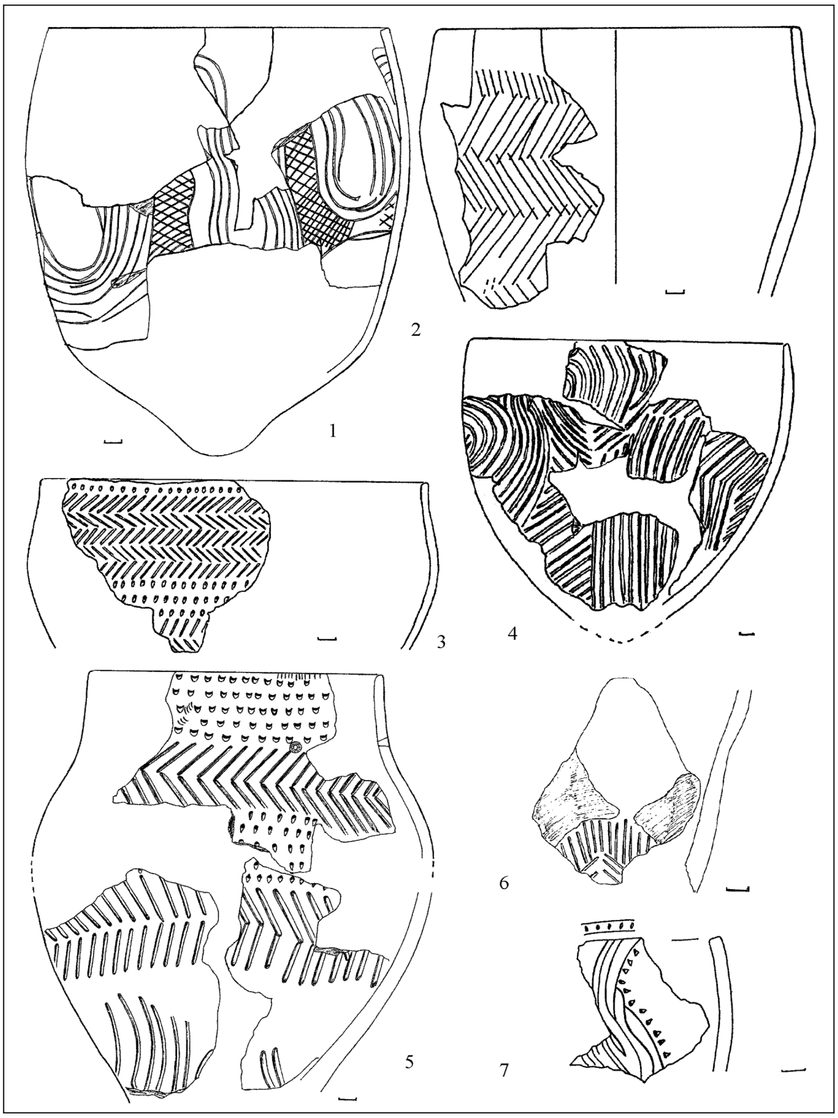

Fig. 11. Pottery of the first period of the Bug-Dniester culture: Bazkov island, lower layer (1, 2, 7); Sokoltsy 2 (3–6).

The eastern component of the Bug-Dniestr culture consists of linear and impression ornamentation on a few pots with point bottoms (Fig. 11). These elements are similar to the steppe Neolithic pottery and could have been borrowed from the Neolithic populations of the Dnieper and Azov Sea area (Figs. 1.6, 10; 2.4–6). But another explanation is also possible. These types of ornamentation and point-bottom pots could have been innovations which appeared in the midst of Bug-Dniestr population.

The animal husbandry of the Bug-Dniestr culture consists of two herd compositions. Dniestr herd structure was based on cattle and pig breeding. These domestic animals were known early in this region, at the Aceramic Grebeniki sites (Soroki 2). The structure did not change during the transition to the Pottery Neolithic.

Bug herd structure consists of cattle, pig, horse, sheep and goat (*Kotova 2003*). The composition testifies that the animals have been introduced from the eastern steppe region, where they were bred since 6900 calBC.

Numerous finds of hoes, grind stones and pestles at settlements allowed Danilenko (*1969*) to assume that the Bug-Dniestr inhabitants were engaged in agriculture. As he emphasized, the territory of the Bug variant had included a zone of broad-leaved woods with occasional meadows. Only river banks and islands with fertile loess-silt soils accumulating during spring and autumn next to river ridges were suitable for agriculture. The topographical arrangement of fields caused the topography of sites to be located on banks, shores and islands.

Janushevich and Pashkevich investigated the imprints of cultivated plants on Bug-Dniestr pottery (*Markevich 1974. 152–153; Kotova 2003*). Judging from the results of that study, the Bug-Dniestr population in the Dniestr basin *c.* 6300–5900 calBC cultivated *Triticum monoccocum* and *Triticum dicoccom*, as well as *Triticum spelta*. The people of the Bug variant cultivated *Hordeum vulgare*, *Panicum miliaceum*, and, probably, *Linum usitatissimum*. These data allow the assumption that the set of cultivated plants of the Bug variant was introduced together with conical-bottom pottery and cattle breeding from the steppe area. The agriculture was practiced by Matveev Kurgan group since 6500–6300 calBC. However, *Hordeum vulgare*, *Hordeum vulgare var. nudum* and *Panicum miliaceum* were cultivated in the Northern Caucasus at the Chokh site at about 6900 calBC.

The cultivated plants of the Dniestr variant could have been borrowed from the Early Neolithic population of the Balkan region, together with pottery.

At about 6200 calBC, at peak aridity, the natural zones moved north. The steppe landscape occupied the forest-steppe zone (*Spiridonova and Lavrushin 1997*). The southern steppe became unfavorable to life. The central area could not provide sustenance for many people and some groups of the Rakushechny Yar, Surskaya and Bug-Dniestr populations moved north along the rivers and tried to find a habitable landscape and maintain the traditional economy. Due to this expansion, the neolithisation of the modern forest-steppe and forest zones of Ukraine and Russia began. For example, the big Dnieper-Donets culture was formed in Ukraine (*Kotova 2003*).

In this period, the valleys of the smaller rivers in the southern and central steppe probably became depopulated or were visited only occasionally. According to radiocarbon dates from Semenovka 1 and Kamennaya Mogila 1, some groups of Surskaya bearers dwelt in the basin of the Molochnaja River (Tab. 4). But the basic area of the Surskaya culture was the northern part of the modern steppe zone in the Dnieper valley.

During the drought, Surskoy Island 2 was inhabited in that region (Tab. 4; Figs. 6.19–23; 7.11–19). Cattle breeding and hunting (red dear, roe deer and wild boar) produced equal percentages of meat for the Surskaya inhabitants (Tab. 5). Cattle were the most numerous in herds, but some horses, pigs and a few ovicapries were also bred. Fishing played an important role.

A wet period replaced this long period of severe drought around 6000 calBC. At first, the maximum extent of the pine woods was in the western Asov Sea area, near the Molochnaja River (*Bezus'ko et al. 2000*). The Neolithic population began to return to the southern steppe. This was the beginning of the Middle Neolithic in the Pontic steppe, a period connected with a modification of the old Neolithic cultures and the formation of new ones.

Thus the expansion of the Neolithic package in the Northern Black Sea steppe was a long process, with four stages. Modifications in culture and economy were associated with climate change. The peculiarity of the Pontic steppe is ease of response to climate changes. During arid conditions, life in the region deteriorated and most of the population migrated to northern areas and maintained the traditional economy, in which hunting played a significant role. Fewer people changed economic strategies and adapted to the new climate and vegetation. One variant of adaptation was to borrow early animal husbandry, agriculture and pottery. During the wet period, people returned in the south. All these migrations and, as a result, contacts with different cultures, modified the culture of the steppe population.

It is possible that neolithisation on the Northern Black Sea steppe began around 7500 calBC with early animal husbandry in the Western Azov Sea area. According to provisional data, the local population bred cattle, horse, sheep and goat. The second stage of neolithisation (6900–6500 calBC) was connected with the origins of the Rakushechny Yar culture in the Lower Don region. This population used pottery and bred cattle, pig, sheep and goat. The beginning of this stage coincides with an arid period around 7000–6900 calBC. The third stage of neolithisation (6500–6300 calBC) took place during a wet period, when the Grebeniki population migrated east and occupied the steppe zone from the Dniestr to the Don. In addition to early animal husbandry, the steppe population borrowed the first pottery from the Rakushechny Yar culture.

The period of aridity around 6300–6000 calBC played a key role in the neolithisation of Eastern Europe, with the Surskaya and Bug-Dniestr cultures appearing when it began. When the drought was at its most severe and the steppe landscape spread to the modern forest-steppe and forest zones, northward population movement increased, and neolithisation began in those areas.

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Three successive waves of Neolithisation: LBK development in Transdanubia

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ABSTRACT – *Due to the latest research, the LBK formation in Transdanubia must have involved an essentially Mesolithic subsistence, complemented by certain elements of the Neolithic package brought here by migrant late Starčevo groups. Many small sites were located in marshy areas, unsuitable for food production as a basis of livelihood. The currently available evidence suggests that there was a 4–5 generations long period, when it was not self-evident that the sedentary way of life would be fully accepted and adopted. During the ensuing earlier LBK period, the culture spread across the entire area of Transdanubia and a few settlements were even established on the left Danube bank, still, no substantial changes can be noted in the density of the settlement network and the layout of the settlements. In sharp contrast to the preceding period, the Keszthely and Notenkopf phases saw the settlement of larger communities on arable loess plateaus and the adoption an economy based exclusively on farming. New evidence from 53rd century BC sites such as Balatonszárszó-Kis-erdei-dűlő reflects fundamental changes in the size and layout of settlements, as well as in subsistence strategies.*

IZVLEČEK – *Zadnje raziskave so pokazale, da je morala biti pri nastanku LTK v Transdanubiji vključena močna mezolitska gospodarska osnova z elementi neolitskega paketa, ki je prispel s selitvijo Starčevo skupine. Mnogo malih najdišč se nahaja na močvirnih področjih, neprimernih za kmetovanje. Podatki kažejo, da se je sedentarni način življenja uveljavil v času 4–5 generacij. V času zgodnje LTK se je kultura razširila na celotnem področju Transdanubije. Nekaj naselij je bilo postavljenih celo na levem bregu Donave. V tem času ni opaznih bistvenih sprememb v poselitvenem vzorcu in obliki naselbin. Očitna sprememba nastopi v fazi 'Keszthely' in fazi 'ornamenta v obliki not', ko naselja postanejo večja in so postavljena na terasah orne puhlice. Gospodarstvo temelji izključno na kmetovanju. Najdišča Balatonszárszó-Kis-erdei-dűlő iz 53 stoletja BC dokazujejo temeljne spremembe v velikosti in obliki naselja ter gospodarskih strategijah.*

KEY WORDS – *Transdanubia; neolithisation; LBK periods and phases; settlement patterns*

Earlier models of the neolithisation of Europe hypothesising a single wave of colonisation and a single-event scenario have in recent years been supplanted by more complex ones offering a fresh perspective on this process, which is now seen as involving interaction and reciprocal cultural impacts, with a focus on the gradual transformation of subsistence strategies. New approaches have been developed for the study of settlement patterns, the archaeological heritage, social organization and, also, ideology.

While studies written from an 'indigenist' or, conversely, a 'migrationist' perspective both have much to contribute to a better understanding of neolithisation, there can be little doubt that the transition to the Neolithic in the Carpathian Basin can best be described by scenarios combining the two, by an 'integrationist' approach. It is not mere chance that studies arguing for both immigrant and indigenous contributions to the process offer the most fruitful ideas, even if elaborated for geographic regions other than the one discussed here (*Zvelebil 1986; 2000; 2001; Gronenborn 1994; 1999*). The gradual nature of the transition has been documented in more distant regions, too: for example, Catherine Perlès has convincingly argued that the neolithisation of the Balkans should probably not be conceived of as a direct diffusion from Anatolia (*Perlès 2005*), but more likely as the outcome of two geographically and chronologically distinct population movements, one a maritime migration from the Levant and the southern Turkish coast, the other an overland migration towards Bulgaria (*Özdoğan 1997; 1999; 2000*). In neither case, however, was the full Neolithic package adopted. According to Perlès, the cultural elements which were not introduced to the newly colonised areas were in part deliberately rejected and in part suppressed by local traditions. These examples offer good parallels to other regions such as the Carpathian Basin: following the transition to the Neolithic in the Balkans, the Early Neolithic, which can be conceptualised as phases of dynamic innovation alternating with more tranquil periods of settlement, proceeded at varying rates in various regions, including the southern frontiers of Transdanubia.

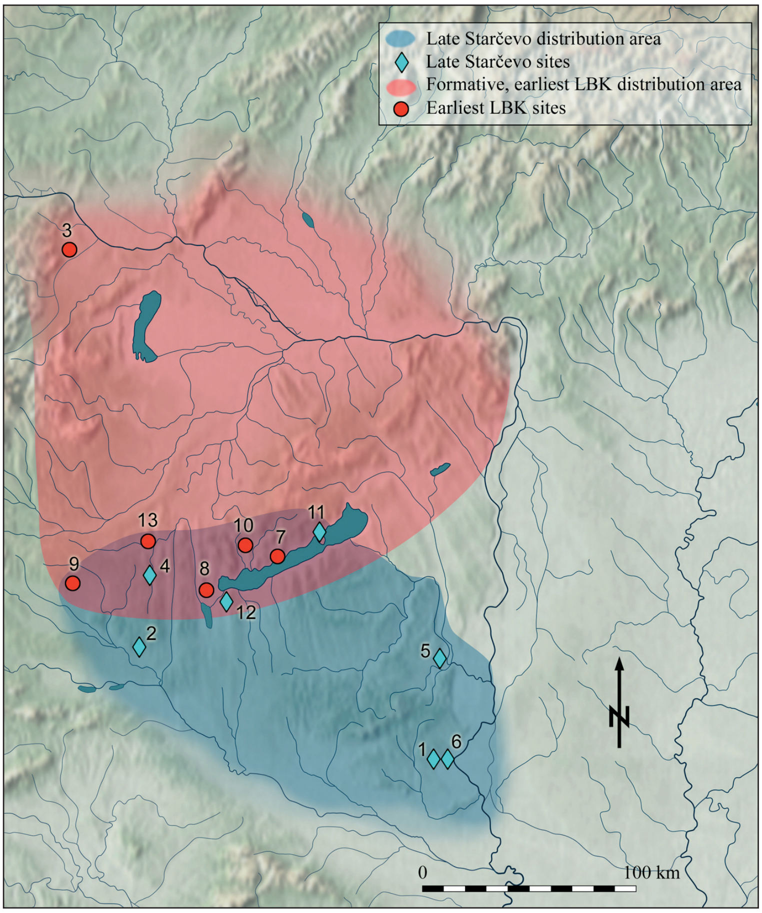

Fig. 1. The late Starčevo and formative, earliest LBK distribution in Transdanubia with some important sites: 1. Babarc; 2. Becsehely I-Bükkaljai-dűlő; 3. Brunn am Gebirge; 4. Gellénháza-Városrét; 5. Harc-Nyanyapuszta; 6. Medina; 7. Révfülöp; 8. Sármellék; 9. Szentgyörgyvölgy-Pityerdomb; 10. Tapolca-Plébániakert; 11. Tihany-Apáti; 12. Vörs-Máriaasszonysziget; 13. Zalaegerszeg-Andráshida-Gébárti-tó.

In this sense, Transdanubia (lying in the western part of the Carpathian Basin) shares certain similarities with the Balkans, in that the transition was a complex process. It became clear from the 1990s that the single most decisive impact stimulating the transition came from the late phase of the Starčevo culture, an immigrant group from the Central Balkans, which advanced as far as the Balaton region (*Kalicz 1990; 1993*). This model has only been challenged by a few prehistorians (*Pavúk 1994; 2004*). Postulating the significance of late Starčevo groups, but assuming also the participation of indigenous foragers in the process, an integrationist model was presented for Transdanubia, and it was furthermore suggested that this region played a key role in the neolithisation of the Danube Valley and, on a broader scale, of the greater part of Central Europe (*Bánffy 2004*). The new model of neolithisation was based on both the archaeological record and the findings of palaeo-environmental and micro-regional research projects (*Bánffy 2006a; Zatykó et al. 2007*), as well as new material recovered during the large-scale salvage excavations preceding motorway construction. In the light of more recent research and the growing body of evidence, a model of multiphase neolithisation can now be constructed. The earliest wave was the appearance of the Starčevo culture in southern Transdanubia, which will not be discussed here. The early LBK in Transdanubia can be divided into an earliest, formative phase, and an earlier phase (*Bánffy and Oross in press*), differing from the late LBK period in terms of settlement density and settlement layout, material culture, cultural connections with the Balkan Neolithic and subsistence strategies. Discussed in the following will be the revised LBK sequence for Transdanubia.

The research projects mentioned above yielded a wealth of new information, as well as a considerably more detailed picture of the emergence and development of the LBK. The dynamic changes from the beginning to the end of the LBK sequence are presented in a chronological and spatial model (Tab. 1). This model describes the entire LBK sequence as a

Fig. 2. Reconstruction of the two timber-framed buildings of the formative LBK settlement at Szentgyörgyvölgy-Pityerdomb.

series of transitional phases and the formation of new structures according to a certain rhythm in time. This rhythmic change can be noted both in time and space, and seems to have survived and to have had an impact during the centuries following the LBK period, *i.e.* in the Late Neolithic of Transdanubia, as reflected by the distribution of the Sopot culture of southern origin and, later, the Lengyel period, extending into the Early Copper Age and occupying a larger territory than the LBK. One point that clearly emerges from this sequence is that the fully sedentary, food producing Neolithic life-style cannot have evolved earlier than the late LBK period, corresponding to the Notenkopf and early Keszthely phases respectively, during the 53rd century BC.

The earliest, formative LBK

Aside from the already known fact that the Starčevo culture played a key role in the transition to the Neolithic, very little was known about the actual nature of the culture's impact, not to speak of the scanty information about the culture's distribution in Transdanubia and its settlement patterns, and especially about the mode(s) of contact and interaction with indigenous groups. It was earlier assumed that Transdanubia was devoid of Mesolithic foragers and that the LBK emerged from a peripheral branch of the Starčevo population (*Kalicz 1993*). Recent research has furnished data enabling a reconstruction of the peopling of central Transdanubia, with evidence for the presence of both Starčevo and indigenous forager groups (*Bánffy 2000; 2004; Bánffy et al. 2007*). A number of new Mesolithic sites have been identified, of which the Regöly site has been excavated (*Eichmann et al. in press*). The late Mesolithic settlements and their occupants appear to have played a major role in the transformation of the terminal Starčevo culture. The blending of diverse traditions can be noted in both the archaeological and palaeo-ecological record. Transdanubia can be divided into two main geographic regions during this period, with Lake Balaton in the centre (Fig. 1). This division was very probably a reflection of two distinct palaeo-ecological zones, separated by what has been termed the Central European-Balkan Agro-Ecological Barrier (CEB AEB) by Pál Sümegi and Róbert Kertész (*Sümegi and Kertész 2001*).

We now also have a better understanding of settlement patterns and settlement layouts. The generally small settlements formed smaller clusters, reflecting a loose system of farmsteads sited relatively close to each other. These sites shared one important feature, namely that they lay in areas unsuited to agriculture as a secure source of livelihood. The soil types and the hydrological conditions would have enabled no more than a form of horticulture combined with a few domesticated plants. At the same time, the marshland areas were excellent for hunting and fishing, as well as for gathering wild plants and fruit. Most sites were located directly by Lake Balaton or on islets in the region's marshland.

Our knowledge of the period's architecture is restricted to the two house plans from the Szentgyörgyvölgy-Pityerdomb settlement (Fig. 2). Uncovered at

Period/Phase		Northern Transdanubia	Central Transdanubia	Southern Transdanubia	Absoulute Chronology
Early LBK	Earliest LBK	Mesolithic and LBK	Formative LBK	Starčevo culture	5600/5500–5350 calBC
	Earlier LBK	Bicske-Bíňa phase			5450–5300/5250 calBC
		Milanovce phase			
Late LBK		Notenkopf	Keszthely		5300/5250–5000/4900 calBC
		Zseliz	Zseliz and Keszthely	Keszthely	

Tab. 1. Chronology and regional distribution of the LBK in Transdanubia.

this site were long pits (Längsgrube) flanking the houses and a substantial amount of burnt daub fragments, enabling the reconstruction of rectangular, timber-framed above-ground houses of the type current in the Central European distribution of the early LBK (*Bánffy 2004.35–47; Bánffy and Réti 2008*). However, the archaeological features noted at Szentgyörgyvölgy were insufficient to identify possible divergences from the internal timber structure of the early LBK houses in regions west of the Carpathian Basin. Given that not one single building has yet been found in the Hungarian Starčevo distribution, the possible Early Neolithic antecedents of the two buildings of the formative LBK phase can only be surmised from the few house remains excavated in the Great Hungarian Plain. While the Körös buildings unearthed at Tiszajenő-Szárazérpart (*Selmeczi 1969; Raczky 1976.Figs. 1–2*) and Szajol-Felsőföld (*Raczky 2006.381–383, Fig. 2a–c*) allow the reconstruction of above-ground houses, these can hardly be regarded as direct architectural antecedents of the Central European LBK. The Brunn II site in Austria is crucial to our understanding of the architecture of the formative LBK phase, and the detailed publication of the house remains from this site will no doubt shed light on several as yet little understood issues (*Lenneis et al. 1996.Abb. 3; Stadler 1999; 2005*). What is quite certain is that the residential buildings of the period were above-ground constructions and that pit-houses were not used as human dwellings.

Fig. 3. Vessel of the formative, earliest LBK from Szentgyörgyvölgy-Pityerdomb.

Another category of evidence is provided by pottery finds. The late Starčevo ceramics from the north-western fringes of the culture's distribution, *i.e.* from the Balaton region, can be assigned to a special and rather peripheral sub-type, which has much in common with the pottery of the formative LBK. The first evidence in this respect came from the Szentgyörgyvölgy-Pityerdomb site, which yielded a rich assemblage of some fifteen thousand pottery fragments. After identifying the main features of this pottery, a search for similar assemblages revealed that the few sites with a comparable ceramic inventory all lay around the lake and in the adjacent western Transdanubian region (*Bánffy 2006b.130–132, Fig. 5*), suggesting that while the earliest LBK pottery was undoubtedly produced in this region, the 'know-how' of pottery manufacture most certainly originated from the Balkans. Vessels were fired to a bright red colour at a low temperature; the fine wares often have a red slipped and polished surface and are occasionally decorated with lightly polished lines (Fig. 3). Vessel pedestals are often no higher than a foot-ring. Both sharply and more gently carinated forms occur among bowls with a concave upper part. The pottery shows strong affinities with the late Starčevo assemblages from the Balaton region and bespeaks an intensive connection between Balkanic immigrants and the formative LBK communities.

The single most striking feature of the lithic assemblage is the astonishing diversity of types. According to Katalin T. Biró, the many tool types are a reflection of a wide range of activities, such as hunting, fishing, gathering and, also, food production (*Biró 2001; 2002; 2006*). The raw material used almost exclusively for the manufacture of stone tools in the earliest LBK assemblages was red radiolarite from the Bakony Mountains, preferred not only by the Transdanubian Starčevo communities, but also by the early LBK migrants advancing along the Danube Valley. The presence of Szentgál radiolarite has been documented on Austrian and Moravian LBK sites, although in a decreasing proportion (*Mateiciucová 2001; 2002*), and even as far away as central Germany (*Gronenborn 1994; 1997; Zimmermann 1995*).

Taken together, the above suggest a transitional phase between Late Mesolithic and Early Neolithic subsistence strategies. The Mesolithic lithic tradition has much common with LBK manufacturing techniques: the similarities in tool-making technology can probably be interpreted as reflecting similarities in subsistence strategies (*Mateiciucová 2003; 2004*). The plants earlier tended as part of Late Mesolithic garden cultivation were most probably cultivated in small Early Neolithic fields (*Gronenborn 1999; Jeunesse 2003; Gehlen and Schön 2003*) and complemented with cereals. Domestic animals, such as sheep, goat and cattle, were brought to this region from the northern Balkans (*Halstead 1996*), enabling the diet to be enriched without a break in overall subsistence patterns. The first phase can thus be conceptualised as a slow transformation rather than a sweeping change.

The radiocarbon series for Szentgyörgyvölgy-Pityerdomb, based on ten measurements, indicated a uniform date of 5480–5340 calBC for the settlement's occupation (*Bánffy 2004.299–309*). These dates and the ones quoted in the following conform to a 1 σ confidence probability. The beginning of the Brunn am Gebirge site is put at 5620 calBC in some publications (*Stadler 1999.8*), while the date of Brunn IIa, the earliest site, has recently been defined as 5540–5210 calBC (*Stadler 2005.270*). The beginning of the radiocarbon ranges for the formative LBK phase cluster around two possible dates, 5600 calBC and 5480 calBC. Some calibration programmes also allow the beginning of calibrated ranges falling between 5560 and 5510 calBC. In the light of the available evidence, the emergence of the LBK in Transdanubia can be put between 5600 and 5500 calBC (*Bánffy and Oross in press*). The formative phase spanned a roughly 150–200 year period between 5600/5500 and 5400/5350 calBC. The absolute chronological dates also indicate contemporaneity with the latest Körös and Starčevo phases (*Oross 2007. 575–582, Tab. 27.18, Tab. 27.20*).

The earlier LBK period

The sites and assemblages discussed in the following were regarded as the earliest LBK period in the western half of the Carpathian Basin (*Kalicz 1978–79a*) before the discovery of the settlements at Szentgyörgyvölgy-Pityerdomb (*Bánffy 2000; 2004*) and Brunn II (*Stadler 1999; 2005*), which represent the culture's formative phase. The sites westwards of the Carpathian Basin, where no formative LBK assemblages have been found to date, are usually still designated as the earliest LBK (älteste LBK). Begun in the 1970s (*Kalicz and Makkay 1972*), research on the early LBK phases in Hungary received a new impetus with the excavations at Bicske-Galagonyás (*Makkay 1975; 1978*) and Becsehely (*Kalicz 1978–79a, 15, Taf. 2–7, 14; 1978–79b*). The first overview of this period, written by Nándor Kalicz, discussed the distinctive traits of the period's pottery and its chronology based on finds from fourteen sites (*Kalicz 1978–79a*). His study appeared at the same time as Juraj Pavúk's work on the early LBK period in Slovakia, which he divided into four phases (Nitra, Hurbanovo, Bíňa and Milanovce; *Pavúk 1980*).

LBK research soon established that the culture was distributed across all of Transdanubia (Fig. 4). The initially identified distribution territory

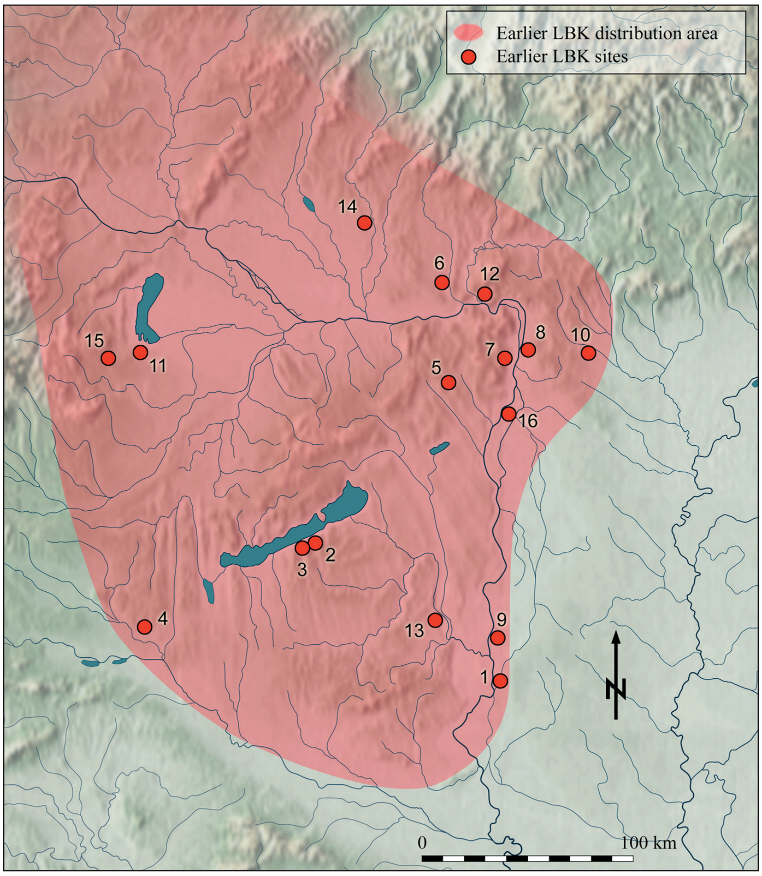

Fig. 4. The earlier LBK distribution in Transdanubia, with some important sites: 1. Baja-Bajaszentistván-Szlatina; 2. Balatonszárszó-Kis-erdei-dűlő; 3. Balatonszemes-Bagódomb; 4. Becsehely II-Homokos; 5. Bicske-Galagonyás; 6. Bíňa; 7. Budapest-Aranyhegyi út; 8. Dunakeszi-Székesdűlő; 9. Fajsz-Garadomb; 10. Galgahéviz; 11. Hidegség; 12. Ipolydamásd; 13. Medina; 14. Milanovce; 15. Neckenmarkt, 16. Szigetszentmiklós.

was later expanded to include sites in the wider Budapest area, such as Budapest-Aranyhegyi út (*Kalicz-Schreiber and Kalicz 1992*), Szigetszentmiklós (*Virág 1992*) and Dunakeszi-Székesdűlő (*Horváth 2002a; 2002b*). LBK settlements have also been identified in the narrow zone along the Danube's left bank along the river's southern Hungarian course, for example at Fajsz-Garadomb and Baja-Bajaszentistván-Szlatina, where the earlier occupants were communities of the Körös and not the Starčevo culture (*Kalicz 1994. 71–72, Abb. 1–5; 1995.26, 29, 55–56, Abb. 8, 12–14*). The extent of the LBK distribution in Hungary became complete with the sites discovered due east of the Danube, along the Zagyva, Tápió and Galga rivers (*e.g.* at Galgahéviz; *Kalicz and Kalicz-Schreiber 2001. 27, Abb. 1–3*). The period's Transdanubian sites are rather uniform, with no trace of the south-north division characterising the formative phase, when the terminal Starčevo sites in southern Transdanubia were still occupied. It should at this point be recalled that the LBK spread over large areas of Central Europe exactly during this period, and that its settlements in southern and central Germany, such as those at Eitzum (*Schwarz-Mackensen 1983; 1985*), Eilsleben (*Kaufmann 1982*), Niedermörlen (*Schade-Lindig 2002*) and Schwanfeld (*Lüning and Modderman 1981*), became firmly established at this time.

Fig. 5. Vessel of the Bicske-Bíňa phase from Balatonszárszó-Kis-erdei-dűlő.

In spite of the large-scale excavations conducted over the past two decades, many final details regarding the layout of the settlements and the settlement network are still unclear. Settlement features of the LBK, including house plans, burials and the section of an enclosure, have been uncovered over an area of 10 ha at Balatonszárszó-Kis-erdei-dűlő, a site investigated between 2000 and 2006 as part of the salvage excavations preceding the construction of the M7 Motorway connecting Budapest with Slovenia and Croatia (*Oross 2004a; 2004b*). The finds from three house plans and their associated features uncovered in the extensive Neolithic settlement's north-eastern part can be dated to the Bicske-Bíňa phase of the earlier LBK. Another house plan can be assigned to the later, Milanovce phase of this period (*Marton 2004.84–85, Fig. 3; 2008.202–203, Figs 1–3; Marton and Oross in press*). The layout resembled the one observed at Szentgyörgyvölgy-Pityerdomb, with the buildings sited relatively far from each other. At the same time, the two house plans excavated at the Dunakeszi-Székesdűlő site, dating from the same Milanovce phase of the earlier LBK, lay directly beside each other; however, there was nothing to indicate they were contemporaneous (*Horváth 2002a.6. kép 4; 2002b.Abb. 6. 4; 2004.Abb. 1*). The currently available evidence would suggest that no fundamental changes occurred either in settlement layout or in the density of the settlement network compared to the earliest, formative LBK phase.

The early LBK settlements of Central Europe which can be correlated with the Bicske-Bíňa and the Milanovce phases, such as those at Mohelnice (*Stäuble 2005.Taf. 85–87, 89; Tichý 1962*), Schwanfeld (*Stäuble 2005.Taf. 147–148*) and Nieder-Eschbach (*Stäuble 2005.Taf. 112*), are characterised by buildings with at least five rows of posts. The house structure of five rows of posts combined with outer bedding trenches (Außengraben) can be seen as a distinctive trait of early LBK buildings (*Lüning 1988; Stäuble 2005.167–178*). The presence of outer bedding trenches has not been documented in the culture's Hungarian distribution. The buildings from the earlier LBK period are among the most poorly preserved house plans of the Balatonszárszó settlement and thus their internal structure cannot be studied in detail. The two houses excavated at Dunakeszi-Székesdűlő were interpreted as atypical buildings, with three rows of posts (*Horváth 2002b.24–28; 2004*), even though they could equally well be reconstructed as buildings with five rows of upright timbers. In fact,

Fig. 6. Vessel of the Milanovce phase from Balatonszárszó-Kis-erdei-dűlő.

burnishing and spherical vessels decorated with a row of impressions under the rim enjoyed widespread popularity (*Kalicz 1994.69; 1995.41, 49*).

The pottery types described above, labelled Pattern I by Tibor Marton, are typical of the earliest phase of the Balatonszárszó-Kis-erdei-dűlő settlement (*Marton 2008.202–203, Fig. 2*). The ceramic inventory from Bicske, Bíňa, the north-eastern section of the Balatonszárszó settlement and several other sites is virtually identical, providing a firm basis for using the label 'Bicske-Bíňa phase' for describing the earlier LBK assemblages succeeding the culture's formative phase. Kalicz had earlier argued that the period's finds from Hungary had a uniform nature, making the identification of internal phases practically impossible (*Kalicz 1994.69*). However, a spatially well-circumscribed assemblage differing both from the Bicske-Bíňa type and the late LBK finds can be distinguished at Balatonszárszó. Biconical vessels have a rounded carination. Conical bowls become widespread. One popular decoration, typical of this phase, is a bundle of wavy lines encircling the vessel body (Fig. 6). These pottery assemblages, labelled Pattern II in the pottery sequence from Balatonszárszó, can be correlated with finds assigned to the Milanovce phase in Slovakia (*Marton 2008.203, Fig. 3*).

house plans with an axis aligned parallel to the long pits can only be gained with a reconstruction of five rows of posts (*Oross 2008*). The architectural evidence from Dunakeszi indicates that the standard LBK house with five longitudinal rows of posts had probably evolved by the earlier LBK period, or during this period at the latest in Transdanubia.

The legacy of the Starčevo culture in pottery forms and vessel decoration can easily be distinguished in the ceramic material. These include biconcal vessels with an out-turned neck and incurving upper part. Other surviving forms are low and medium high hollow pedestals, pannier vessels and amphorae. A variety of pinched decoration and nail impressions, small grooves, sprinkled and channelled barbotine, as well as stroke burnished patterns, too, can be regarded as a heritage of the Starčevo culture (*Kalicz 1994.68; 1995.29*). A previously unencountered variant of deep biconical bowls with strongly profiled neck and a sharp carination dividing the vessel into two equal halves can be regarded as the period's hallmark. The deeply incised linear designs adorning these vessels often include a bundle of three horizontal lines and two or three curved lines. These two motifs are generally repeated three times in an alternating design. The knobs set on the carination are also arranged in a triple symmetry. Vessels of this type have been found at Bicske-Galagonyás (*Makkay 1978.Pl. VI, 1–4*) and Bíňa in Slovakia (*Pavúk 1980.Abb. 5, 1–4*), as well as at Balatonszárszó (Fig. 5). Pedestals of both the high hollow and massive solid variety make an appearance during this period. Deeply incised linear motifs, vessels fired to a grey or black colour with polished surface, pattern

János Makkay noted the connection between the earlier LBK finds from Bicske-Galagonyás and the earliest Vinča assemblages (*Makkay 1978.30–31*). Kalicz discussed the possible relation between the early Vinča culture and the new traits of the pottery, such as solid pedestals, pattern burnished designs and the row of impressions under the rim, suggesting a meaningful relation between the emergence of the Vinča culture and the assemblages in question (*Kalicz 1994.69–70; 1995.49, 53–54*). In his recent analysis of an ornamental motif – incised curved lines arranged in a semicircle – Ferenc Horváth has argued for the strong influence of the early Vinča culture (*Horváth 2006.309–313*).

Not one single radiocarbon series has yet been published for the period's Hungarian sites. Some of the few available single dates lack the standard accompanying information, such as laboratory number and standard deviation (Budapest-Aranyhegyi út: *Kalicz*

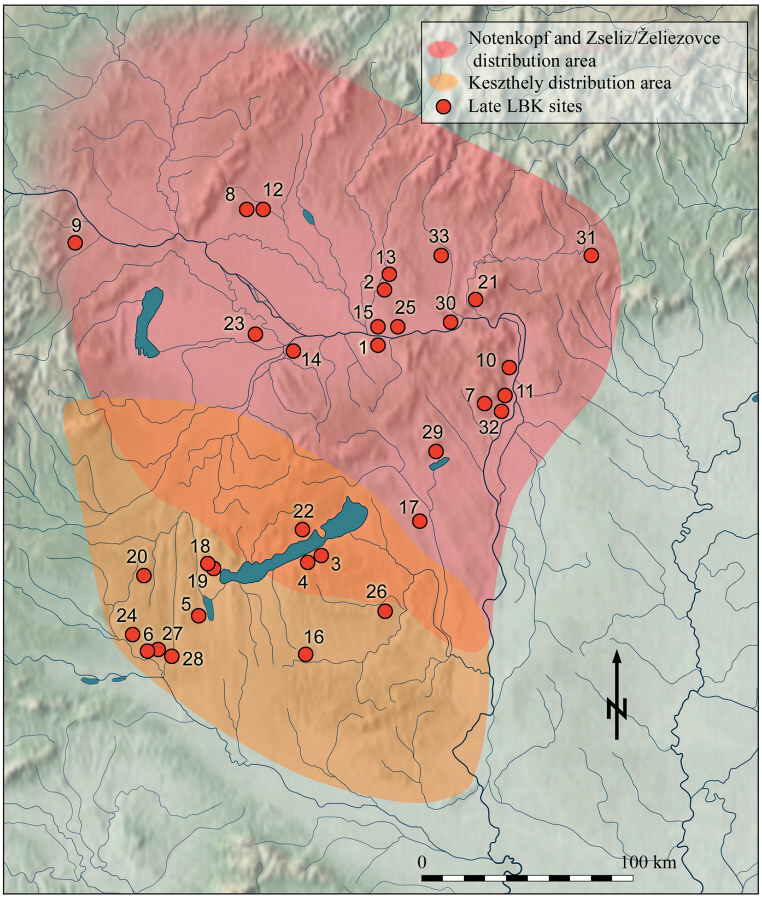

Fig. 7. The late LBK groups in Transdanubia (after* Kalicz 1991*) with some important sites: 1. Almásfüzitő-Foktorok; 2. Bajč; 3. Balatonszárszó-Kis-erdei-dűlő; 4. Balatonszemes-Szemesi-berek; 5. Balatonmagyaród-Kápolnapuszta; 6. Becsehely II-Homokos; 7. Biatorbágy-Tyúkberek; 8. Blatné; 9. Brunn am Gebirge; 10. Budapest-Békásmegyer; 11. Budapest-Kőérberek-Tóváros lakópark; 12. Čataj; 13. Dvory nad Žitavou; 14. Győr-Pápai vám; 15. Iža-Velky Harčas; 16. Kaposvár-Téglagyár; 17. Káloz-Nagyhörcsök; 18. Keszthely-Dobogó; 19. Keszthely-Zsidi út; 20. Kustánszeg-Lisztessarok; 21. Letkés; 22. Mencshely-Murvagödrök; 23. Mosonszentmiklós-Egyéni-földek; 24. Muraszemenye-Aligvári-mező; 25. Patince; 26. Pári-Altacker; 27. Petrivente-Újkúti-dűlő; 28. Sormás-Török-földek; 29. Sukoró-Tóra-dűlő; 30. Štúrovo; 31. Szécsény-Ültetés; 32. Törökbálint-Dulácska; 33. Želiezovce.

1995.53; Becsehely II-Homokos: *Barna 2005.23*), and their interpretation raises additional questions. The most secure chronological anchors for dating this period are the radiocarbon dates for the preceding formative phase and the succeeding late LBK period, as well as the dates for two sites in Austria: Strögen and Neckenmarkt (*Lenneis and Stadler 2002*), suggesting that the earlier LBK falls roughly between 5450 and 5300/5250 calBC in the western half of the Carpathian Basin. However, this broad date can hardly be a substitute for a later analysis based on a radiocarbon series, which can be securely correlated with a pottery sequence.

The late LBK period

The onset of the late LBK period is marked by the appearance of Notenkopf wares in northern Transdanubia and south-western Slovakia, and by Keszthely type pottery in southern Transdanubia. While Notenkopf wares were eventually succeeded by the pottery decorated in the Zseliz/Želiezovce style in the north, the ceramic inventory from southern Transdanubia continued to be dominated by Keszthely type pottery until the end of the LBK sequence. A zone characterised by mixed assemblages containing both Keszthely and Zseliz/Želiezovce wares appeared in central Transdanubia, extending in a north-west to south-east direction (*Kalicz 1991.25, Abb. 1*).

The geographic divide between the two northern wares (Notenkopf and Zseliz/Želiezovce) and the southern (Keszthely) pottery types (Fig. 7) essentially corresponds to the one that existed two periods earlier, between the indigenous groups with formative LBK and the late Starčevo (Fig. 1).

Fundamental changes can be noted in settlement layout and settlement networks at the start of the late LBK period. Settlements were now established on fertile loess plateaus. At Balatonszárszó-Kis-erdei-dűlő, this period is represented by the site's southern part. Of the forty-eight excavated house remains where indications of the timber framework could also be documented (Category A), forty-four house plans dated from the late LBK period, and forty-three of these lay in the settlement's densely built-up southern part (Fig. 8). Even a cursory glance at the settlement plan reveals that the southern settlement part differs markedly from the northern section dating from the earlier LBK period, where buildings were more scattered. The house plans of the late LBK period obviously span several generations of houses, and the length of this settlement section's occupation exceeded by far the occupation of the settlement of the earlier LBK period. Even so, the extent of occupation density cannot be explained simply by

Fig. 8. Balatonszárszó-Kis-erdei-dűlő: aerial photo of the southeastern part of the site.

one-time timber framework, ten houses could be reconstructed from the long pits flanking the house sites. The pottery finds dated the investigated settlement section to the beginning of the late LBK period. This would suggest that several settlements had been established at roughly the same time within a relatively small area (*Marton and Oross in press*). While settlements appear to have been more closely built-up at the onset of the late LBK period, their size exceeded by far the extent of the settlements of the preceding period.

Large-scale investigations have been conducted on several LBK sites during the past two decades, as a result of which some 150 house plans are now known from western Hungary (in contrast to the few timber-framed buildings known before 1990). The remains of the timber framework could be documented in the case of over one hundred buildings. The currently available evidence shows that some 93–95% of the buildings can be dated to the late LBK phases. Most

differences in length of occupation. Some house clusters can be dated to a relatively brief period on the basis of the pottery finds and the radiocarbon dates, indicating that some of the close-set buildings in a particular cluster were contemporaneous and inhabited at the same time (*Marton and Oross in press*).

The Balatonszárszó settlement is by no means unique. Another LBK settlement lay a few kilometres to the west, at Balatonszemes-Szemesi-berek (*Bondár et al. 2000; 2007*). Although there remained no indications of the

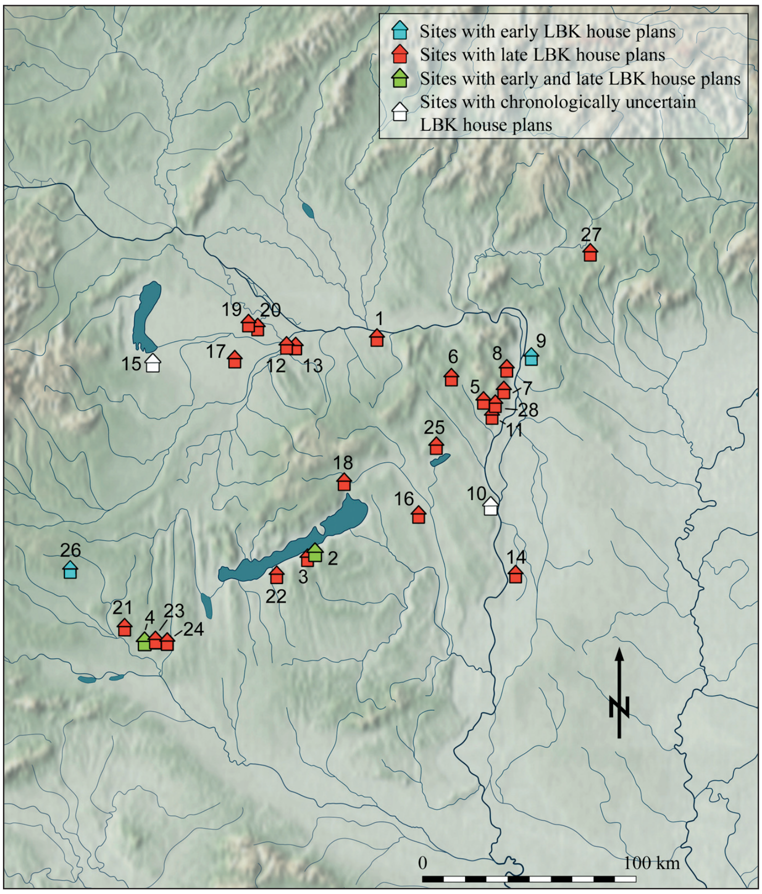

Fig. 9. Transdanubian LBK sites with above-ground house plans: 1. Almásfüzitő-Foktorok; 2. Balatonszárszó-Kis-erdei-dűlő; 3. Balatonszemes-Szemesi-berek; 4. Becsehely II-Homokos; 5. Biatorbágy-Tyúkberek; 6. Bicske-Galagonyás; 7. Budapest-Kőérberek-Tóváros lakópark; 8. Budapest-Óbuda-Nánási út; 9. Dunakeszi-Székesdűlő; 10. Dunaújváros; 11. Érd-Hosszú-földek; 12. Győr-Ménfőcsanak-Eperföldek; 13. Győr-Pápai vám; 14. Harta-Gátőrház; 15. Hegykő; 16. Káloz-Nagyhörcsök; 17. Kóny-Barbacsi-tó; 18. Litér-Papvásárhegy; 19. Mosonszentmiklós-Egyéni-földek; 20. Mosonszentmiklós-Pál-major; 21. Muraszemenye-Aligvári-mező; 22. Ordacsehi-Bugaszeg; 23. Petrivente-Újkúti-dűlő; 24. Sormás-Török-földek; 25. Sukoró-Tóra-dűlő; 26. Szentgyörgyvölgy-Pityerdomb; 27. Szécsény-Ültetés; 28. Törökbálint-Dulácska.

sites yielded house plans from this period exclusively; the number of sites featuring buildings from both the early and the late LBK period is expressly low (Balatonszárszó-Kis-erdei-dűlő and perhaps Becsehely II-Homokos; Fig. 9). The house plans of the Balatonszárszó settlement reflect similar proportions as the general pattern in Transdanubia: four of the excavated house plans can be assigned to the early LBK, while the overwhelming majority of the buildings, 91–94% in all, belong to the late LBK (depending on whether solely house plans of Category A with indications of the timber framework are considered, or whether the house plans of Category B reconstructed from the position of the long pits and a random scatter of post-holes are also taken into consideration). The archaeological record indicates that settlements were more intensively occupied and that the settlement network became denser during the late LBK phases (*Bánffy and Oross 2009.226–233, Tab. 2, Abb. 6*).

Fig. 10. Zseliz/Želiezovce style vessel from Balatonszárszó-Kis-erdei-dűlő.

The house plans and associated settlement features from the Hungarian late LBK distribution, such as from Almásfüzitő-Foktorok (*Vadász 2001.Fig. 1*), Balatonszárszó-Kis-erdei-dűlő (*Oross 2004a.63, Abb. 5; Oross 2008*), Budapest-Óbuda-Nánási út (*Virág online*) and Törökbálint-Dulácska (*Virág 2005*) allow the reconstruction of rectangular timber-framed houses. In addition to three internal rows of upright timbers, the two longitudinal walls of these buildings were supported by two outer rows of smaller posts. It would appear that the transition to the late LBK period was not accompanied by any major changes in house structure (*Marton and Oross in press*).

Kalicz described the finds of the Keszthely group as remarkably uniform assemblages, in which the pottery remained virtually unchanged throughout the period (*Kalicz 1991.27*). The single anchor for an internal chronology was that certain features of the preceding period could be noted in early Keszthely assemblages. These had disappeared by the classical phase and, disregarding a few Notenkopf fragments, imports of other contemporary groups are lacking. The assemblages of the Keszthely group's late phase from south-western Transdanubia are characterised by the presence of Notenkopf, Zseliz/Želiezovce, Sopot, Malo Korenovo and Šarka wares (*Kalicz 1991. 26–27*). A detailed typo-chronological framework for the Notenkopf and Zseliz/Želiezovce assemblages from northern Transdanubia, comparable to that elaborated for the Zseliz/Želiezovce phase in Slovakia (*Pavúk 1969*), has not been proposed yet, and thus the Slovakian system is also used for the Hungarian distribution.

Globular vessels (Bombengefäß) can be regarded as the hallmark of the pottery from both regions (*Kalicz 1991.19, Abb. 6.3*). Conical and semi-spherical bowls, as well as amphorae with cylindrical necks are other common forms. The hollow pedestal of pedestalled bowls is often pierced with triangular or oval perforations. Face pots occur in assemblages both from northern (*Fábián 2005; Pavúk 1969. 309–315*) and southern Transdanubia (*Draveczky 1971; Kalicz 1991.25; Marton 2004.Fig. 7*), with depictions of faces appearing on globular vessels and amphorae with cylindrical necks. The incised linear patterns are interrupted by or terminate in punctates on the Notenkopf pottery. The most typical features of Zseliz/Želiezovce pottery are bundles of incised lines combined with vertical incisions (Fig. 10). The Keszthely style is characterised by designs of wide, deeply incised lines. Globular vessels often have an incised line encircling the body under the rim, while the patterns on the vessel body are comprised of a curved horseshoe shaped or spiral motif alternating with chevrons or hook motifs (Fig. 11).

Zseliz/Želiezovce wares were often painted red, with a design of alternating polished and red painted bands. Polychrome patterns in red and yellow were also quite popular. The assemblages brought to light during recent excavations indicate that the use of red was also widespread in the Keszthely distribution, *i.e.* in southern Transdanubia.

The Balatonszárszó-Kis-erdei-dűlő site lies in the area characterised by the joint occurrence of Keszthely and Zseliz/Želiezovce wares. A detailed analysis of the large body of ceramic finds offers a unique opportunity for creating a typo-chronological sequence for the late LBK period of this transitional zone. Some settlement features of the southern, densely built-up area, which can be wholly dated to the late LBK period, yielded mixed assemblages (defined as Pattern III by Marton). These assemblages were spatially restricted to certain areas, usually one or another farmstead parcel, and they mark the start of the southern settlement section. A few elements of the preceding period, such as rounded biconical forms, survived into this period. At the same time, the appearance of the typical Keszthely vessel forms and ornamental repertoire can also be noted. These assemblages contain a low proportion of Notenkopf pottery, although it is unclear whether these were locally made or imported (*Marton 2008.203–204, Fig. 4; Marton and Oross in press*).

The succeeding phase in the pottery sequence, labelled Pattern IV, is dominated by Keszthely wares. The few Zseliz/Želiezovce fragments come mainly from bowls decorated on their interior (*Marton 2008. 204–205*). In contrast, the proportion of Zseliz/Želiezovce wares in the pottery assemblage from certain farmstead parcels in the southern settlement section is identical with or even exceeds 50% of the decorated pottery. These assemblages, assigned to Pattern V, were recovered from farmstead parcels in the central part of the southern area and, more typically, along the western and southern edge of the excavated area.

The Balatonszárszó pottery could be ordered into a typo-chronological sequence corresponding to the one described by Kalicz. One major difference compared to his system is that Notenkopf fragments typically occurred in the formative Keszthely assemblages (Pattern III), suggesting that wares decorated in the Notenkopf style represent a relatively brief timespan at the start of the late LBK period.

Compared to the preceding period, no major technological differences could be identified in the lithic implements of the late LBK from Balatonszárszó, although the late LBK saw the appearance of large, long blades, often bearing sickle gloss or traces of use-wear on their edge (*Marton and Oross in press. Fig. 9, 2, 4–6*).

The published radiocarbon dates for various Transdanubian sites (*Bánffy and Oross 2009.Tab. 3*) and the radiocarbon-based dating of certain Austrian sites (*Lenneis and Stadler 1995.Abb. 8*) suggest that the onset of the late LBK period can be placed in the decades before 5200 calBC. Other data, such as more recent AMS dates, would rather indicate a dating around 5300/5250 calBC (*Bánffy and Oross 2009. 233–235; Stadler 2005.270*). The calibrated dates for the earliest LBK in Germany and the succeeding Flomborn phase span the entire 53rd century BC (*Cladders and Stäuble 2003. 496–497*). In sum, the start of the late LBK period can be confidently dated to the 53rd century BC. There is increasing evidence that an earlier date around 5300/5250 calBC might also be justified, although additional large radiocarbon series are necessary to prove this. It must also be noted that the cluster of the starting dates of the calibrated intervals

Fig. 11. Keszthely style vessel from Balatonszárszó-Kis-erdei-dűlő.

around this date is a consequence of the wiggles in this section of the calibration curves. The end of the LBK sequence in Transdanubia can be dated between 5000 and 4900 calBC. The latest dates coincide with the radiocarbon dates for the early Lengyel culture (*Bronk Ramsey et al. 1999.202–203*).

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Tradition and innovation between the Mesolithic and Early Neolithic in the Adige Valley (Northeast Italy). New data from a functional and residues analyses of trapezes from Gaban rockshelter[1]

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ABSTRACT – *The Neolithisation of the Northern Italy is particularly interesting since archaeological data show dynamics of interaction between the last hunters and the early farmers of the region. In this paper the authors present the results of use-wear and residues analyses carried out on an assemblage of trapezes from one of the key-sites of the Neolithisation in the Adige Valley: Gaban rockshelter. The functional data have been compared and discussed with other strands of archaeological evidence available for the region.*

IZVLEČEK – *Študij procesa neolitizacije v severni Italiji je zanimiv zato, ker arheološki podatki kažejo na dinamike interakcij med zadnjimi lovci in nabiralci ter prvimi poljedelci v regiji. V članku predstavimo rezultate analiz sledov uporabe in ostankov na trapezoidnih kamenih orodjih z enega ključnih najdišč v dolini Adiže: v spodmolu Gaban. Rezultate analiz primerjamo in analiziramo v kontekstu ostalih arheoloških podatkov v regiji.*

KEY WORDS – Mesolithic-Neolithic transition; use-wear and residues analyses; trapezes; hunting strategies; aestethic traits; ochre

Introduction

The Neolithisation of northern Italy is peculiarly interesting, since several strands of archaeological evidence suggest more intense interactions between the last hunters and the early farmers in the region than elsewhere on the peninsula (*Bagolini and Biagi 1988; Biagi et al. 1995*). The active role of local Mesolithic groups in the formation and definition of the first Neolithic of the region has been described by various authors (*Bagolini in primis*), on the basis of various strands of evidence (techno-typological similarities in the lithic industries of the transition, presence of pottery in the Castelnovian levels, etc.) as an acculturation phenomenon. The dynamics of the transformations in north-east Italy have not yet been defined and fully understood. However, the archaeological record shows that Neolithisation was a gradual process in which diffusion, interactions and exchanges were involved.

The Neolithisation of the Adige Valley occurred in the second half of the 6th and the first half of the 5th millennia calBC. Mesolithic hunters had inhabited diverse ecological niches across the Alpine region since the Preboreal (*c.* 9500 calBC), and numerous

1 This paper was written on the basis of the results obtained in the course of a project funded by the Autonomous Province of Trento (PAT 2007–2009).

sites were located both in the lowlands and at high altitudes, suggesting the dynamism of human adaptations across the region. The role of local groups in the formation and definition of the first Neolithic of north-east Italy has been emphasised by some authors, who define this change as a slow and gradual process of acculturation (*Broglio 1990; 1994; Bagolini and Biagi 1988; Biagi et al. 1985; Pedrotti 2001; 2002*). This vision of the Mesolithic-Neolithic sequence in the south of the Alps is based mainly on the evidence of the lithic industries, as well as the continuity of raw material acquisition modalities, technological, morphological and typo-metrical aspects of tools and microliths between the Mesolithic and the Neolithic (*Bisi et al. 1986*). However, these similarities are not absolute, and in fact, new lithic types appear in the Early Neolithic of north-east Italy (for example, the so-called burin of Ripabianca: *Bisi et al. 1996*); also, the dimensions and asymmetry of microliths seems to have increased during this period.

Given their technological and morphological variability, the category of trapezes (the microliths which characterise the Castelnovian and the Early Neolithic) could be considered as a good proxy for defining transformations that took place in the Adige Valley during the early-middle Holocene. Furthermore, some archaeological findings and the results of the rare functional analyses carried out on trapezes testify to the multitasking nature of these microliths: they were, in fact, used in different ways: a) as projectile points at the sites at Loshult in Sweden (*Malmer 1969*), Nizhneye Veretye in north-east Russia (*Oshibkina 1989*), at Duvensee 9 (*Bokelmann 1991*) and Seedorf (*Bokelmann 1994*) in Germany, and in England. At the Star Carr site, for instance, there were microliths still covered with resin remains (*Clark 1954*); b) as composite knives for plant gathering, processing and cutting organic soft material at Gleann More in Scotland (*Finlayson and Mithen 1997*) and at Uzzo Cave in Sicily (*Longo and Isotta 2007*).

In this article, we present the results of a functional analysis carried out on a portion of the assemblage of trapezes from one of the key-sites of the Mesolithic- Neolithic transition in the Adige Valley: Gaban rockshelter. Our study was aimed at understanding the possible connection between the morpho-technological differences identified in the Mesolithic and Neolithic trapezes of the Adige Valley and their function. We show how these results can contribute to debates about the Mesolithic and Neolithic transformations in the region. After introducing the site and

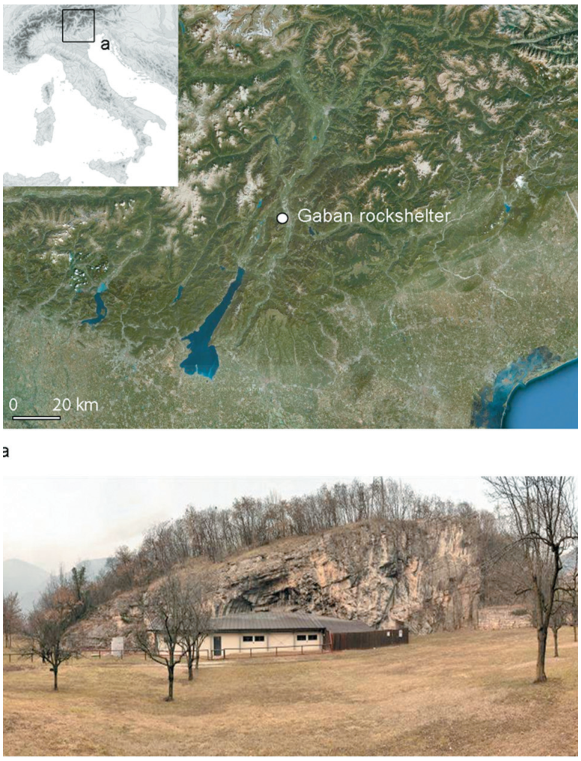


Fig. 1. a) Localisation of the Adige Valley and Gaban rockshelter; b) view of Gaban rockshelter.

the characterisation of the chronological and stratigraphical context of our research, a methodologic approach to the analyses of trapezes will be defined. In the conclusions, the results of functional and residue analysis will be discussed and compared with other strands of archaeological evidence available for the region.

Gaban rockshelter

Gaban rockshelter is among those sites found in the Adige Valley that humans used continuously from the Mesolithic (7500 calBC) throughout the Neolithic and Middle Bronze Age (1600 calBC). It is situated about 3km north of the city of Trento at 270m asl. The site is in a dominant position on the eastern side of the Adige River (Fig. 1.a). The shelter is about 30m long, 6m high and from 2 to 4m wide (Fig. 1.b). Bernardo Bagolini conducted the first archaeological excavations at this site, starting in 1971 and ending in 1979. Further research focused on Mesolithic levels, and was carried out by Kozlowski and Dalmeri from 1982 to 1984. Bagolini divided the excavation area into 5 sectors (from south to north sectors II, I, IV, III and V). Drainage works in the 1600s and 1700s removed Bronze and Copper ages levels from sectors I and III, partially including the Neolithic layers. In the other sectors (II, IV, V), the sequence,

Fig. 2. a) The Gaban Venus; b) technological features of the artefact: 1) traces of abrasion visible on the shoulders (3.2x); 2) traces left by engraving the necklace (6.3x); 3) cutting traces left during the production of the osseous blank of the Venus (1.6x); 4) decoration visible on the lower part of the body (upper surface) (2.5x); 5,6) traces of abrasion visible on the lateral side of the lower part of the body (5:1,6x; 6:5x); 7) position of the Venus on red deer metatarsal.

still visible in the remnant at the centre of the shelter, is untouched, and the different cultural levels have been radiocarbon dated, although the correlation of various sectors remains problematic. Kozłowski and Dalmeri excavated in sectors III and IV. In 2007 excavations at the site recommenced under the direction of Annaluisa Pedrotti (University of Trento)[2].

The Early Neolithic, characterised by the eponymous Gaban group, is represented by spits 1 to 10 in layer D; the Late Mesolithic (Castelnovian) was found in spits 1 to 6 in layer E (Bagolini excavations), while its early phase was marked as layer FA (Kozłowski and Dalmeri excavations); the lower layers, FB and FC, are representative of the Early Mesolithic occupations (Sauveterrian). The Early Mesolithic presence at the site was attested across 12m^2 in the course of Bagolini's excavations (*Bagolini 1980*), while Kozłowski and Dalmeri exposed an area over 6.5m^2 in sectors IV and III, excavating over 1m of sediment from this occupation phase (*Kozłowski and Dalmeri 2002*).

The available dates for the Late Mesolithic (Layer E) and Early Neolithic (layer D) range from the beginning of the 7th to the middle of the 5th millennium calBC (Tabs. 1, 2). The Castelnovian occupation at the site begins around 7000 calBC (layer FA) and ends around 5900 calBC (layer E). Two dates (KIA-10362; UtC-10453) available for layer D (spit 9), stratigraphically related to the Early Neolithic occupation, are too early when compared to other dates from layer D (Bln-1777; Bln-1777a; Bln-1778), and they are also too early for the Early Neolithic chronology of northeast Italy in general (*Perrin 2007*). It is possible that these dates – which cluster around the end of the 7th millennium calBC – could relate to the Castelnovian occupation and refer to residual materials from areas disturbed by digging on the upper levels. In fact, it should be pointed out that sector IV was indeed cut by several Neolithic pits (unedited field diaries, *Kozłowski and Dalmeri 2002; Perrin 2007*).

The Neolithisation of the Adige Valley

Bagolini and Biagi introduced the term 'Gaban' to define the Early Neolithic group present in the Trentino Alto Adige region (*1977*). It differs from other groups diffused in the Po Plain in the shapes and de-

2 The archaeological researches have been carried out by the Dipartimento di Filosofia, Storia e Beni Culturali of the University of Trento in collaboration with D. Angelucci, F. Cavulli, C. Della Volpe, S. Gialanella and S. Grimaldi and thanks to projects funded by the Autonomous Province of Trento (*2007; 2009*).

corations of pottery and, furthermore, in the presence of lithic and osseous industries characterised by a strong Mesolithic tradition.

The results of the analyses carried out on the Gaban rockshelter faunal remains indicate that, in the first levels with pottery, the economy was based mainly on hunting and gathering. On the basis of the stratigraphic data, the authors recognised a first phase of the Neolithic (also called the phase of 'potterisation'), and a second one, characterised by an increase in 'graffiti' and shapes with flat bottoms on the pottery, as well as the first presence of domesticated animals (caprovines and bovines)[3]. This group should have achieved the new economy through a long and slow process of interaction and acculturation (*Bagolini and Biagi 1977; Bagolini 1980*)[4].

Recently, Perrin (*2007; 2009*), identified a chronological gap of about 500 years between the most recent Late Mesolithic occupation (Castelnovian) – *c.* 5500 calBC – and the earliest Gaban Group occupation – *c.* 5000 calBC – on the basis of ^{14}C dates for Gaban rockshelter (Tabs. 1, 2). Mainly on the basis of this hiatus, he criticised the hypothesis that the Gaban group could have been formed through an acculturative process from local Mesolithic communities.

The observations on the chronological gap are intriguing and should be certainly deepened. In fact, a new field campaign has been carried out to revise the stratigraphic relations in Gaban rockshelter and collect new samples in order to date the transition from the Mesolithic to the Neolithic. At the same time, many data tend to confute the new model proposed by Perrin, verifying the hypothesis of an adoption of the new economy by local groups as a gradual acculturative process which happened through interaction and exchange (*Bagolini and Biagi 1977; Bagolini 1980; Bagolini and Broglio 1985; Kruta 1982; Pessina and Tine 2008; Pedrotti 2001*).

In the last thirty years, the archaeological research carried out in the Adige Valley has shed light on a number of important archaeological sites. The Holocene colonisation of eastern Alpine valleys and mountainous parts has been reconstructed on the basis of these results. The Mesolithic inhabitation of the region was particularly intense in lowland rockshelters. Yet, hunters were fully adapted to the diversity of the Alpine ecosystems, and numerous sites have been attested at high altitudes and generally interpreted as seasonal camps for catching wild mountain caprids (*Capra ibex* and *Rupicapra rupicapra*) (*Bagolini et al. 1984; Broglio 1994*). Since the 6[th] millennium calBC, in tandem with improved

Site	Level	Cultural attribution	Date reference	Date BP	calBC (1σ – 68,2% confidence)	calBC (2σ – 95,4% confidence)	Bibliography
Gaban rockshelter (Trentino)	D2 D8 E	Late Mesolithic	KlA–10362 UtC–10453 KIA–10363	7283±38 7241±50 6968±41	6212–6091 6208–6052 5898–5786	6226–6066 6219–6021 5978–5745	*Improta et al. 1984*
Romagnano III rockshelter (Trentino)	AB 1–2	Late Mesolithic	R–1137 R–1137A R–1137B	7850±60 7500±160 7800±80	6801–6602 6506–6117 6746–6503	7029–6531 6651–6029 7023–6464	*Improta et al. 1984*
Pradestel rockshelter (Trentino)	D 1–3	Late Mesolithic	R–1148	6870±50	5835–5710	5878–5661	*Improta et al. 1984*
Vatte di Zambana rockshelter (Trentino)	3 5	Late Mesolithic	R–487a R–488 R–488a	7250±110 7540±75 7585±75	6225–6020 6467–6267 6558–6376	6381–5913 6560–6233 6595–6255	*Improta et al. 1984*

Tab. 1. Dates from the main Castelnovian occupations of Trentino Alto Adige region[5].

3 These data have been confirmed by the micromorphological analyses carried out by D. Angelucci, G. Boschian and S. Frisia on the archaeological remnant section. In the following field campaigns, the micro-morphological study will focus on the definition of the sediments formative processes, trying to single out abandoned or erosional levels. This work will be fundamental for reconstructing of a coherent picture of the archaeological evidences from the site.

4 Today, thanks to the archaeological excavations carried out at the site of Lugo di Grezzana, we are able to confirm this subdivision of the Neolithic of Gaban rockshelter suggesting that the most recent phase could be dated around 4900–4700 calBC and is contemporaneous to the Square Mouthed Pottery Culture diffusion in the Po Plain (*Pedrotti and Salzani in press)*.

5 All the radiocarbon dates were calibrated using OxCal 4.1 program (*Bronk Ramsey 2001*).

Site	Level	Cultural attribution	Date reference	Date BP	calBC (1σ – 68,2% confidence)	calBC (2σ – 95,4% confidence)	Bibliography
Gaban rockshelter (Trentino)	D	Early Neolithic – Gaban Group	Bln–1777	6030± 45	4991–4849	5045–4800	*Bagolini, Biagi 1990*
	D2		Bln–1777a	5750 ± 60	4686–4541	4723–4459	
	D8		Bln–1778	5990 ± 45	4940–4806	5000–4749	
Romagnano III rockshelter (Trentino)	AA1-2	Early Neolithic – Gaban Group	R–1136	6480±50	5485–5376	5529–5330	*Bagolini, Biagi 1990*
	T4		R–781a	6060±50	5035– 4855	5207–4804	

Tab. 2. Dates from the main Early Neolithic occupations of the Trentino Alto Adige region which present Late Mesolithic and Early Neolithic levels[6].

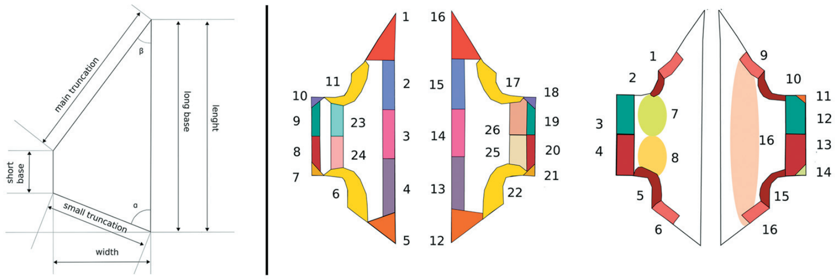
climatic conditions, hunter-gatherer groups showed a tendency to exploit the lowland resources, particularly foraging in woodland and hunting birds, freshwater fish and small mammals. During this phase, an important shift is reported in the structure of the lithic industries, mostly represented by an increase in blade dimensions and the adoption of new hunting tools: flint trapezes and harpoons made from antler and bone (*Cristiani in press*). Some of the lowland rockshelters were colonised *ex novo*, while frequentation of mountain areas decreases. Among the faunal remains cervids are dominant (mostly *Cervus elaphus* and *Capreolus capreolus*), while ibex and chamois (*Capra ibex* and *Rupicapra rupicapra*) disappear from the archaeological record (*Bagolini 1980; Lanzinger et al. 2001*). All the lowland sites show a stratigraphical continuity between the Late Mesolithic and the Early Neolithic, and no interruption can be evidenced in the Adige valley occupation in the mid-6th millennium calBC when ^{14}C dates from different sites are compared (see Tab. 1, 2).

A barley seed found in a core made during a pollen sampling in the Isera peat bog (south of Rovereto – TN) gave a date of 5500–5300 calBC, suggesting that small farming communities might have co-existed with the local Mesolithic group in the Adige valleys at least since the middle 6th millennium calBC. Actually, it is not possible to hypothesise about the duration of these sites or about the reasons the first farmers/herders penetrated the Alpine valleys. On the basis of pottery types found, for example, in Gaban rockshelter, it is possible to stress that they came from the south (*Pedrotti 2001*).

The hypothesis of strong interaction dynamics between the last autochthonous groups and the new farmers is demonstrated by several specificities in the material culture of these groupes. Together with the introduction of new elements like pottery or, relating to the lithic industry, the burin of Ripabianca and the rhomboid, the persistence of a Mesolithic traditions is documented by continuity in the production of antler blade axes instead of polished stone ones. In the first Gaban groups, hard animal tissues (antler, tooth, bone) are preferred to clay in reproducing 'symbols' of the new ideology. The most original documentation of this topic is the 'Gaban Venus' a bone plaquette in the form of a female figure with arms just chalked out in a 'hanger' shape and ending with a pointed morphology (Fig. 2.a). This item is covered by a thick red ochre layer on the lower surface – with the exception of the hair – and on all the basal part of the upper surface up to the belt (see Fig. 2.a). The arms, hair and necklace style, and the representation of a vulva with a tree-like motif, suggest a connection of this symbolism with an agriculture cult (*Gimbutas 1991; Guilaine 1994.309*). The surface shaping technique[7] is characteristic of the Neolithic tradition (sandstone abrasion, Fig. 2.b1 and b5), while the raw material selection (a *Cervus elaphus* metatarsal) shows strong Mesolithic connections (*Pedrotti 2001; 2002; Cristiani et al. in press*). Microscopic examination has also revealed traits of a Palaeo-Mesolithic tradition in the modality of application of the colour (ochre) to the plaquette: the pre-

Fig. 3. Some of the trapezes discussed in the paper.

6 All the radiocarbon dates were calibrated using OxCal 4.1 program (*Bronk Ramsey 2001*).
7 The techno-functional analysis of the "Gaban Venus was carried out by one of the authors (E.C.).



a b

Fig. 4. a) Nomenclature used for trapeze description; b) system of polar coordinates. On the left: polar coordinates used for the position of use-wear traces; on the right: polar coordinates used for the position of residues.

sence of a white limestone layer just above the bone blank constitutes the base for the ochre painting (*Cristiani et al. in press*). The same procedure has been found on some Epigravettian decorated stones recovered at the Dalmeri rockshelter (Marcesina plateau – Trento, *Belli et al. 2007*).

An 'integrated' functional study of geometric microliths

a) Sampling the archaeological assemblage

The archaeological sample is comprised of 182 microliths (Fig. 3) from 10 spits, encompassing the period of the supposed Neolithisation process: spits 5 to 1 from the final Late Mesolithic layer E (N = 92 trapezes) and spits 10 to 6 from the very Early Neolithic layer D (N = 90 trapezes) excavated in sector IV. We decided to analyse trapezes from this sector, since this is the most reliable of the three excavated (III, IV and V) and it was not heavily disturbed by Neolithic and later pits. Furthermore, the study of the microliths from sector IV allowed us to have tight control over the stratigraphic sequence in this part of the shelter.

b) Methodology of use-wear analysis

The use-wear analysis was carried out integrating visual inspections, and low and high resolution observations. In particular, the trapezes were studied by means of a stereoscope Leica M12.5 with magnifications from 8 to 100x, and an incident light metallographic microscope Leica DC2500 with magnification from 50 to 400x. The cleaning procedures were carried out using alcohol and acetone only.

The homogeneity of the analysed tools and the scarcity of publications regarding use-wear traces on trapezes led us to refer to the article by Fisher *et al.* (*1984*) and to the wide scientific literature on the functional utilisation of points and microliths (*Dockall 1997; Fischer 1990; Kelterborn 2001; Lombard and Pargeter 2008; Odell 1978; Odell and Cowan 1986; Nuzhnyj 1989; 1990*) in order to define the analytical criteria for our sample. The validity of diagnostic macrotraces as well as the applicability of a 'common' terminology to other non-trapezoidal microliths was evaluated during the analysis and some criteria were integrated and updated on the basis of the specific features of our sample. As an experimental comparison, the publications of Fisher *et al.* (*1984*), Plisson and Geneste (*1989*) and O'Farrell (*1996*) were considered among others. The use-wear traces identified on the archaeological tools were plotted by means of a polar coordinate system (Fig. 4.b) (*Van Gijn 1990*). This method allowed us to evaluate the presence of recurrences in the location and distribution of the functional modifications.

c) Methodology of residue analyses

A multi-analytical, mostly non-destructive approach has been adopted for a complete characterisation of the archaeological residues.

As stated, optical microscopy (OM) observations of the microlithic specimens were carried out to visualise potentially interesting topographic features of the residues present on the surface of the materials.

Environmental scanning electron microscopy (ESEM) observations were conducted on some of the trapezes in order to better identify those details falling beyond the resolution of the optical microscope. The working principles of an ESEM allowed us not to use any conductive coating which would have otherwise been required in the case of conventional, *i.e.* high vacuum, scanning electron microscopy, owing to the insulating nature of our samples. In this way, any interference with the X-ray emission spectra from selected regions of the specimens was avoided. The X-ray spectra were collected with an Energy Disper-

Distal fractures	Impact fract.	Proximal fract.	distal+ prox. fract.	Hafting macro-traces	Hafting frictions, glossy, striations	MLIT
68	45	12	19	63	33	19

Tab. 3. Location and types of macro and micro traces identified on trapezes from Gaban rockshelter.

Red	Brown	Red + Brown	Total
10	10	7	27

Tab. 4. Types of residues identified on trapezes from Gaban rockshelter.

sive X-ray Spectroscopy (EDXS) system during the ESEM observations in order to obtain analytical data from selected regions of the investigated specimens. Subsequently, for the identification of the particular substances present in the residues, *in situ* Attenuated Total Reflection Fourier Transform Infra-Red (ATR-FT-IR) spectroscopy measurements were carried out on the same specimens already examined with other experimental techniques. Two different routes were followed for the identification of the characteristic lines present in the infra-red spectra: either FT-IR spectra resulting from the archaeological trapezes were compared with an available database and electronic sources, like the Internet site *www.irug.org*; or real reference standards were created using modern substances, possibly reproducing the residues. These substances were selected on the basis of archaeological or ethnographic data and palaeo-climatic information, with particular reference to the influence of local vegetation available for north-east Italy, and dating back to the early to middle Holocene period (*Cattani 1992; 1994; Ombrelli and Ravazzi 1996*). Our set of standard references contained samples of beeswax, vegetal bitumen, animal glues from boiled bones, boiled tendons and boiled skin, vegetal bitumen mixed with beeswax, wood and pitch, and resins from various pines.

A polar coordinate recording a protocol similar to that used for the use-wear traces was used for the results obtained from the residues. In this way it was possible to evaluate the relationship between functional traces and the spatial distribution of residues.

Results of the functional study

a) Use-wear analysis

The trapezes show a generally good state of preservation, although thermal alterations and a glossy patina were identified on one third of the sample. The intensity of the post-depositional modifications did not limit the identification of use-wear traces, and it was always possible to observe macro-traces, given the general absence of mechanical alterations along the edges (such alterations were found in 10 cases only). Macro-fractures that occurred due to use were observed on the distal ends of 68 trapezes out of a total of 182. In particular, they are located in the area of the trapeze formed by the long truncation and the long base of the tool (Fig. 5) in sectors 1– 16 of the polar coordinates system (Fig. 4.b). The 66 % (N = 45) of the recognised macro-traces represent typical impact fractures and were classified as impact scars, snaps, bending, burin-spall and spin-off fractures (*Fisher et al. 1984*). The remaining traces are not well developed or diagnostic of specific activities. No differences were identified in the nature of the distal fractures between the Mesolithic and Neolithic trapezes. Other types of macro-traces confirm the use of the trapezes as projectile points. Linear traces visible at low and high magnification were identified in 19 cases, often in connection with impact fractures (Figs. 6.a, d–e). They are located on both dorsal and ventral surfaces, and their orientation can be longitudinal and oblique.

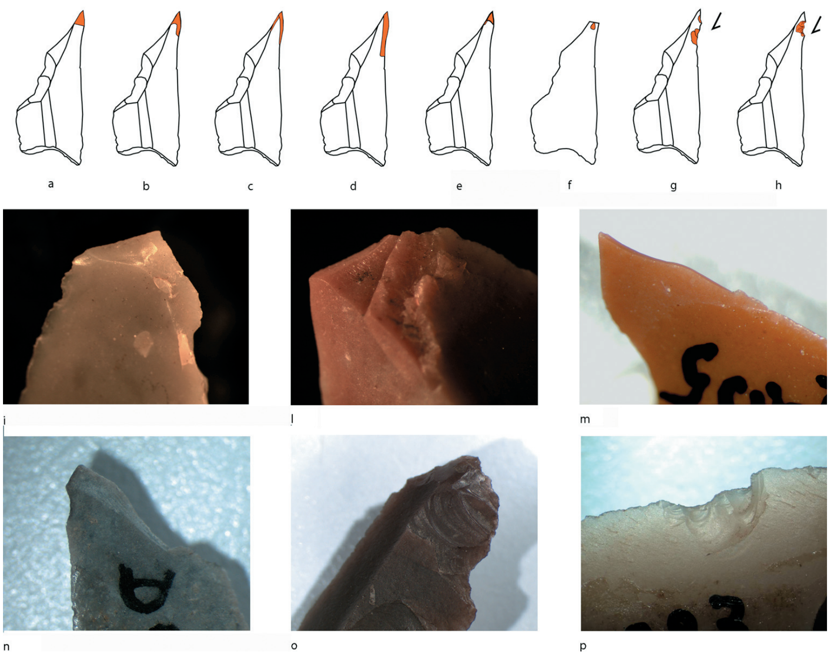


Fig. 5. Localisation and description of use-wear traces identified on the distal end of the trapezes (**piquant triedre*****): a) snap fracture; b) bending-hinge fracture; c)* languette *fracture; d) burin-like fracture; e,f) spin-off fracture; g,h) invasive macro-detachments. Archaeological use-wear traces: i,l) bending-hinge fractures (i: 2x; l: 5x); m)* languette *fracture (4x); n) burin-like fracture (2.5x); o,p) invasive macro-detachments on the distal part of the long base (o: 2x; p: 2.5x).***

The superimposition of different micro-striations on the same microlith proves the recurrent use of the same projectile. Modifications related to hafting were identified on 63 trapezes (Fig. 7). They were observed both at low and high magnification and can be characterised by different appearance and location. In particular, bending-feather scars are mostly located on the short edge of the artefacts, and on the proximal part of the long edge (sectors 7–10 and 3–5 of polar coordinates system, Fig. 4b), while rectangular-trapezoidal scars are diffused on the short edge of the artefacts (sectors 7– 10 of the polar coordinates system, Fig. 4.b). Experimental literature data relate the former to contact with the binding used for hafting, and the latter to the insertion of the proximal part of the trapezes into a shaft (*Rots 2003; 2008*). A different category of hafting traces (Fig. 7. h–q) is represented by scars and fractures distributed on the basal wing of 31 artefacts (sectors 5 and 12 of the polar coordinates system, Fig. 4.b). These fractures are often associated with very well developed micro use-wear traces, such as friction gloss, rounding, striations and bright spots that can be observed at high magnification. The latter were not identified among the post-depositional alterations, and for this reason their association with other types of use-wear traces and experimental data in the literature (*Rots 2003; 2008*) were interpreted as produced by the insertion of a microlith into a shaft. A technological abrasion of the short edge, probably intended to improve attachment to the shaft, was observed on 10 trapezes (Fig. 7.b).

b) Microstructural characterisation and analytical data of residues

Residues were identified on 27 lithic artefacts (Tab. 4). They were classified, according to their dominant colour, as 'red' and 'brown' residues (Fig. 8).

In all cases, residues were localised on the ventral or dorsal surfaces of the trapezes, in a position that, according to their orientation and relationship to the relevant use-wear traces, can be associated with the hafting zone (sectors 3–8 and 10–15 of the polar coordinates system, Fig. 4.b).

Optical micrograph in Figure 8.d shows an example of red residue on a flint trapeze (sample nr. 1261). The same spot is imaged in the ESEM micrograph shown in Figure 9.a. The X-ray spectroscopy analyses provide clear indications on the composition of these reddish residues. Figure 9.b shows the X-ray emission spectrum from the 'red' residue displayed in Figure 9.a. The characteristic emission lines indicate that in addition to the obvious contribution from the flint substrate (SiO_2), the following majority phases seem to be present: haematite (Fe_2O_3), calcite ($CaCO_3$) and unidentified alumino-silicate phases, the latter being at least partly ascribable to a contamination from the burial ground and clay. The overall composition of the 'red' residue seems to be compatible with some kind of red ochre, in which the red pigment would be haematite, whereas calcite and possibly the other mineralogical phases certainly present in the mixture, would act as so-called white pigments. They were intentionally added to iron oxide not only to tune the intensity of the resulting colour, but also to improve

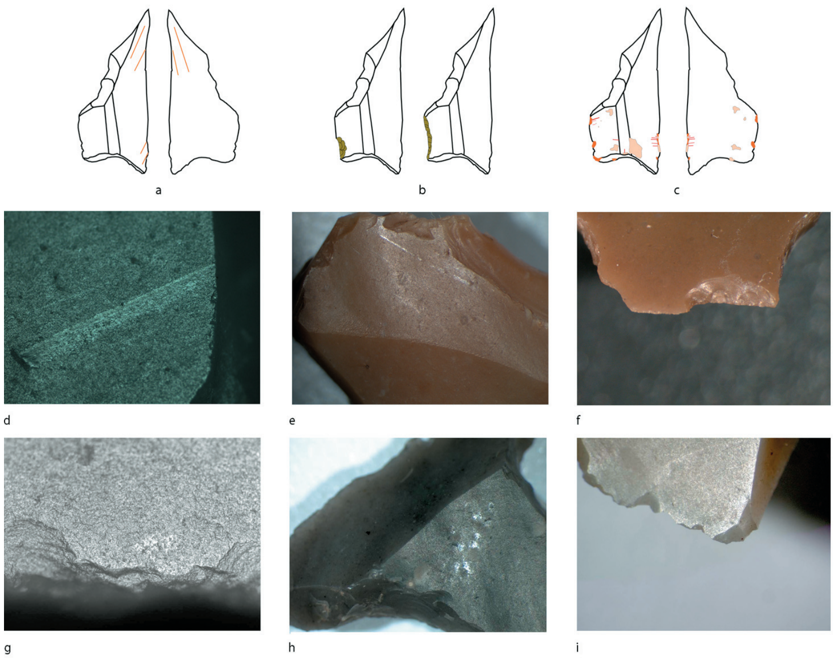


Fig. 6. Localisation and description of technological and functional traces identified on the trapezes: a) MLITS (Micro Linear Striation); b) technological abrasion carried out on the short base of some trapezes; c) bright spots, glossy, striations and use-retouches related to hafting. Archaeological use-wear traces: d) MLITS photographed at high magnification (100x); e) a MLITS (3.2x); f) technological retouch of the short base (3.2x); g) bright spot photographed at high magnification (200x); h, i) bright spots related to hafting (h: 2.5x; i: 4x).

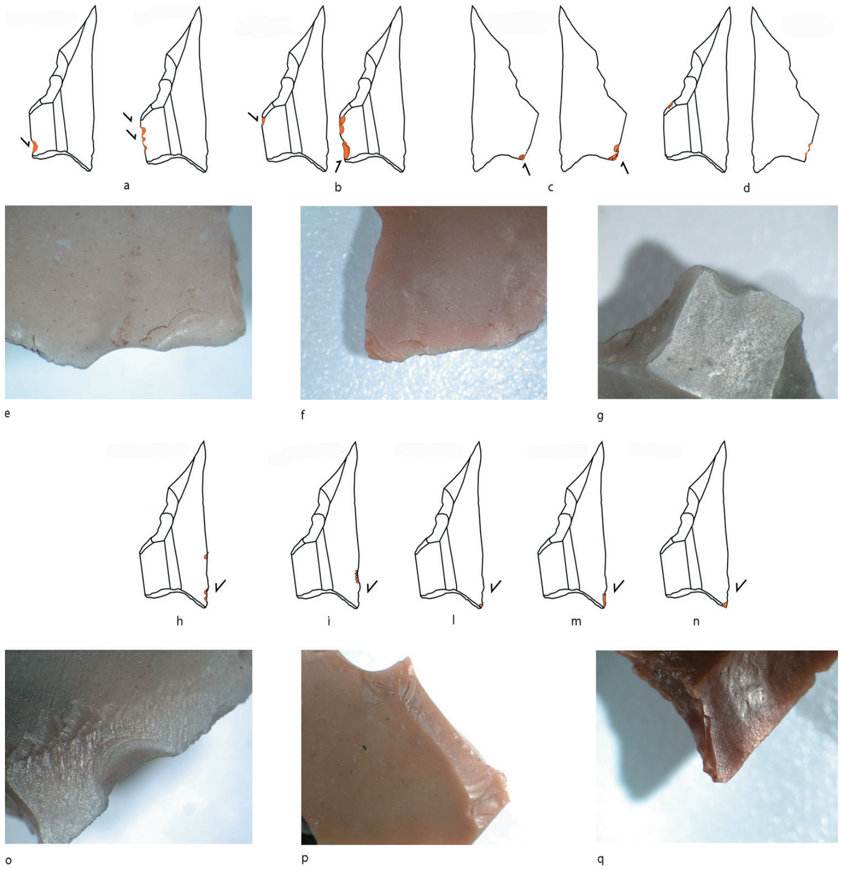


Fig. 7. Localisation and description of use-wear traces identified on the short base and wing (formed at the intersection of the small truncation and the long base) of the trapezes: a) bending-feather use-retouches; b) half-moon bending-step use-retouches; c) trapezoidal-rectangular cone-step use-retouches. Archaeological use-wear traces: d) circular cone-feather use-retouches; e,f) trapezoidal-rectangular use-retouches on the short base (e: 5x; f: 5x); g) bending-feather use-retouch related to hafting (2.5x). Localisation and description of use-wear traces identified on the long base and the wing of the trapezes: h) bending-feather use-retouches; i) scalar use-retouches; l) bending-feather use-retouches; m) **languette** ***or burin-like fractures; n) snap fractures. Archaeological use-wear traces: o) bending-feather use-retouch on the proximal part of the long base related to hafting (4x); p) burin-like fracture localised on the short base (1.25x); q)*** **languette** ***fracture (2.5x).***

the archaeological properties of praehistoric paint (*Colombo 1995*).

As for the 'brown' residues, such as that seen in the optical micrograph in Figure 8.a (sample nr. 1418), the relevant EDXS spectrum displays the presence of a particularly intense carbon characteristic line (Fig. 9.d), which can be taken as a preliminary indication of the probable organic nature of these residues. Indeed, the FT-IR spectrum in Figure 9.e confirms that the brown residual has a largely organic character due to the presence of the typical absorption bands corresponding to the C-H stretching at 2919 cm^{-1} and 2850 cm^{-1} (boxed in the Figure).

From a comparison of the FT-IR spectra of the reference materials with that of the 'brown' residue, the best match is the FT-IR spectrum of the mixture of natural bitumen and beeswax (Fig. 9.f).

Results obtained by integrating use-wear and residue data suggest a hafting procedure as depicted in Figure 10. As it is shown, on the basis of the nature and the distribution of the functional traces, trapezes were probably used with the *piquant-trièdre* as the pointed end of the arrow (Fig. 10.a, b) as well as lateral barbs (Fig. 10.c).

Up to now, the analytical results are inconclusive regarding the nature of the material into which the trapezes were hafted. Neither the hypothesis of a wooden arrow shaft, nor a bone point can be excluded, even considering that both retaining materials have been shown through archaeological research (*Dal 2003*).

Between tradition and innovation in the Adige Valley

The results of the functional analysis show that the trapezes from Gaban rockshelter constitute a highly specialised type of tool used in hunting. This homogeneity relates both to the Mesolithic and Early Neolithic layers, and it seems that it was not affected by the morphological and dimensional differences between the two periods identified through technological analysis.

Considered separately, the functional data available on the microliths give us a partial vision of the economic and social dynamics of the last hunters and the first Neolithic groups of the Adige Valley. A comparison of the results of functional analysis with technological aspects of the lithic industry and faunal remains will better define the scenario of early-middle Holocene adaptations in the region.

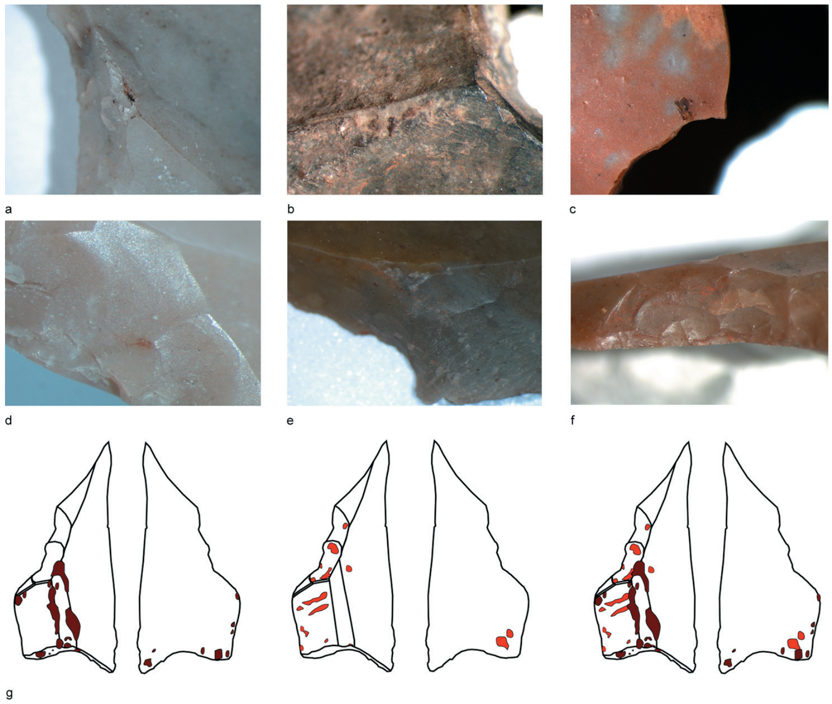


Fig. 8. Archaeological residues: a, b, c) macro-photos of brown residues (a: 3.2x; b: 4x; c: 4x); d, e, f) macro-photos of brown residues (d: 10x; e: 2.5x; f: 4x); g) distribution of brown and red residues. The drawing on the right shows the distribution of both red and brown residues and their perfect match on the trapezes.

The functional data on the trapezes integrate and confirm what has already been pointed out in relation to raw material acquisition and the lithic technology at Gaban rockshelter (*Perrin 2007*). In particular, the analysis of cores and tools from layer E (Castelnovian) and layer D (Neolithic) indicated "*the existence of two distinct industries that show a clear convergence from both the technological and typological points of view*" (*Perrin 2007.117*). The available data for Gaban rockshelter show that no substantial difference can be found in the lithic technology in the layers referring to the Late Mesolithic and Early Neolithic: the strategies of lithic acquisition are identical, as well as the blade *débitage* (characterised by indirect percussion and pressure), the faceting of blades and bladelet striking platforms, the presence of a 'common' toolkit (carried out on flakes produced during the blade operational sequence) and, finally, the use of the same modality of trapeze production (the so-called microburin technique). The diversity in the Early Neolithic industry at Gaban rockshelter can be synthesized as the use of a single striking platform seen in the Neolithic cores, the production of bigger and more asymmetrical trapezes and the introduction of new tool types, such as burins on lateral notch called burin of Ripabianca and the rhomboids (*Perrin 2007*). As many authors have underlined, these differences do not represent elements of a technological differentiation of lithic production between the last hunter-gatherers and the first Neolithic groups. Analogous considerations emerged after typological, technological and morpho-metrical analysis of the lithic industries from other important sites of the Adige Valley (in particular, Romagnano III and Pradestel rockshelters, *Bisi et al. 1986*). Therefore the Mesolithic-Neolithic sequence of the region seems to have been a continuous phenomenon at least in terms of modalities of flint-knapping and geometrical microliths use.

Furthermore, the analysis carried out on the residues on the trapezes provides new clues to understanding the dynamics of the acquisition of a Neolithic economy in the Adige Valley. The use of a specific glue produced by mixing beeswax and bitumen, and the use of ochre in the hafting of these microliths seem to be features of a regional tradition which could probably be traced back to end of the Late Glacial period. In fact, the use of beeswax is known since the end of the upper Palaeolithic from the Dalmeri rockshelter (Marcesina Plateau, Trento) (*Belli et al. 2007*), since this material constitutes part of the recipe used to fix the decoration on the numerous painted stones found at the site. Bees products (not only wax, but also propolis) were among the grave goods in the Epigravettian burial at Villabruna in the Cismon Valley (Venetian Alps) (*Aimar et al. 1994*), and were also found in the Castelnovian burial at Mondeval de Sora[8] (*Fontana 2006*).

Regarding the ochre, the analysis carried out on the residues from the Gaban rockshelter has verified the

8 In particular, an amount of resin and propolis was found as a grave good (*Fontana 2006*).

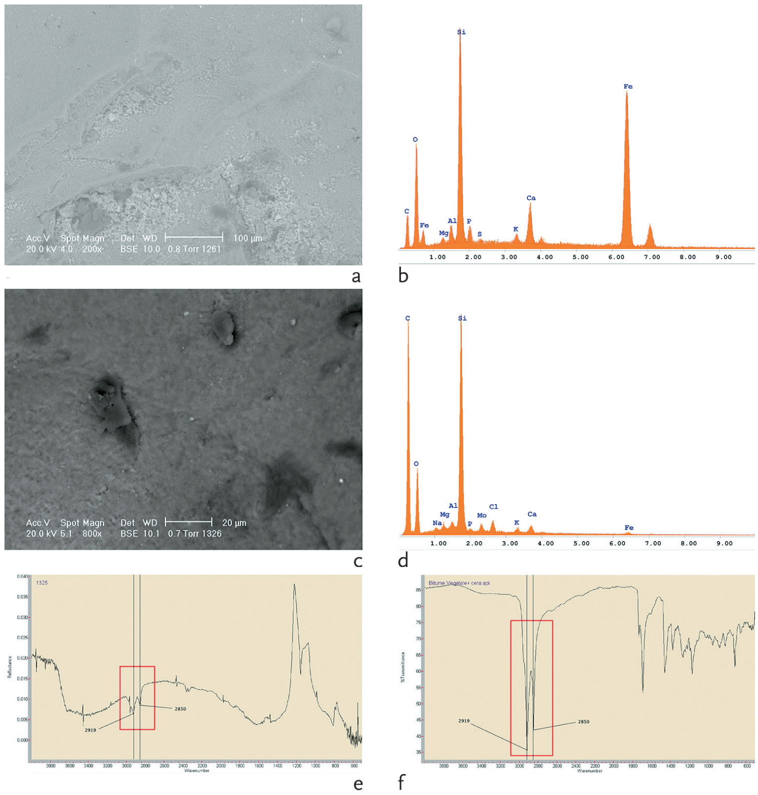


Fig. 9. a) ESEM micrograph showing a higher magnification view of the 'red' residue on sample nr. 1261 (stereo-photo: Fig. 8.f); b) EDXS spectrum obtained from 'red' residue. In addition to the characteristic lines of the flint substrate (SiO_2), the presence of haematite (Fe_2O_3), calcite ($CaCO_3$) and unidentified alumino-silicate phases can be inferred from the other X-ray peaks; c) ESEM micrograph showing a higher magnification view of the 'brown' residue on sample 1418; d) EDXS spectrum obtained from a 'brown' residue on sample 1326 (see stereo-photo: Fig. 8.a); e) FT-IR spectrum obtained from 'brown' residue; f) FT-IR spectrum obtained from the mixture of beeswax and natural bitumen, prepared as a reference standard to identify the unknown organic phases in the 'brown' residues.

aesthetic/symbolic value of this element, since no trace of it has been recognised in the physical-chemical composition of the mastic. Excluding its functional efficiency in a hafting system[9], it is possible that ochre might have been used to dye the bindings used to fix the trapezes to the shaft. As for the beeswax, it is comparable to other Late Glacial and Mesolithic sites in the region. Furthermore, the use of red bindings has been suggested for the hafting of Epigravettian bone points at Dalmeri rockshelter and, at the same site, coloured threads were also used to attach ornaments (shells and red deer canines, *Cristiani in press*). It could not be accidental that, at the same site, red ochre dye on leather had been processed using both lithic and osseous tools (as testified by the use-wear analyses results – *Lemorini et al. 2006 and Cristiani 2007*). Traces of contact with minerals (iron oxides?) have been found in association with hafting traces at the Epigravettian occupation of the Val Lastari site on the Cansiglio Plateau (Venetian Alps) (*Ziggiotti 2007*). In the Adige Valley, the use of ochre has been suggested for the suspension of *Columbella rustica* ornaments found in the Mesolithic as well as the Neolithic layers of most of the lowland rockshelters (with no differences between the two occupations) (Fig. 11).

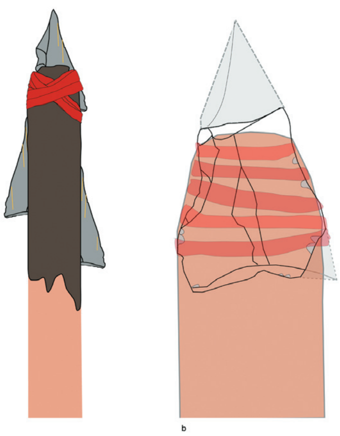


Fig. 10. Reconstructions of the use of the trapezes a) trapeze position as an element of a composite arrowhead. The yellow lines represent MLIT distribution and orientation on the trapezes; b) use of the trapeze as a single distal point. Note the localisation of the main traces (distal fracture and lateral macro-detachments).

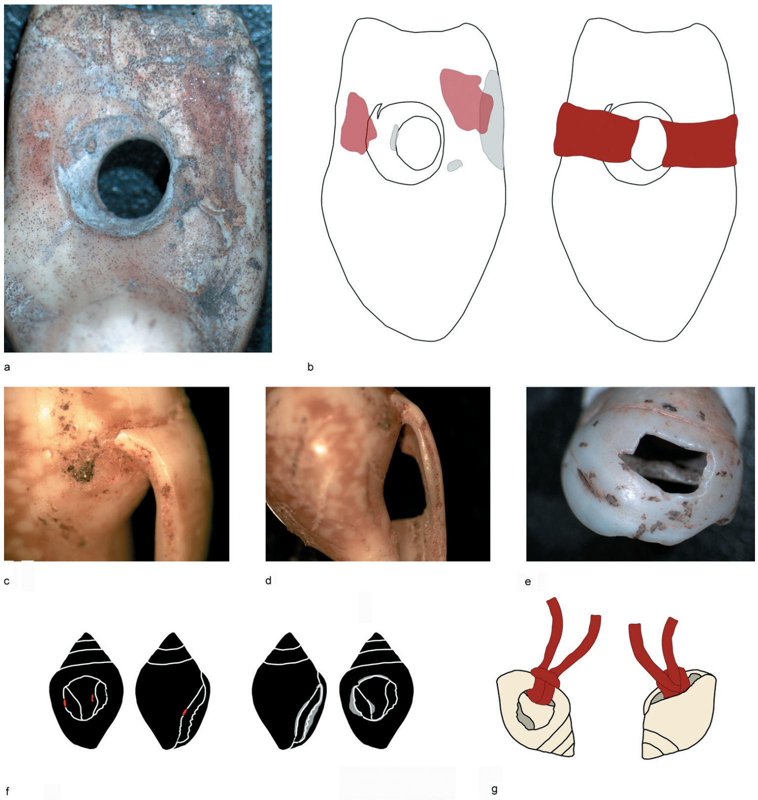
This practice constitutes an additional element of a Palaeo-Mesolithic tradition among the Neolithic communities of the Adige Valley, and supports what has already been suggested for the 'Gaban Venus'.

Conclusion

Our analysis confirms a continuity of functional choices connected with the use of geometric microliths between the Castelnovian and the Early Neolithic at Gaban rockshelter. Some aesthetic aspects, not di-

9 The use of ochre for hafting has been documented in other praehistoric contexts (*Lombard 2007*).

Fig. 11. Epigravettian and Mesolithic ornaments from north-east Italy: a) Red deer canine showing ochre residues from Dalmeri rockshelter (2x); b) residues and use-wear traces distribution on the red deer canine and reconstruction of the modality of its suspension; c,d) ornaments on* Columbella rustica *showing ochre residues from Gaban rockshelter, Neolithic levels (c: 4x; d: 2.5x); e) ornament on* Theodoxus fluvialis *showing ochre residues from Pradestel rockshelter, Castelnovian levels (2.5x); f) distribution of residues (red) and use-wear traces (gray) on the* Columbella rustica *ornaments from the main Adige Valley rockshelters (both Mesolithic and Neolithic levels); g) reconstruction of the modalities of* Columbella rustica *suspension at Pradestel and Gaban rockshelters.



rectly related to the utilisation of the tools (in particular, the use of ochre in their hafting modalities), probably have their roots in previous periods and constituted, since Late Glacial times, a distinctive regional pattern. Such a pattern seems to confirm hypotheses of socio-economic transformations within local Mesolithic groups at the end of the 6th millennium calBC (already suggested by *Bagolini and Biagi 1988*). This feature does not characterise Neolithic communities newly formed at the south of the Adige Valley. For example, at the Lugo di Grezzana site (Lessini Mountains, Verona), which can be attributed to the Early Neolithic Fiorano Culture (5500–4800 calBC), the functional analysis carried out on the whole assemblage of lithic trapezes documents homogeneity in the use of these microliths and the absence of the aesthetic traits (ochre) that we have demonstrated to be a characteristic feature of the Palaeolithic and Mesolithic traditions of the Adige Valley region. What we have presented up to now clearly demonstrates that at the beginning of the 5th millennium calBC these Mesolithic local communities had adopted and translated into their own language a specific ideological knowledge that they had learned from the Neolithic groups. We hope that the results of the research in progress will provide new data to deepen the scenario of the Mesolithic and the Early Neolithic interactions and dynamics in the Adige Valley.

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The action of the masticatory muscles and cranial changes in pigs as results of domestication

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ABSTRACT – *The comparative study of wild boar and domestic pig skulls suggests that a change in feeding habits under human control may have been a factor influencing the action of the masticatory and neck muscles in reshaping the cranial region. This paper offers both an anatomical and an osteological comparative morphological argument supporting this hypothesis.*

IZVLEČEK – *Komparativen študij lobanj divjega in domačega prašiča sugerira oceno, da je bila sprememba prehranjevalnih navad pod človeškim nadzorom lahko dejavnik, ki je vplival na delovanje žvekalnih in vratnih mišic pri preoblikovanju lobanjskega predela. Članek ponuja anatomski in osteološki komparativno morfološki dokaz, ki podpira to oceno.*

KEY WORDS – *differential feeding; masticatory muscles; biomechanical stress*

Introduction

The domestication of animals is one of the most important and debated chapters in archaeological and zoo-archaeological research. Researchers are trying to answer a number of questions: why domestication; why certain species; how it happened, when and where first; what may be considered as markers of domestication; and what actually is the definition of a domestic animal. Although metrics have played a significant role in making a differentiation between wild and domestic samples, it may be that such measurements alone offer a false image (*Zeder 2006*). In offering answers to questions such as those above, zoo-archaeology has increasingly looked to other sciences, especially genetics (*Albarella, Dobney, and Rowley-Conwy 2006; Berry 1969; Larson et al. 2005; Larson et al. 2007; Mignon-Grasteau et al. 2005; Vila, Seddon, and Ellegren 2005*).

The present study attempts to explore aspects of pig domestication less investigated by zoo-archaeologists: the relationship between the action of the masticatory muscles and the reshaping of the skull. The author suggests that a drastic change in pig feeding habits due to human control, may have been an important factor in triggering cranial morphological changes; therefore, in the absence in an archaeological record of other measurable elements (as teeth), the angle of the ascending ramus of the mandibula, of the zygomatic arch, and of the occipital, may assist in differentiating between wild and domestic individuals.[1]

Materials

This study considered more than 500 pig skull fragments, and skulls found at the locations listed below. Due to space restrictions, photos of only some of these materials are shown here.

❶ Contemporary domestic pig and wild boar skulls from: the National Museum of Natural History 'Grigore Antipa' (20); University of Bucharest the Fa-

1 All anatomical terms used in this study are in conformity with the latest revised edition of Nomica Anatomica Veterinaria prepared by International Committee on Veterinary Gross Anatomical Nomenclature (I.C.V.G.A.N.) 2005.

culty of Veterinary Medicine – Laboratory of Comparative Anatomy (8); The National History Museum – New Center for Pluridisciplinary Research (8). In Bucharest, Romania.

❷ Contemporary wild boar skulls and skull fragments obtained by the authors in the village of Dubova (8), region of Danube Iron Gates, Romania.

❸ Contemporary domestic pig skulls obtained by the authors from the villages of Varteju (2), Frasinet (3), Rotunda (1), and Topoloveni (2), Romania.

❹ Mesolithic pig remains from the sites of Ostrovul Banului (4), Ostrovul Corbului (5), Cave Climente II (10), Icoana (212) and Schela Cladovei (20) region of Danube Iron Gates; The Institute of Archaeology 'V. Parvan'. In Bucharest, Romania.

❺ Neolithic pig remains from Cuina Turcului (8), Veterani (25); The Institute of Archaeology 'V. Parvan'. In Bucharest, Romania.

❻ Neolithic pig remains from Chitila (5), Mariuta (8), Poduri (2), Vitanesti (6), Bordusani (29) and Insuratei (2); The National History Museum – New Center for Pluridisciplinary Research. In Bucharest, Romania.

❼ Neolithic pig remains from the sites of Cascioarele (98) and Varasti (23); The Center for Anthropological Research 'Francisc Rainer'. In Bucharest, Romania.

What is different?

Considering wild pig habitats and behaviour, feeding habits, and the nature and quality of its food compared to that of the domestic pig, the problem presented in this study can be divided into two inextricably related aspects: the action of the neck muscles, and the action of the masticatory muscles. The present study considers only the latter; the action of the neck muscles will be considered in future research.

It is obvious that there is a major difference between the skull shapes of wild and domestic pigs (Figs. 1, 2). Especially when looked at akrokranion (*von den Driesch 1976*), in wild pigs no areas of the occipital bone or tuberculum nuchale can be seen, which otherwise are perfectly visible in a domestic pig skull (Figs. 1, 2). This is because the angle of the occipital and of the ascending ramus of the mandibula in domestic pigs is much closer to 90° compared to those in wild pigs; in other words, if the snout is oriented towards 2π (1, 0) in a trigonometric circle, the orientation of the occipital and the ascending ramus of the mandibula of a domestic pig follows a trajectory most likely from the 3rd quadrant to the 1st quadrant closer to π/2, while in the wild pig this orientation tends to be from the 4th quadrant to the 2nd quadrant, more likely towards 2π/3. In some cases, the skull of an old domestic pig may display morphological changes more closer than its wild cousin, but such cases are extremely rare; usually domestic pigs are sacrificed at a younger age.

What could have caused these differences? It may be that such changes occurred during the process of domestication; however, it would be incorrect to say that humans deliberately selected pigs having a less sharp mandibular and occipital angle. During the process of domestication, humans may have selected animals that were less aggressive, smaller, and easier to manage; such action constitutes direct human involvement, whereas the reshaping of the skull of the selected animals as in the case presented here is a side-effect of domestication, totally independent of human intentions.

The starting point for this analysis lies in the fact that there is a marked difference in the feeding behaviour of wild and domestic pigs. Generally, the mammalian masticatory apparatus is similar (*Turnbull 1970*). Under human control, however, pigs chew on softer food, and generally, their feeding behaviour has drastically changed. It has been accept-

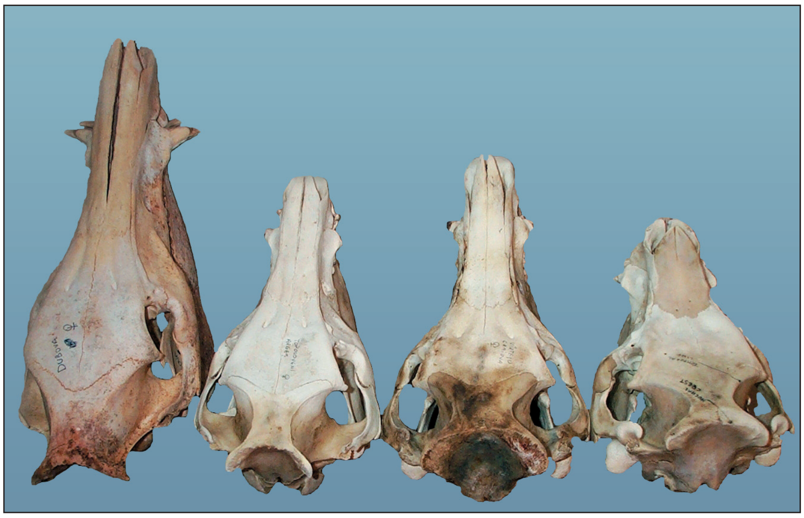

Fig. 1. Differential angle of the occipital. Far left: wild pig from Dubova, Iron Gates; Next three, domestic pigs. Skulls collected by the author.

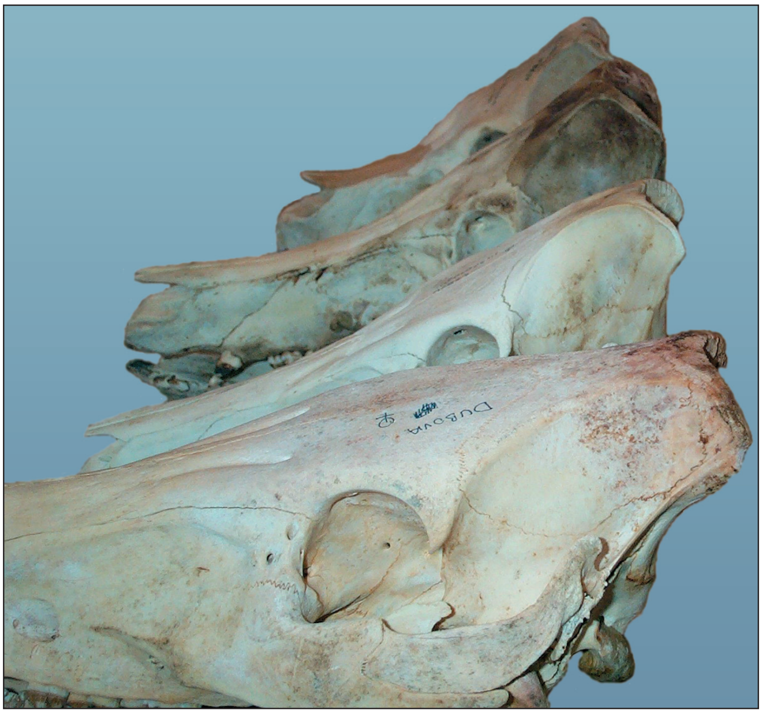

Fig. 2. Same pig skulls as in Figure 1, lateral view.

ed that during the process of mastication: "*Masticatory muscle activation and coordination determine the direction of the jaw movement, control occlusal force, and deform the skull in a variety of ways.*" (*Herring 2006*).

Basically, the study considers the action of Wolff's Law (*Chamay and Tschantz 1972; Dowthwaite 2007; Enlow 1968; Forwood and Tuner 1995; Rubin, McLeod, and Bain 1990; Vainionpaa et al. 2007; Wolff 1892(1986)*). Generally stated, as the law of bone transformation (or remodelling), it holds that bone is not what it appears to be: hard, inflexible, and immutable. On the contrary, bone is responsive to biomechanical stress, and changes according to changing needs not only as material build-up, but also in shape.

During the process of domestication, changes in the feeding pattern of herbivores did not occur to an extended degree; sheep, goats, horses, and cows were still herded and grazed on pastureland. Pigs, on the other hand, may have been subject to a more drastic change from an early stage (*Minagava, Akira, and Naotaka 2005; O'Regan and Kitchener 2005*) if kept in an enclosure at site. Generally considering the action of the Law of Bone Remodelling (Wolff) when there was a change in the pattern of stress developed by the mastication muscles on the cranium, the bones reacted accordingly. In domestic pigs, the muscles of the head, and especially those associated with mastication, are used less intensively, triggering a similar response from the cranial skeleton. The reshaping of the skull from wild to domestic is visible mainly at the level of the maxillary complex, especially in the angle of the temporal and zygomatic bones, in the angle of the ascending ramus of the mandibula, and in the cranium, especially in the angle of the occipital. At the frontal level (face), the anterior height increases.

Previous studies

There have been many studies of the process of mastication in fields such as biochemistry, physiology, and orthodonty (*Fisher, Godfrey, and Stephens 1976; Freeman, Teng, and Herring 1997; Herring 1980, 1985; 1992; 1993; 2006; Herring, Anapol, and Wineski 1991; Herring, Peterson, and Huang 2005; Herring et al. 2001; Herring and Scapino 2004; Herring et al. 1996; Herring and Wineski 1986; Kakizaki et al. 2002; Langenbach et al. 2002; Lieberman et al. 2004; Liu et al. 2004; Popowics and Herring 2007; Rafferty et al. 2007; Sato et al. 2005; Sun, Liu, and Herring 2002; Teng, Herring and Ferrari 1996*). The subject of such research constitutes the bones and muscles included in this study, but for purposes totally unrelated to animal domestication. Rather, it is directed to a better understanding of human disorders and treatment. Pigs have become an increasingly important component in such research, providing extremely valuable information on the biomechanics of muscle and the skeleton (*Larsson et al. 2005; Lieberman et al. 2003; Liu et al. 2004; Rafferty et al. 2007; Risinger and Gianelly 1970; Sato et al. 2005; Sun, Liu, and Herring 2002; Usui et al. 2004; Zhang, Peck, and Hannam 2002*).

With regard to the cranial muscle-bone relation, such studies indicate extremely intensive strain activity in the region of the zygomatic-squamosal (zygomatic process of the temporal bone) – upper ascending mandibular ramus, mainly as a result of the action of the masseter and temporalis muscles during food processing (*Freeman, Teng and Herring 1997*). In fact, the masseter muscle appears to be the key force for the entire mechanism triggered by the process of mastication: "*If there is a unifying theme in this analysis of masticatory biomechanics, it is the* *masseter muscle. The masseter muscle is directly responsible for bending the zygomatic bone in plane, and the load transmitted from the zygomatic bone to the squamosal bone is responsible for the out-of-plane bending of the squamosal. By moving the mandible to the opposite side, the masseter is indirectly responsible for the strain patterns in the zygomatic flange and probably the premaxilary bone. In conjunction with the temporalis muscle, the masseter twists the braincase and tenses the braincase sutures. Reaction forces from masseteric contraction compress the mandibular condyle, and occlusal forces produced by masseteric contraction bend the snout dorsally. The pull of the masseter, in combination with the bite force, twists the body of the mandible.* (*Herring et al. 2001.219*).

According to some, the mechanical requirements of feeding delineate skull design (*Mayer and Lehr Jr. 1988*). The wild pig has a diet rich in coarse foods; among the muscles of the head, masticatory muscle contraction causes both jaw movement and tissue deformation, suggesting that mastication is a forceful cranial activity that produces obvious loads on the craniofacial components, especially on the jaw joint. The masseter muscle, the largest jaw adductor, is the major source of masticatory loads. Its activity in both pars profunda and pars superficialis was found to be highly correlated with condylar neck and squamosal bone strains. These results suggest that bone strains are driven by different mechanical regimes (*Herring 1992; Herring et al. 2001; Liu et al. 2004a; Liu and Herring 2000*), in other words, by differential feeding.

Food consistency affects the duration of muscle burst activities differently in different muscle groups. Studies considering the muscles for closing the jaws (masseter), for opening them (digastric), for extending the tongue (genioglossus), and for retracting the tongue (styloglossus) (*Fehrenbach and Herring 2002; Ghetie 1971; Sinelnikov 1988*) suggest that the duration of burst activity is longer for hard food than soft food in the masseter and styloglossus; no difference with regard to differential food was detected in the digastric and genioglossus (*Kakizaki et al. 2002*). Significant mandibular morphological differences in pigs (as well as in rats), fed on soft and hard diets were also indicated in other studies (*Kiliaridis, Engstrom, and Thilander 1985; Larsson et al. 2005; Yamamoto 1996*).

Due to the closing jaw group action during mastication, the zygomatic arch is distorted on both sides of the skull, the largest strain being in the suture (*Herring et al. 1996*), compressive in the vertical part and tensile in the horizontal part; all parts of the zygomatic bone show tension aligned with the pull of the masseter (rostrodorsal); the squamosal is bent out-of-plane, with the lateral surface becoming more convex. The axis of tension on the lateral surface is caudodorsal. These strains can be explained as a result of the masseter's backward and downward pull on the zygomatic, which is braced at its sutures with the maxillary and squamosal bone, suggesting that the squamosal and the region of the occipital-parietal-nuchal crest is affected upwards and forwards. Studies of strain in the zygomatic arch have indicated that the most likely cause of bending of the squamosal during mastication is the inward pull of the masseter. Condylar strain results from the downward force exerted by the articular eminence on the condyle when the upward-acting jaw adductors contract (*Fisher, Godfrey, and Stephens 1976; Herring 1992; 2006; Herring, Anapol, and Wineski 1991; Herring, Peterson, and Huang 2005; Herring et al. 2001; Liu and Herring 2000*). Strains in all brain case bones and sutures are produced by the action of the masseter, temporalis, both pterygoids, and the neck extensors. The overall loading patterns in the skull of the pig especially may produce drastic bone alterations (*Herring et al. 2001.Fig. 7*).

As a skull grows from infancy to adulthood, the normal forces of mastication in the skull bones produce differential strains (*Langenbach and van Eijden 2001; Langenbach et al. 2002*). These strains cause the skull to grow in such a way as to minimize the strains, and to make them less variable over the skull as the skull matures. This result is very much dependent upon the type of force magnitude applied to the masseter, temporalis and medial pterygoid muscles. The variance of the strain magnitude decreases from infant to adolescent to adult, thus indicating that as the animal matures, the bones distribute the induced strain across the skull in a manner which minimizes strain variances (*Fisher, Godfrey and Stephens 1976*).

Generally, there is a differential fiber structure between the masticatory muscles of wild and domestic animals (*Essen-Gustavson and Lindholm 1984; Fiedler et al. 1998; Ruunsen and Eero 2004*). Could this be a result of a differential mastication process triggering differential biochemical reactions, as shown by some studies (*Luck et al. 2005*)? In the mandible, the orientation of the compressive axis is similar to the vector of the masseter muscle, suggesting that the masseter muscle might be particularly important in engendering the reaction force. The masseter is not the only source of maxillary strain, but no other muscle plays such a significant role. It is possible that the maxillary strain, which is very similar to that of the neighbouring zygomatic bone, directly reflects the pull of the masseter muscle transmitted through the zygomatico-maxillary suture.

The pterygoid has also been subject of a number of studies (*Herring, Grimm, and Grimm 1984; Herring and Scapino 1973*). The strain caused by this muscle is located mainly on the mandibular condyle, which is generally affected significantly by strains from both masseter and pterygoid, although the later action is lesser compared to the former. Nevertheless, the pterygoid does cause a significant and different bone strain in the mandibula. The lateral pterygoid is extremely important in protrusive movements, but less important for loading.

The muscles

This study considers only the possible effect of the masticatory muscle in reshaping the cranial area. Although there are many muscles involved to one degree or another in the process of mastication (*Daumas, Xu, and Bronlund 2005; Fehrenbach and Herring 2002; Ghetie 1971, Gorniak 1985*), we have focused on the two muscles whose action elevates the mandible: 1) the masseter, which is the largest, most powerful, and most active masticatory muscle, and, 2) the temporalis, which, due to its origin, is the masticatory muscle directly related to the cranial region.

❶ The masseter has two heads:

- **a.** the superficial head or pars superficialis originates on the anterior-interior two thirds portion of the lower border of the zygomatic arch and inserts on the mandibular angle (*Fehrenbach and Herring 2002; Ghetie 1971*).
- **b.** the deep head or pars profunda originates on the medial-posterior interior one third and medial portion of the zigymatic, and inserts on the masseteric fossa (*Fehrenbach and Herring 2002; Ghetie 1971*).

Main action: for the most part, during mastication the two heads of the masseter have a different function. Basically, during the power stroke, the deep head is most active on the balancing side of the jaw and serves to retrude the balancing mandibular condyle; the superficial head is the most active on the working side, and serves to generate occlusal force. The action of the superficial head will be considered in this paper.

❷ The temporalis, despite its name, originates in the temporal fossa or planum parietale and inserts on the internal side of the coronoid process of the mandibula. According to some authors, the insertion occupies the entire rostral region down to the 3rd molar (*Ghetie 1971.508*). Main action: a complete contraction of the temporalis elevates the mandible.

Other muscles important in assisting mastication are:

❶ Pterygoid. It has two branches:

- A. the medial pterygoid originates from the pterygoid fossa on the medial surface of the lateral pterygoid plate of the sphenoid, and inserts on the interior medial surface of the angle of the mandibula. Main action: the contraction of the medial pterygoid raises the mandibula. However, the muscle is weaker than the masseter muscle in this action.
- B. the lateral pterygoid has two heads
  - a. The superior head originates from the inferior surface of the greater wing of the sphenoid and,
  - b. The inferior head originates from the lateral surface of the lateral pterygoid plate of the sphenoid.

Both heads unite and insert on the anterior surface of the neck of the mandibular condyle and the pterygoid fovea. Main action: the inferior head of the muscle has a slight tendency to depress the mandibula. When both medial and lateral branches contract, a protrusion of the mandible occurs. If only one lateral pterygoid muscles contracts, a lateral deviation of the mandible occurs.

❷ Buccinator (main action: pulls the angle of the mouth laterally and shortens the cheek both vertically and horizontally, keeping the food pushed back on the occlusal surface of the teeth).

❸ Muscles that, due to their origin, may have played a role in reshaping the bones to which they are attached, such as the zygomaticus major (main action: elevates the angle of the upper lip) and zygomaticus minor (main action: elevates the upper lip) (*Fehrenbach and Herring 2002; Ghetie 1971*). These muscles, as well as the muscles of the neck, will be considered in future research.

Among the muscles involved in mastication, some authors have pointed out the particular importance of the masseter and temporalis: *"Masticatory muscles, through their direct action on bony attachments and their indirect action in loading the teeth and the jaw joints, constitute the major biomechanical challenge to the skull. Direct effects of a muscle attachment are sensitive to the particular muscles used and to the pattern of muscle coordination. For example, the temporalis and masseter twist the pig braincase in opposite directions, and because these muscles usually act in opposite-side 'couples', the effect is exaggerated rather than cancelled."* (*Herring 2007*).

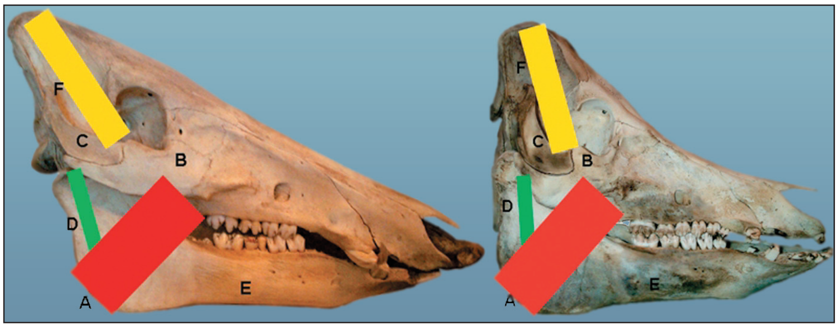

Fig. 3. Left: skull of wild pig. Right: skull of domestic pig. A: mandibular angle. B. temporal process of the zygomatic bone. C: zygomatic process of the temporal bone. D: the ascending ramus of mandibula. E: the horizontal ramus (the body) of mandibula. F: fossa temporalis (planum parietale). Schematic representation of: (red) masseter pars superficialis; (green) masseter pars profunda (zygomaticomandibularis), and (yellow) temporalis.

It must be clearly underlined, however, that the line of action in the jaw muscles is extremely difficult to determine. The muscles extend over complex skull surfaces, and the fibres do not run exactly from bone to bone, but rather between internal tendons. The pig's masseter superficial head in particular, has fibres that run in different directions: more vertically in the anterior part, and more horizontally in the posterior part (*Susan W. Herring, personal communication*). In both muscles, the elevation of the mandible is a result of the average line of action generated by these fibres.

The sum of these lines of action in both the masseter and temporalis are always divergent in all mammals due to general skull morphology (*Daumas, Xu and Bronlund 2005*). The purpose of this study is not to identify these lines of action, but to see if, due to their general direction – the result of these lines of action – the chewing force differentially applied for harder of softer foods may affect jaw deformation (*Langenbach and van Eijden 2001; Langenbach et al. 2002*) in the case of wild pigs and domestic pigs.

As can be seen (Figs. 1, 2, 3) and explained earlier in this paper, there is a marked difference between the angle of the ascending ramus of the mandibula, zygomatic, fossa temporalis, and the occipital when wild and domestic specimens are compared. The 'V' formed by the orientation of the vectorial forces developed by the action of masseter and temporalis follow the same pattern. Evidently, if the angle of the mandibula and of the temporal fossa is closer to 90°, the smaller the angle of 'V' becomes. Might a decrease in this angle result in differential chewing (crushing) forces? It must be underlined that in Figure 3 the anatomical locus of the muscles is not represented, but rather a schematic representation of the masticatory muscles orientation. For instance, in reality, the superficial head of the masseter is much larger, superimposing on most of the deep head.

Considering the drastic differences shown in Figure 3, it may be assumed that, over time, a more refined diet, and therefore less muscle activity, could have triggered an alteration in the mandibular angle, the angle of the zygomatic arch, and the angle of the parietal fossa. Human control of pig diets may explain such a drastic change in the vectorial forces acting on the remodeling of the skull bones. Of course, the contribution of all the other muscles of the head and neck to this process of morphological change must also be taken into account.

The bones

In order to verify the assumption stated above, we compared a number of samples of known wild and known domestic pig, to both Mesolithic and Neolithic pig remains. The latter, even if subject of previous metric studies for establishing the status of wild or domestic, were considered simply as 'unknown', the present research not being interested in evaluating metric caractheristics.

First, in Figures 4, 5, 6, the angle of the ascending ramus of the mandibula of a modern domestic pig was compared to the angle in Neolithic pigs from Bordusani, Cascioarele, and Insuratei.

It is obvious that in the three cases, the mandibular angle in the Neolithic samples and modern do-

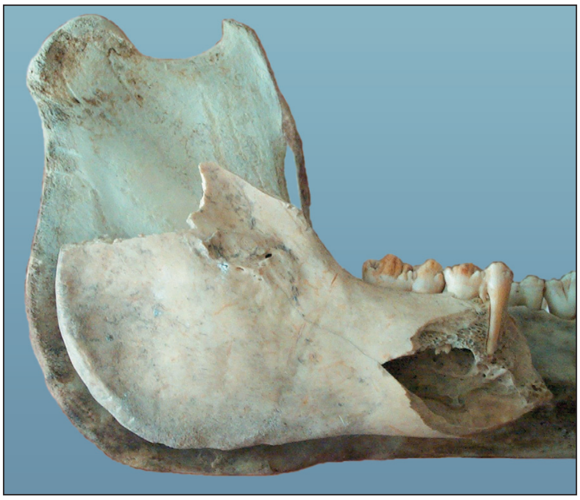

Fig. 4. The angle of the madibula of a modern domestic pig and a Neolithic Bordusani pig.

Fig. 5. The angle of the madibula of a modern domestic pig and a Neolithic Cascioarele pig.

mestic samples are identical, and that they were subject to the same feeding patterns, generating the same pattern of mechanical strain.

In Figures 7 and 8, the planum parietale of a modern wild boar is compared to remains from the Neolithic site of Varasti and the Mesolithic site of Icoana.

The temporalis muscle, which follows perfectly in the planum parietale (fossa temporalis), due to its origin and insertion, is set at an angle following the ascending ramus of the mandibula. The angle of this alignment has two points of conjuncture: it contributes to the increase or the decrease of the mastication force, and is in direct relationship with the angle of the occipital. In the two cases presented above, the morphology and the angle are identical, suggesting identical action of the mastication muscles, generating the same type of stress on the skull bones. The most probable cause is identical feeding patterns.

In Figures 9 and 10, the temporal process of the zygomatic bone of a modern wild boar is compared to an example from the Mesolithic layer site of Schela Cladovei.

The morphology and angle match perfectly, obviously both subject to the same type of biomechanical strain.

In Figures 11 and 12, two zygomatic processes in the temporal bone of a modern wild pig are compared with Mesolithic remains from Icoana and Schela Cladovei.

Again, the morphology and angle are identical, both obviously subject to the same type of biomechanical

Fig. 6. A pig mandibula ascending ramus from the Neolithic site of Insuratei compared to a modern domestic example.

strain. As the jaw opens, the muscles that open the jaw shorten and become less forceful. Meanwhile, they have to stretch the muscles which close the jaw. A function of the coupling between head and jaw movements is to extend the gape of the jaw, the extension forward contributing to the extended opening of the jaw. The forward extension of the head involves neck muscle action (*Koolstra and von Eijden 2004*).

The neck muscles

Although the action of the neck muscles will be addressed in future research, it may be useful to note a few aspects here. Wild pigs make strenuous and constant use of the head and neck for rooting and for penetrating forest undergrowth and thicket, as well as for fighting. In the absence of support offered

Fig. 7. The parietal fossa, nuchal crest, and zygomatic process of the temporal bone of a pig skull from Varasti compared to a modern wild pig skull from Dubova.

Fig. 8. Fragment of occipital-temporal-parietal fossa from Mesolithic Icoana compared to a modern wild pig skull from Dubova. The morphology and angle match perfectly.

by the cervical ligament, this peculiar behaviour redistributes the function and pressure of the muscles of the neck and head. In addition, the weight of the head is redistributed to the neck muscles.

Three layers of paired muscles directly link the skull either to the cervical and thoracic vertebrae or to the shoulder griddle (*Dutia 1991; Fehrenbach and Herring 2002; Ghetie 1971; Richmond and Vidal 1988*). These include the large muscles of the neck that act across three or more neck joints (example of extensors: splenius, longissimus capitis, biventer cervicis and complexus; example of flexors: obliquus capitis inferior and superior), as well as short suboccipital muscles that act specifically in the region of the upper cervical joints (rectus capitis posterior and rectus capitis anterior muscles). Of extreme importance to the subject presented here is the trapezius muscle, having an origin that extends from the occipital to the 10th thoracic vertebra (*Ghetie 1971*); the role of its action in relation to the morphology and angle of the occipital is obvious.

Fig. 9. The temporal process of zygomatic bone from Mesolithic Schela Cladovei compared to a modern wild pig skull from Dubova. The morphology and the angle match perfectly, obviously both subject to the same type of biomechanical strain.

It has also been pointed out by some authors that among domesticated animals, the pig has the most developed iliocostalis cervicis muscle (*Ghetie 1971*), which originates on the first rib, attaches in its trajectory to all the cervical transverse processes, and inserts on the atlas wing. In addition, each neck vertebra is linked to its neighbors by short intervertebral muscles that attach to the transverse and spinous processes (*Dutia 1991*).

Movements of the head on the neck are achieved by the coordinated realignment of the cervical and thoracic vertebrae, and involve simultaneous movements around many vertebral joints. The forward extension of the head involves neck muscle action (*Koolstra and von Eijden 2004*). The articulation between the skull and the first cervical vertebra (the atlanto-occipital joint) allows a large amount of extension and flexion typical of wild pig feeding and fighting behaviour, but much reduced in domestic pigs.

Fig. 10. The same bone shown in Figure 11, from a different angle.

Discussion and conclusion

There are certain aspects of pig domestication that are very difficult to address. For instance, one pig-keeping practice, still found in some parts of the world, is to let the animals roam freely (Fig. 13).

This practice may result in both a continuation of feeding associated with wild boar feeding habits, and in hybridization (Fig. 14).

At this point, it is impossible to say if such practices were present during the early period of domestication. Although they may have been present, it is impossible to asses how widespread they were. It may be that the nature of the environment, unfriendly neighbours, or other social and political circumstances greatly influenced patterns of animal husbandry. Moreover, the fact that there is historical and contemporary evidence for such practices does not mean that they originated in the Neolithic, or that people from widely separated geographical regions followed the same patterns of husbandry. It may be that keeping pigs on site was practiced in order to protect wealth, to insure food storage on the hoof, or as a disposal of kitchen garbage.

However, the problem of hybridization is a very serious issue. The skull of the resulting individuals strongly retains the characteristics of the wild boar. Detecting hybrid specimens in the archaeological record may be extremely difficult. The measurement of the mandibular angle may offer answers, but there are some uncertainties; for instance, how a mandibular angle in a hybrid individual can be differentiated from the mandibular angle of an individual entirely controlled by humans, but still at an earlier stage of domestication. Despite such problems, it appears that the cranial morphological changes associated with the domestication of pigs were rapid, and due primarily to changes in the biomechanics of mastication.

The data included in this paper represents only a small fraction from an impressive number of studies on pig; the studies listed here were totally unrelated

Fig. 11. Mesolithic squamosal (zygomatic process of the temporal bone) from Icoana compared to a contemporary wild pig skull from Dubova.

Fig. 12. Mesolithic squamosal (zygomatic process of the temporal bone) fragment from Schela Cladovei compared to a modern wild pig from Dubova.

Fig. 13. Domestic pigs left to roam freely on the island of Ostrovul Mare, region of the Iron Gates, southwestern Romania.

Fig. 14. Hybrid wild and domestic pigs in Dobrogea, southeastern Romania, not far from the Danube Delta.

to archaeological questions such as animal domestication, but, used in conjunction with archaeological data, may be of great help in producing clues to this process. Therefore, the present author suggests that restricting zoo-archaeological research to traditional methods of analysis such as metrics, morphology, and economic patterns, may lead to an incomplete, or even erroneous picture of what, and how, animal domestication occurred.

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The materiality of dung: the manipulation of dung in Neolithic Mediterranean caves

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ABSTRACT – *This paper discusses the formation of layers of burnt herbivore dung in Neolithic, Eneolithic and Bronze Age Mediterranean caves. While these layers are clearly connected with transhumant pastoralism and the practice of keeping herds in the caves, their formation should not be seen as the result of purely practical and 'rational' reasons. In this paper, I develop an argument that they are remnants of a complex manipulation of substances which includes burning dung to make white ash. Thus instead of seeing dung as a culturally neutral refuse which has to be disposed of, we might see its burning and deposition as the cultural manipulation of potent substance.*

IZVLEČEK – *Članek se ukvarja z nastankom plasti sežganega živalskega gnoja v neolitiku, eneolitiku in bronasti dobi v jamah Sredozemlja. Te plasti so nedvomno povezane s transhumantnim pašništvom in prakso zapiranja živali v jame, a njihovega nastanka ne moremo pripisati zgolj praktičnim in 'racionalnim' razlogom. Članek razvija argument, da so te plasti rezulat kompleksnega manipuliranja s snovmi, ki vključuje tudi sežig gnoja in njegovo transformacijo v bel pepel. Gnoj ni bil kulturno nevtralen odpad, ki se ga je potrebno znebiti; premikanje, sežig in odlaganje pepela je potrebno razumeti kot kulturno manipulacijo potencialno močne substance.*

KEY WORDS – *archaeology; Neolithic; Mediterranean; herding; dung; materiality*

Introduction

Neolithic, Copper and Bronze age occupation levels in Mediterranean caves often consist of curious white powdery sediments. They were recently identified as layers of burnt herbivore dung. They represent the remnants of complex manipulations of matter, which includes the burning of dung to create white ash. These sediments pose a number of interesting question, not only on how and why they were produced, but also what meanings are objectified in the materiality of dung and the daily practices associated with it.

Overview: burnt animal dung

The pioneering work of Jacques É. Brochier (*1991; 1992; 1996; 2002; 2006*) has demonstrated that mineralized dung residues in archaeological deposits can be identified by the occurrence of spherulites, microscopic crystals of calcium salt and grass phytolits. This leads to the identification of herding strategies and penning practices in Mediterranean caves from the Neolithic onwards. Thus, in the Neolithic, Eneolithic and the Bronze Age, caves were used as pens for domestic animals, mostly sheep and goat. This is further supported by the identification of shed milk teeth often found in stable deposits. However, there is also evidence that caves were probably used simultaneously for domestic activities. Caves were obviously seasonal stations in the system of transhumance (*Boschian and Montagnari Kokelj 2000; Mlekuž 2005; Miracle and Forenbaher 2005*).

A unique depositional practice identified in many of these caves consisted of the burning of animal dung. This practice can be recognized in layers of either alternating black and white lenses (so called 'layer-cake' deposits), or white powdery lenses embedded in the sediment. The thin, layered lenses suggest that the process was repeated cyclically, probably over a long period.

Herbivore dung

Herbivores can produce large quantities of dung. Modern sheep breeds can produce around 1.5kg per day, which amounts to between 500 and 900 kg/year per animal; goats are even more productive. Cattle can produce up to 10 000kg of dung per year per animal (*Slicher van Bath 1963*). And even if animals do not stay in caves for the whole year and only part of the day (night, midday), a small herd can produce a large quantity of dung. Thus a herd of 100 sheep, which spends 8 hours per day in a cave for a month, can accumulate around 4000kg of fresh dung.

Cow dung has a high water content – around two to three times its dry weight (fresh dung is 75–60% water), but this greatly depends on diet and season (*Dickinson et al. 1981.129–41*). Sheep and goat dung has a lower water content.

Experiments on cow pats have shown that water content falls rapidly (to below 100% of dry weight) over the first few weeks following excretion if it is protected from rainfall. Dung contains around 50% of organic content, which is highly dependent on diet regimes. Protected dung pats show little loss of water content in the first months after excretion. Even less noticeable is the loss of calorific values (*Dickinson et al. 1981*).

In dry, warm conditions a thick crust is formed over the pat, which protects it from leaching. In caves where sheep are penned, the formation of 'migon', a dried surface comprised of a trampled accumulation of soft sheep dung can be observed. It consists of a dark, compacted organic paste, which breaks into platelike shapes; deep desiccation cracks form during the dry season (*Dickinson et al. 1981*).

However, in the long term (decades, centuries), a process of mineralization, the loss of degradable organic matter through oxidation, slowly transforms dung into a layer of phytolits, calcareous spherulites and detritic dust.

Dung as fuel

Dung can burn and, is used as fuel in many parts of the world, especially where firewood is not readily available. Cattle dung is formed into 'cakes' which are dried in the sun and stored as fuel for cooking and heating fires.

'Buffalo chips' or 'bois de vache', bison dung, were collected and used as fuel in the plains of north America (*Brink 2008*). Various travelers reported that dung "*in dry weather is a an excellent substitute for wood, but when moistened by rain, the smoldering pile will smoke for hours before it condescends to burn*" (cited in *Brink 2008.198*) and that smoke from buffalo chips "*produces an ardent, but transient flame, sufficient for cooking our daily food; but evolves a smoke, which, to the nasal organs of a stranger, is far from agreeable*" (*Brink 2008.198*).

Experiments suggest that cow dung fueled fire can reach a maximum temperature of 640 degrees Celsius and sheep dung maximum of 570 degrees C. Sheep pellets can smolder for quite some time (*Shahack Gross 2008*).

The burning of dung depends on many variables, first and most important being water content. Dung that is improperly dried can produce a lot of smoke and can be very difficult to ignite. The second factor is oxygen supply. Some reports suggest that dung fueled fire needs steady a supply of air in order to burn properly; without sufficient wind, it smolders, produces a lot of smoke and gives off little heat. The third variable is composition, which depends on animal species and diet.

In some cases, piles of fresh dung can ignite and burn spontaneously, due to the heat released during the decomposition and oxidation of cellulose material. In large dung piles with a limited oxygen supply, a smoldering fire starts when organic material reaches ignition temperature. This type of fire produces smoke and heat, but no flame. When more oxygen is present, a glowing fire can occur, producing smoke, more heat and higher temperatures. With abundant oxygen, a flaming fire with very high temperatures will ensue (*James 1928.481–5*).

Deposition practices

Lets return to the black and white sediments in the Mediterranean caves. We now know that the major quantity of deposits derives from herbivore dung altered in many ways, either by burning, by the slow process of mineralization and different kinds of reworking. But how exactly did these formation processes operate; how were dung deposits manipulated?

One of the most distinctive features are 'layer cake' sediments of alternating white and black lenses. The layers are thin and form stacks that can be up to several meters thick. Theses sediments cover large areas of the caves (Fig. 1).

Layer cake sediments are the result of the periodical burning of the dried and trampled dung deposited on the cave floor (migon). Thus in layer cake sediments, with alternating black/white layers each combination of white and black layer is a remnant of a single burning event and probably relates to a single occupation of the cave. White ashy layers are the result of properly burned dung, while thinner black layers comprise the bottom and lateral parts of the burnt dung, and contain charred and partially burned organic matter (*Brochier 2002*).

The formation of such sediments was observed in Greek and Sicily caves (*Acovitsioti-Hameau et al. 1988; Brochier et al. 1992*). At the end of autumn, after a summer period of drying, shepherds burn the dung deposited in sheep pens. All except the wettest areas are burnt. Contact between the burnt and unburnt material results in a black carbonaceous layer at the bottom and edges of the burnt ashy layer. The ashy layer is discontinuous and, like examples from archaeological excavations, has an irregular outline (Fig. 2).

There are many practical reasons for burning dung. Probably one of the main reasons was to reduce the volume of manure deposits, as dung loses about 97% of its volume and 95% of its mass as a result of degradation by burning (*Shahack-Gross et al. 2005. 1417–31*). Other reasons include the disinfection of caves and the protection of animals from parasites in the dung.

The distribution and shape of layer cake sediments in the caves can be therefore be explained by the pattern of less dry dung in the cave, the result of precipitation and dripping from cave roofs.

However, not all deposits can be explained in this way. It seems that layer cake deposits are relatively late phenomena, associated with the Copper and Bronze ages. In the Neolithic, we come across other types of sediment derived from dung that are clearly not the result of this depositional practice. Many caves contain thick, rather homogenous brownish deposits, with abundant cultural remains. At microscopic scale, they appear to be a mix of several components, such as large charcoal fragments, organic matter at various stages of ageing or charring, bone, snail shells, ash, phytoliths, and faecal spherulites (*Boschian 2006*).

Fig. 1. 'Layer cake' deposits from Eneolithic and Bronze Age layers of Grotta Cotariova/Čotarjeva jama, Italy (after* Montagnari Kokelj et al. 2002. Fig. 8*).

Boschian proposed that they were the result of the trampling and reworking of layer cake deposits (*Boschian and Montagnari Kokelj 2000.331–71*), but there is no evidence of large-scale displacements of sediment. On the other hand, they contain plentiful evidence of human daily activities in the cave (cooking, knapping, butchering etc), and the presence of animals (spherulites), and can be interpreted as occupation debris accumulated when people stayed in the cave with their herd.

Within these layers, small heaps of white ash appear. Thus in Pupićina Cave (*Boschian 2006*), the ash patches have irregular shapes and are often clustered in groups that lie on the same surface. Boschian suggests that they are the result of the disturbance of wider lenses. On the other hand, elsewhere (for example in Mala Triglavca), they appear in thick, circular piles which seem to be undisturbed (Fig. 3).

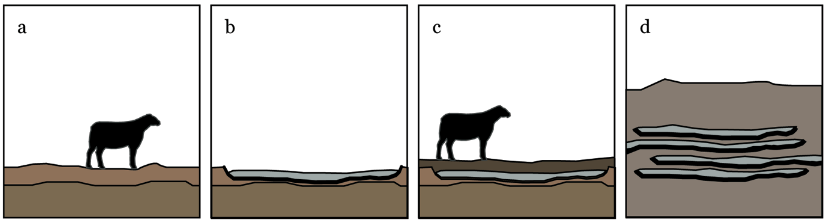

Fig. 2. Model of formation of 'layer cake' deposits. Herbivore dung is accumulated during penning of animals (a); dried and trampled dung deposited on the cave floor (migon) is burned, dark, carbonised material marks the edge between ash and unburnt dung (b); subsequent pennings introduce new layers of dung (c). Slow mineralisation process reduces dung deposits to their mineral contents, while ash and carbonised material stays in place (after* Brochier 2002.Fig. 9*).

There is a distinctive spatial pattern, where heaps of ash are located near the cave walls, while in the central parts of the caves, usually well lit and high enough for a person to stand upright, there are homogenous deposits (*Boschian 2006*). Therefore, the distribution of dung derived sediments cannot be explained only by the level of moisture due to precipitation from the cave roof.

Caves were not only pens for herds of animals, but also places where shepherds lived at the same time. Thus the spatial distribution of dung derived sediments testify to the human organization of the living space and the manipulation of dung.

There are many possible scenarios: either ash was raked and heaped together at the cave walls, or dung was cleared from the central part of the cave, heaped in an area near the cave wall, left to dry and ignited. However, it seems that dung was heaped before burning, probably when it was still wet and untrampled, as the evidence of preserved coprolite structures in ash piles suggest. The dung was then left to dry and ignited. Another possibility was the spontaneous ignition of dung.

There is no evidence of regular patterns of dung burning, such as in the case of layer cake sediments. The rhythm of burning of dung heaps was much slower and less regular; perhaps it was burned every few years, or even every few decades.

All this care and work involved in its transformation suggests that the dung accumulated in the living spaces of Mediterranean caves was not neutral 'refuse'. It was a substance that played an active role in the articulation and negotiation of social relations between people, animals and places.

The materiality of dung transformation: some questions

To tackle the active role of dung and its tranformation in the negotiation of relations between people, animals and places, it is essential to examine the specific qualities and contexts of manipulation, transformation and discarding of dung. In order to address these matters, to approach the materiality of dung, of its transformation and its end product, we must have a closer understanding of the operational sequence of burning dung. There are still many unanswered question, which can be resolved only through practical, experimental engagement with dung and re-creations of dung burning events.

Drying and ignition. How long does dung in a cave dries? How long does it take to dry when it is heaped, and how long when it is spread on the cave floor? When is it dry enough? When can dung be ignited? How can it be ignited? What are the mechanics of igniting dung? How can a heap of dung be burnt? How can a dried and trampled dung surface (migon) be burnt? When does spontaneous combustion occur? Can these conditions be regularly re-created, or do they depend on many random, uncontrollable variables?

Combustion. How does dung burn? With a hot, visible flame, or does it only smolder? At what temperature does dung burn? What variables govern the burning of dung? What effect does the temperature of a dung fire have on the transformation of dung into ash, or on other material organic matter such as twigs, or litter? How do combustion and the temperatures reached affect material buried in dung (*e.g.* bone, pottery)? How does it affect the surface/living floor where it was deposited? Does it change the colour of material; does ash adhere to the material?

Duration. How long does dung burn – for weeks, months, seasons?

Smoke. How much smoke does it produce – enough to fill a cave, enough to be visible from a distance? How is smoke related to variables such as the water

Fig. 3. Circular heap of burnt herbivore dung from Neolithic layers of Mala Triglavca cave, Slovenia.

content in dung? What is the colour of the smoke? Smell?

Quantity. How much dung was burned in a single event? An on-site burning experiment by Ruth Shahack-Gross (*Shahack-Gross et al. 2005*) suggests that volume change related to dung degradation by burning is around 97%. This implies that if a 100cm layer of dung accumulated, after volume reduction, only a 3cm layer of ash will remain.

End products. Burning transforms dung into a white ashy powdery substance. What properties does dung ash have? Consistency? Colour? Smell? Can it be used as a raw material (as a pigment, for example)?

Postdepositional transformations. Can it be trampled easily? How is a layer of dung ash affected by trampling? Does it mix with other sediments?

Discussion

Why was dung regularly burned? Most explanations focus on the practical aspects of disposing of dung. While there might be a number of practical reasons for burning dung, but they are not necessary same as 'our', western, modern, practical reasons; they might be completely different and still completely valid for the culture which practiced the burning of dung. We cannot assume that refuse disposal and site maintenance practices obey some universally applicable notion of functionality and hygiene (*Brück 1999.313*). Dung is not necessarily a dirty, polluted substance, refuse, which has to be disposed of.

Since Mary Douglas' seminal Purity and Danger (*1966*), dirt and garbage offer an important insight into the beliefs, rituals and practices of every society. Cross-culturally, attitudes to refuse and dirt are extremely variable. For excample, Ian Hodder reports that the Nuba of Sudan are not concerned with the practicalities of cleanliness, but will cook and eat surrounded by refuse (*Hodder 1982*). Roma groups keep their caravans very clean, even though their camp-sites may be littered with refuse. This is because rubbish, a dirty and dangerous substance, is used to mark out boundaries between Roma and other societies by highlighting the hazards and tensions inherent in relations between both groups. Refuse therefore plays an active role in the negotiation of relations between people and places (*Okely 1983*). For the Dogon, dirt and refuse in the household compounds is an index of life, activity and reproduction. Littering, the deposition of smoke and dirt – thus, refuse – imbues the household with life and vitality (*Douny 2007*).

Therefore, dung in other cultures may have completely different meanings. For example, burnt animal dung is the main constituent of ashmounds, monumental landscape features of the Neothlithic in the Indian sub-continent. The huge volumes of the ashmounds indicate that the material was accumulated periodically over a long time. They can be related to pastoralism, as they are associated with cattle pens and butchering floors. Ashmounds probably originated in daily activities associated with stock enclosure maintenance. Its association with animals (as an animal product) and the fertility of the land (as fertilizer), transformed the everyday manipulation of dung from a maintenance activity into a cyclical practice, which included the ritual destruction of dung, a highly valued substance (*Johansen 2004.309–30*).

Manipulation – the burning of dung – is also a symbolic manipulation of matter. The burning of dung is a process which transforms dung into new substance, white ash. The process involves burning the dung, subjecting it to fire, which produces large quantities of smoke and heat, and can take quite a long time. During the long process of transformation, the material changes colour, texture, smell and volume. The regular and formalized nature of these depositional episodes suggests that they were an important part of occupational episodes in maintaining the floors of the living space in caves.

Dung is a product of daily routines and is therefore a cultural construct. It is invested with particular meanings, according to the context and its state. Although dung dropped from animals can be seen as a form of disorder, by being processed and burned, and redeposited it induces ontological order (*Douglas 1966*).

Dung is also an animal product; it is literally a digested, condensed landscape brought into a cave by the agency of animals. Deposits of burnt herbivore dung are produced in pastoral societies, where people share their lives with their animals and are closely dependent on them. Therefore, the proper manipulation, burning, and deposition of burnt dung can be an important part of maintaining relations between people and animals, places and landscape.

These practices have a clear temporal dimension. The dung takes a significant period to dry, and then to burn or smolder. The burning marks a period when a cave is abandoned and empty. The act of burning is literally an act of temporally un-making, dismantling the camp in a cave. Here we can point to similarities with Balkan Neolithic houses, which appear to have conventionally been burnt at the end of their use, and Ruth Tringham suggests that this burning may have taken place on the death of the head of the household (*Tringham 1991.93–131*).

The regular deposition of dung in the same place, near the cave wall, suggests that deposition practices were concerned mainly with the maintenance of the relation with previous occupations and continuity of cave use. This is further supported by the fact that heaps of ash appear to be undisturbed and sometimes carefully preserved from trampling by covering with plate-like rocks. In this perspective, burnt animal dung can be seen as a 'stuff of memory', a material record of previous occupations and the activity of ancestors. Repetition of material practices of dung manipulation might have been a way of constantly retaining and renewing the association of people, animals and places.

Summary

Deposits of burnt animal dung in Mediterranean caves are strong indicators of a pastoral way of life. The cyclical deposition of these sediments testify to a rhythm of repeated activities connected with seasonal (transhumant?) movements and the use of caves as shelters for herds and people.

It appears that the distribution of different types of dung derived sediments is not merely the result of natural conditions (water in sediment due to dripping from the roof), but the effect of human activities which structured the cave space. Dung, being an animal product, thus played an active role in the negotiation of activities between people, animals, places and landscape. Cyclical, regular and highly structured activities connected with the transformation of dung mean that deposits of burnt dung from previous occupations constitute a material memory which established relations with past occupations and ancestors.

Thus, instead of seeing dung as culturally neutral refuse which has to be disposed of, we might see its burning and deposition as the cultural manipulation of a potent substance.

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Some thoughts on social versus cultural complexity

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ABSTRACT – *Socially complex hunter-gatherers are characterised by (1) inherited, permanent leadership and (2) sustained control over non-kin labour. Archaeologists have tended to infer social complexity through evidence of cultural complexity (i.e., artistic elaboration, composite tool technology, religion, etc). Complexity theory, however, indicates that patterns suggestive of social complexity can be produced through simple behavioural rules that do not necessitate social hierarchies. Therefore, evidence of cultural complexity cannot be used to infer social complexity in archaeological societies, nor should social complexity be emphasized in discussions of hunter-gatherer achievement or evolution of food production.*

IZVLEČEK – *Socialno kompleksne skupnosti lovcev in nabiralcev označuje (1) dedno, trajno vodstvo in (2) nepretrgan nadzor nad ne-sorodstvenim delom. Arheologi so se s pomočjo dokazov o kulturni kompleksnosti (i.e., umetniškem delovanju, tehnologiji sestavljenih orodij, religiji, itd.) nagibali k oceni o socialni kompleksnosti. Vendar teorija kompleksnosti kaže, da so vzorci, ki kažejo na socialno kompleksnost, lahko produkt enostavnih pravil obnašanja, ki ne zahtevajo socialne hierarhije. Zato dokazov o kulturni kompleksnosti ne moremo uporabiti za sklepe o socialni kompleksnosti arheoloških skupnosti, niti ne bi smeli poudarjati socialne kompleksnosti v razpravah o lovsko-nabiralskih dosežkih ali razvoju pridelovanja hrane.*

KEY WORDS – *complex hunter-gatherers; complexity theory; Mesolithic; sociocultural evolution*

> *[In] literature as a whole, successful farmers have social relations with one another, while hunter-gatherers have ecological relations with hazelnuts.* (Bradley 1984.11)

This paper examines recent attempts to consider social relations in the European Mesolithic that led to the portrayal of the Mesolithic as a social evolutionary stage characterised by socially complex hunter-gatherers. Social complexity consists of (1) hereditary social differentiation and (2) control over non-kin labour. Increasing cultural complexity, on the other hand, refers not only to socio-economic organisation, but to all aspects of culture, including art, technology, and religion. The paper begins by reviewing debates about complex hunter-gatherers and about Mesolithic hunter-gatherers. This is followed by a consideration of archaeological applications of complexity theory. I critique the use of complexity theory in the creation of a new social evolutionism. We should consider culture in its entirety, rather than just socio-economic organisation, as the non-linear adaptive system whose evolution we want to study. Essentially, this is the same adaptationist argument that Peter Rowley-Conwy (*2001*) and many others before him have made, although as archaeologists we cannot hear it often enough. The final sections of this paper review recent debates about the social organisation of the Levantine Natufian and the Lepenski Vir culture of the Iron Gates Gorges; both regions appear to be characterised by culturally rather than socially complex hunter-gatherers.

Complex hunter-gatherers

The dominant discourse in the West has traditionally portrayed hunter-gatherers as radically altern Others, highly mobile in their day-to-day food quest and living a simple life without social differentiation. They are thought of as closer to nature than to culture (*i.e.*, civilisation), and their situation has often been clearly juxtaposed, for better or for worse, to that of our modern selves (*Pluciennik 1999; Tringham 2000; Hernando 2002; Kotsakis 2003; Borić 2005*). Thus, Thomas Hobbes famously described this supposedly natural state of humankind as having "*no Culture of the Earth [*i.e.*, no cultivation]; [...] no Knowledge of the face of the Earth; no account of Time; no Arts; no Letters; no Society; and which is worst of all, continuall feare, and danger of violent death; And the life of man, solitary, poore, nasty, brutish, and short.*" (*Hobbes 2003[1651].102*).

Although Marshall Sahlins' concept of the original affluent society (*Sahlins 1968; 1972*; see also *Lee and DeVore 1968*) allowed for a more positive view of hunter-gatherers, the belief remained that they had a comparatively simple social organisation (*Solway 2006*). The explanation for this lack of social complexity hinged on the fact that hunter-gatherer communities were relatively small, while social complexity was understood to generally increase with a rise in population (*e.g., Carneiro 1967*). Moreover, the criteria for measuring complexity were set with Western capitalist states always at the top of the ladder (*Rowlands 1988*).

Socially complex non-agricultural societies, like those of the Northwest Coast of North America and to a lesser extent Siberia (*e.g., Suttles 1968; Donald and Mitchell 1975*; sources cited in *Shnirelman 1992. 15–16*) tended to be explained away as rare anomalies (starting with *Grosse 1896*). Archaeologically, they did not fit the evolutionary scheme that associated any form of transegalitarian[1] social organisation with agriculture. Bakhta (*1986*) sums up this stance by specifically differentiating early farmers from hunter-gatherers based on (1) sedentism, (2) storage, (3) delayed return economy (*cf. Woodburn 1980*), (4) socially differentiated relations of production, (5) intensification of productivity, and (6) specialisation of labour. This view is still very much alive in the Western political and popular imagination (*e.g., Horst Köhler and Günther Oettinger in Licher 2007.8,10*). Rowley-Conwy (*2001*) pointed out that the highly mobile, egalitarian hunter-gatherers came to be (wrongfully) seen as the baseline from which all subsequent human evolution took place. This criticism of presupposing a directional evolutionary trajectory towards greater complexity applies not merely to Victorian social evolutionists, but to Marxist, processual and ecological archaeologists (*Trigger 1998.10*) as well as to pre-Darwinian Enlightenment thinkers (*Chapman 2003.5*). Complex societies are consistently valued more highly (*sensu Shanks and Tilley 1987.164*) than their simple counterparts.

Carneiro (*1967*) perceived population growth as a sufficient cause for more complex social organisation, with sufficient population growth in turn only made possible by the greater productivity allowed for by agriculture. From the social evolutionist viewpoint, this increase in social complexity was defined as the development of social structure (*Spencer 1873*), predicated on growth in the units of society (namely, population growth). Evolution implied both the growth of structural units and the development of new structural units at a higher level of organisation (*Spencer 1866*). Carneiro created a yardstick (*cf. Naroll 1956*) for measuring social complexity based on the presence or absence of 205 traits in 46 societies, concluding that "*the more traits a society had, [and, thus, the more socially complex it was,] the higher its culture level*" (*Carneiro 1967.235*). While presumably devising a measure of social complexity, Carneiro went on to make a value judgment about cultural complexity.[2] The interchangeable use of social and cultural complexity (*e.g., Carneiro 1967.235; Matson 1983.125–126; Maschner 1991; Price 1995b. 423–424; Tainter 1996a.4–8*; and to a lesser extent *Arnold 1996.80*) has caused considerable confusion about what scholars are actually referring to, although they have generally agreed that both types of complexity tend to be associated with agriculturalists.

Since the 1960s, Richard Lee (*1968; 1992; Solway and Lee 1990*), and others, saw the unifying characteristic of all hunter-gatherer 'band societies' in their egalitarian ideology of sharing. This is what Ingold

1 Transegalitarian refers to a degree or level of social complexity intermediate between egalitarian bands and stratified chiefdoms (*Hayden 1993; cf. Johnson and Earle 1987*).

2 See Newell and Constandse-Westermann (*1984*) for a more nuanced argument for the interconnectedness of population growth and density, social complexity, and archaeologically visible complex technology.

(*1988*) calls the hunter-gatherer 'mode of production', a social type implying not only a hunter-gatherer mode of subsistence, but also egalitarian social relations (*sensu Ingold*) and ideology (*sensu Lee*). In Marxist approaches, dialectical materialism specifies a straightforward relationship where the subsistence base determines social relations, which are further reinforced through ideology. Tainter (*1996b*) indicated that hunter-gatherers thus doomed to simplicity, were reckoned to demand little respect from archaeologists more concerned with societies closer in complexity to their own. Sir Mortimer Wheeler even compared a bad archaeological fieldworker to a hunter-gatherer, "*master of a skill, perhaps, but not creative in the wider terms of constructive science*" (*Wheeler 1954.152*). Hunter-gatherers were thus summarily dismissed.

It is in this context that a discourse on 'complex hunter-gatherers' (CHG) emerged in archaeology during the early 1980s (*Koyama and Thomas 1981; Price and Brown 1985a*). At least some hunter-gatherers, as was known, were complex in all the characteristics identified by Bakhta (*1986*) as indicators of a food producing economy. Archaeological correlates of complex hunter-gatherers that have often been proposed include: sedentism (*Matson 1985*); higher overall population, population density, and population growth; storage (*Testart 1982*); delayed return economy (*Woodburn 1980*); logistical collector subsistence-settlement pattern (*Binford 1980*); property rights and territoriality (*Coupland 1985b*); elaboration of ceremony and art (*Soffer 1985*); trade and inter-group networking; technological and labour specialisation; and a division of labour that goes beyond close kin, sex, and age (*Arnold 1996*).

Considering the previous emphasis on agriculture as the enabling precondition of complex social organisation and cultural elaboration, it is perhaps little wonder that early CHG studies focused on the ecological conditions necessary for increasing complexity. Resource intensification (*Dyson-Hudson and Smith 1978; Matson 1983*) was seen as the most crucial variable in the transition from simple to complex hunter-gatherers (*e.g., Price and Brown 1985b; Henry 1989*) and more generally in the transition from the Late Pleistocene to the Holocene (*Hayden 1981*).[3] Zvelebil (*1998*) elaborated on Ingold's (*1988*) scheme of the hunter-gatherer mode of production: some 'hunter-gatherers' existed without the ideology (and social relations) of egalitarianism and sharing, while other 'hunter-gatherers' did not rely on an exclusively non-agricultural subsistence. It is not merely the mode of production, but rather the relations of production and the efficiency of particular economic adaptations to their specific environments that are important in the appearance of social complexity (*Shnirelman 1992*). This point, however, had been lost on many researchers. As Warren (*2005a*) and others pointed out, the CHG discourse made a generalising social evolutionary stage out of complex hunter-gatherers (*e.g., Hayden 1993; 2003. 3*), rather than enabling analysis of variability in their social organisation (*cf. Kelly 1995; Ames 2004*). Levantine archaeologists, for example, now saw the Natufian (complex) hunter-gatherers as a pre-agricultural foundation of Western Civilization (*Bar-Yosef 1991.394*, and less explicitly in *1998.159*).

Like the Man the Hunter conference (*Lee and DeVore 1968*), the CHG debate was originally envisioned to help humanise hunter-gatherer studies. Complexity, as defined by Jeanne Arnold, consists of two things: (1) ascribed and permanent inequality (*i.e.* hereditary social differentiation) and (2) labour relations characterised by sustained, on-demand control by elites over non-kin labour (*Arnold 1996. 78–79*). Arnold (*1996.94*) identifies (social) complexity through mortuary contexts and household architecture and content as evidence for social differentiation, and through production contexts, residential settings and cemeteries as evidence for labour relations. Other aspects of (cultural) complexity – such as art, ritual and symbolism – were previously used by some scholars to infer hunter-gatherer complexity (*e.g., Soffer 1985*). These aspects of cultural complexity not associated with social organisation are seen as "*epiphenomenal*" in Arnold's scheme (*1996.78*); they are merely idiosyncratic features of particular cultures and are thought to be dependent on social organisation. Such a definition sees social complexity as a necessary first step in cultural complexity.

Complex hunter-gatherers have been opposed to 'simple', egalitarian hunter-gatherers (*e.g., Price and Brown 1985b; Ames 1995; Arnold 1996*) – whom Sahlins (*1968; 1972*) called the original affluent society, because they are efficient in satisfying their daily subsistence needs (see also *Rowley-Conwy 2001; Solway 2006*). The distinction between these

3 This has also been described as a switch from *K*-selected to *r*-selected resources (*e.g., Hayden 1981; Gamble 1986*), terms borrowed from animal ecology (*cf. Pianka 1972*).

two societal types is found in the direction of within-group material transfers: from those who temporarily have more to those who have less (*i.e.* sharing) in simple societies, and from those who chronically have less to those who have more (*i.e.* exploitation) in complex societies (*Cowgill 1996*). Complexity was correlated with more people interacting with one another on a daily basis in order to meet everyday needs. Cohen (*1985*) identified scalar stress within such situations, in which interpersonal conflict is more likely to arise, as the driving force in a shift from egalitarian to ascribed, hierarchical social organisation. In this account, social inequality was understood as functional and beneficial to the community as a whole, since higher-level social units were thought to be necessary for dealing with scalar stress. However, Rathje and McGuire (*1982*) demonstrated that cross-culturally such complexity is exploitative – those with power gain more from it than those without power. Tainter goes as far as to call complexity an "*abnormal condition of human organization*" (*1996b.12*, see also *Henry 1989.5*), while Rowley-Conwy (*2001.65*) proposes that it is, in fact, egalitarianism that is the "*most remarkable and specialised social form that humans have ever evolved*".

Many scholars have critiqued the simple-complex dichotomy in hunter-gatherer studies and its social evolutionary heritage (*e.g., McGuire 1996; Rowley-Conwy 2001; Ames 2004; Warren 2005a*). Variability in hunter-gatherer social organisation lies on a continuum or spectrum (*Kelly 1995*), and opposing the two ends of this spectrum needlessly simplifies things. This critique has led to revisions of the simple-complex dichotomy. For example, Arnold (*2004*) now adds an 'affluent' stage between egalitarian and complex hunter-gatherers; this 'affluent' stage is characterised by cultural complexity, but lacks the hereditary inequality and sustained control of non-kin labour characteristic of her (socially) 'complex' hunter-gatherers.[4] Such approaches, and Rowley-Conwy's (*2001*) own four-stage model, have been criticised as still not going beyond the social evolutionary discourse. Warren (*2005a.70*) contends that while "*it is possible to argue that the discussion of 'complex hunter-gatherers' served an archaeological purpose during the 1980's it is now time to move on*" and look at more humanising aspects of the past (*e.g., Warren 2005b*). While applauding the call for a more humanising archaeology, I do not entirely agree with Warren's assessment. Arnold (*2004*) argues that for the Northwest Coast and Plateau of North America, a major anthropological goal remains to discern the exact type of social organisation of the prehistoric populations in these areas. I believe that the same applies to the Natufian, Lepenski Vir and other prehistoric hunter-gatherer societies that have been recently described as socially complex. Although social organisation does not determine other aspects of culture, we should not ignore it altogether as an object of study.

Mesolithic hunter-gatherers

Whereas the preceding discussion of complex hunter-gatherers juxtaposed them to simple hunter-gatherers, studies of the European Mesolithic tend to juxtapose hunter-gatherers (regardless of social organisation) to Neolithic farmers (*Price 1985; Zvelebil 1998*). Wilmsen and Denbow (*1990*; see also *Woodburn 1988*) believe that the egalitarian ideology of many modern hunter-gatherers and their social relations based on sharing (*cf. Lee and DeVore 1968*) are a result of encapsulation by pastoralists; they consider 'simple' hunter-gatherers as a very recent phenomenon. This helped question the idea that simple hunter-gatherers were a baseline of social evolution (*Rowley-Conwy 2001*), which had important repercussions for interpretations of the Mesolithic-Neolithic transition in Europe (*Radovanović 2006; cf. Spielmann and Eder 1994*).

When Lubbock (*1865*) split up the Stone Age, he distinguished the Neolithic from the Palaeolithic on the basis of the presence of (1) polished stone tools, to which others later added the presence of (2) modern fauna (*i.e.*, Holocene epoch), (3) agriculture (in the form of domesticated plants and animals), and (4) pottery. To Victorian social scientists, the Neolithic was simply a chronological stage on an implicit social evolutionary progression from primitive hunter-gatherers to British civilisation (*Pluciennik 1998; Zvelebil 1998*). It was not until V. Gordon Childe's (*1925*) concept of the 'Neolithic Revolution' that the Neolithic came to be seen as a societal type, characterised by a specific social organisation determined by an agricultural mode of subsistence. Zvelebil (*1996*) points out that analogies for the technological and economic aspects of the Neolithic are taken from ethno-historical (and folk studies) accounts of the European peasantry, creating a sense of the Neolithic as an ancestral form of our own societies.

4 In the Japanese tradition (*e.g. Koyama and Thomas 1981*), 'affluent' hunter-gatherers have more in common with Price and Brown's (*1985a*) 'complex' hunter-gatherers, than with Sahlins' (*1972*) 'original affluent societies' (see *Koyama and Uchiyama 2006*).

Aspects of Neolithic social life, on the other hand, are generally taken from ethnographic analogies from outside Europe (*e.g.*, Papua New Guinea), because the European peasantry is considered to have evolved socially (and morally), making it an inadequate source of analogy for early farmers from several thousand years ago (*Zvelebil 1998.12–13*). The last two decades have seen an icreased interest in providing a more coherent reconstruction of Neolithic mentality (*e.g., Hodder 1990; Thomas 1991; Cauvin 2000*). Post-processualists have identified a fundamental wild/tame duality as the basis for many other binary oppositions structuring thought during the Neolithic. Although Zvelebil (*1998*) has shown that Mesolithic hunter-gatherers may already have distinguished the wild from the tame, Cauvin (*2000*) was unwavering about Natufian hunter-gatherers having a fundamentally different mindset than people in the Neolithic, something akin to Ingold's hunter-gatherer ideology of egalitarianism. When combined with the 'cultural circles' approach (*e.g., Kossinna 1911*), which assumes a direct correspondence between archaeological cultures and distinct ethnicities and which is still conventional in much of central and eastern Europe (*Chapman and Dolukhanov 1993*), the definition of regional Neolithic cultures and their Mesolithic 'opponents' takes on both nationalist (*Zvelebil 1996*) and imperialist overtones (*Pluciennik 1998*). The Neolithic was variously understood as both the foundation of European civilisation and as a precedent for (as well as justification of) 19th and early 20th century European imperialism.

Meanwhile, the Mesolithic was first defined by Westropp (*1872*, and later by *Reboux 1873* and *Brown 1893*) and originally referred to what we now know as the Upper Palaeolithic (*Ayarzagüena Sanz 2000*). The Mesolithic was supposed to have bridged the apparent hiatus between the Old and New Stone Ages proposed by de Mortillet (*1872*).[5] Zvelebil (*1998*) argues that unlike the Neolithic, the Mesolithic never came to be characterised by its own societal type; even Childe (*1947*) dismissed it as a mere chronological stage because it did not fit preconceived models of social evolution: "*the Mesolithic was regarded as a period of decline, not of progress, whose diminutive stone tools – microliths – neatly symbolised the irrelevance of the period*" (*Zvelebil 1998.2, cf. Clark 1978.3*). The 1980s attempts to define the Mesolithic as a unique complex hunter-gatherer societal type based on a largely fishing mode of subsistence (*e.g. Price 1985*), and moreover representing a progressive stage on the social evolutionary ladder (*e.g., Hayden 1993; 2003*), were not widely accepted by European scholars (*e.g., Price 1995a; Zvelebil 1998.3*).[6] The view that sees the European Mesolithic and the Levantine Natufian as populated by complex hunter-gatherers only became institutionalised in a few North American introductory textbooks (*e.g., Fagan 2001; Hayden 1993*). Because they are foundational histories (*sensu Leone 2006*), however, these textbooks have shaped the preconceptions of a whole generation of students, myself included, that relied on them.

Beyond the Neolithic and the Mesolithic, a third term – the Epipalaeolithic – has gained currency. The Natufian, originally defined as a Mesolithic industry (*Garrod 1957*), was later called Epipalaeolithic, based on its re-dating to the Terminal Pleistocene (*Belfer-Cohen 1991*). In the Levant, then, the distinction between Epipalaeolithic and Mesolithic was based on the Pleistocene-Holocene boundary. In the Iron Gates Gorges and southern Europe generally, on the other hand, the Epipalaeolithic refers to Holocene (rather than Pleistocene) hunter-gatherers, distinguished from the Mesolithic based on the presumed continuity of life-ways with the Upper Palaeolithic (*Boroneanț and Dinu 2006; Radovanović 1996.12–15*). In the Levant, however, the Natufian Epipalaeolithic (though usually not the preceding Kebaran and Geometric Kebaran) have come to stand for the same evolutionary threshold between simple hunter-gatherers and farmers as the Mesolithic in some areas of Europe (*e.g., Bar-Yosef 1991; 2002; Henry 1985; 1989*). Some scholars therefore label the Natufian a Mesolithic entity (*Clark 1980; Hayden 1993*).

Because they were originally conceived of as chronological markers, the co-existence of Mesolithic and Neolithic was for a long time thought to be impossible. This created problems in areas such as the Iron Gates Gorges, where scholars defined the Lepenski Vir culture as either Neolithic or pre-Neolithic (or

5 De Mortillet (*1883*) concluded that the Palaeolithic inhabitants of Europe moved out and were replaced by Neolithic populations from the Near East after a period of no occupation. This theory had profound implications for future studies of the Natufian, Lepenski Vir, and the Mesolithic-Neolithic transition in southeast Europe generally (*e.g., Childe 1929*).

6 What Zvelebil considers the prevailing view of the Mesolithic would best be summed up by Laurent's humorous drawing of Mesolithic hunters chasing landsnails with microlith-tipped spears in rainy weather (*Laurent 1965.81*, reproduced in *Radovanović and Voytek 1997.20*).

Mesolithic) based on whether they accepted the contemporaneity of pottery and trapezoidal house floors (*e.g., Srejović 1969; 1972 contra Jovanović 1969*). The contemporaneity of at least parts of the LV I layer at Lepenski Vir with the Early Neolithic of surrounding regions to the south eventually led to models of Mesolithic-Neolithic contact (*e.g., Chapman 1989; Voytek and Tringham 1989; Radovanović 1996; Roksandić 2000*). These arguments were often based on Zvelebil and Rowley-Conwy's (*1986*) 'availability model of the moving frontier' of interaction between hunter-gatherers and farmers during the transitions from the Mesolithic to later prehistoric periods in various areas of Europe.[7] However, Alexander (*1977*) had introduced the frontier analogy with explicit reference to Frederick Jackson Turner's (*1893*) 'American Frontier.' He distinguished between an initially 'moving frontier' and four versions of the ensuing 'static frontier' resulting in hunter-gatherers either (1) being 'destroyed', or (2) being absorbed by farmers, or (3) retreating into isolation, or (4) creating a symbiotic relation with farmers. Because of this connection with the manifest destiny of American imperialism, as well as the fact that 'Neolithic farming' eventually predominated over 'Mesolithic hunting and gathering', Pluciennik (*1998; 1999; see also Borić 2005*) felt that Mesolithic-Neolithic frontier models predisposed an eventual static frontier always characterised by the annihilation of the hunter-gatherers. One has to point out, however, that Zvelebil and Rowley-Conwy (*1986*) were arguing precisely against such a position.

The Mesolithic, as currently conceived, is closely tied to hunter-gatherers, if not necessarily to Ingold's (*1988*) hunter-gatherer mode of production. Mesolithic social organisation has been variously interpreted as either simple or complex, as has the general 'state of culture'. However, most research on the Mesolithic has taken an ecological approach (*Price 1995b; Zvelebil 1995a*), focusing on hunter-gatherers' relations with their environment rather than with each other (*Bradley 1984*). While Tringham (*1991*), among others, argued for a focus on ideology, meaning and social relations, Jochim (*1998*) criticises all such approaches as unscientific in their 'sweeping interpretations' unsupported by archaeological data and in failing to take into account alternate hypotheses. Although this does not mean that we should abandon such innovative research altogether, Jochim (*1998.28*) is correct in urging for a clarification of terms and stronger support of arguments by data. In this context, one should point out that Natufian and Lepenski Vir scholars have reconsidered the archaeological evidence for social complexity (see below). A shift in socio-cultural evolutionary theory has accompanied these meticulous reconsiderations of the type of social organisation of temporally and spatially distinct hunter-gatherer groups.

Complexity theory

Complexity theory, as a novel approach to the study of non-linear adaptive systems through computer simulation, was popularised in the 1990s (*Lewin 1992; Waldrop 1992; Gell-Mann 1994*). Essentially, there is feedback in complex adaptive systems between (1) the interaction of constituent parts at the local level and (2) global structures and patterns that emerge from these local interactions (*Mol and Law 2002; Bentley 2003; van Kooten Niekerk and Buhl 2004*). Such an approach is juxtaposed to the reductionist systems theory characteristic of processual archaeology, where the importance of feedback between global- and local-scale phenomena had been understated. Vitalists explained away local phenomena as being determined by some inexplicable global structure, while mechanists explained away global phenomena as being determined by their constituent parts. The insight from complexity theory is that global structures emerge from local interactions, but are more than the arithmetic sum of the system's constituent parts at the local level and, in turn, act back on these constituent parts.

Complexity theory can trace its beginnings to several sources, one of which is the debate on the origins of multicellular life immediately prior to the Cambrian period. Christopher Langton (*1986*) proposed that such life could emerge from interactions of simple single-celled organisms. Once they come to exist, these more complex multicellular organisms propagate themselves, form diverse and ever more complex life-forms, and oscillate periodically between florescence and collapse (*Lewin 1992.63*). They are said to evolve to the edge of chaos (*Langton 1990*), a state precariously poised between order and chaos, characterised by ever-increasing complexity (*i.e.*, species diversity), with periodic collapses of catastrophic dimensions. Langton (*1986*) used cellular automata in his computer model to simulate the

7 According to Zvelebil and Rowley-Conwy, the hunter-gatherers were conceptualised as having diverse and historically specific social organisation (see also *Zvelebil 1998*).

emergence of multicellular life from the interactions of single-celled, inanimate organisms. However, because they are inanimate, cellular automata work best for simulating spatial phenomena that can be conceptualised as stationary, as opposed to kinetic and dynamic systems such as past human cultural systems (*Epstein and Axtell 1996.17–19*).

While much early complexity theory dealt with biological phenomena, it is increasingly being applied to the social sciences (*e.g., Epstein and Axtell 1996; Mol and Law 2002*). Joshua Epstein and Robert Axtell's (*1996*) Sugarscape was a pioneering effort in this direction. Sugarscape is an example of agent-based modelling of artificial societies. These are computer simulations of complex systems involving artificial agents interacting with each other and with an artificial environment modelled on cellular automata. The Sugarscape environment is modelled as a torus-shaped landscape of cells with differing amounts of a resource (called sugar). Sugarscape agents, on the other hand, are modelled as heterogeneous individuals that move through the artificial landscape in search of the sugar they need to live and prosper. Object-oriented programming languages allow this decoupling of landscape and agents (*Epstein and Axtell 1996.179–181; Kohler 2000*). While such artificial societies are not perfect replications of the real world, they allow for a 'bottom-up', generative social science that allows for a positivist testing of competing hypotheses of diachronic trajectories (*Bentley and Maschner 2003b.4*). Agent-based modeling, moreover, (1) allows social scientists to move beyond concepts of equilibrium, linearity and homogeneity, (2) enables a study of emergent phenomena, and (3) is more realistic than deterministic models that fail to account for agents' actions at the local level (*Bentley 2003.21*).

There are two ways of applying complexity theory in archaeology (*Bentley and Maschner 2003b*): empirical and theoretical. Empirically, we can juxtapose observed patterns in the archaeological record to those created by bottom-up agent-based modelling or other simulations of complex, adaptive systems (*e.g., Banning 1996; Dean et al. 2000; Lake 2000*; other contributions to *Kohler and Gumerman 2000*). Theoretically, we can use concepts such as emergence and the edge of chaos as explanatory mechanisms without relying on specific models or simulations as go-betweens (*e.g., Hayden 1993*; several contributions in *Bentley and Maschner 2003a*). On a theoretical level, complexity theory can also support the argument made here that increasing cultural complexity does not necessarily mean increased social complexity.

Agent-based modelling has often served a 'spoiler role' in archaeology (*Kohler 2000.12*). It has been used to derail theories that postulated a need for global rules and centralized processes to account for complex global patterns, which in reality could have been generated by simple rules of interaction at the local level (*Bentley 2003.14*). Banning (*1996*), for example, shows how simple rules of local behaviour can account for patterned village layout in Near Eastern prehistory, a phenomenon Childe (*1950*) attributed to political complexity and centralized control over 'town planning'. In a similar vein, Banning (*2003.8–9*) notes that the standardisation of house shape in the Near Eastern Neolithic could have arisen out of simple local rules of what a house should look like, rather than from a centralised monopoly on house construction by architect specialists. The spoiler role, of course, only provides alternative explanations, as it does not disprove the competing interpretation, but merely shows that a simpler explanation can account for whatever phenomenon is being investigated. However, agent-based modeling also appeals to archaeologists because it can be used as a 'dialogic resource' that allows for experimentation with different scenarios (*McGlade 2003.117*). By specifying different rules for agents, researchers can compare the (hopefully different) outcomes of these rules with patterns observed in archaeological cases, thus narrowing down the possible sets of rules that governed prehistoric behaviour. This allows for a consideration of contingency (*Kohler 2000.14*), as differences in model outcomes can be matched to differences in initial conditions and/or agent rules.[8] An example of this second application of agent-based modelling is Dean et al.'s (*2000*) Artificial Anasazi Project. This project simulated historical trajectories for the 96 km^2 region of Long House Valley, Arizona. The model outcomes indicated that the archaeological evidence for total abandonment of the region at 1300 CE could not have been due to environmental degradation alone, but must also have been due to 'cultural' factors not yet accounted for by the model (*Dean et al. 2000*).

8 In this context, the 'docking' of different agent-based models (*Axtell et al. 1997*), that is, the comparison of model outcomes, is an important undertaking because it compares artificial societies that are potentially structured (coded) differently. Because it compares different models, 'docking' is a stronger test than the comparison of outcomes of runs of the same model, in which each run has different initial inputs of agent attributes, but the rules of agent-agent and agent-environment interaction are coded the same way.

On the theoretical level, the application of complexity theory to archaeology has largely resulted in worldviews of an inevitable diachronic trajectory to ever-increasing inequality. Of course, this is not entirely a new idea: social scientists of the Victorian era argued that human evolution is characterised by increasing complexity over time, where only the most complex societies were believed to be ultimately fit to survive (*Chapman 2003*). Some applications of complexity theory have taken a neo-Victorian stance on increasing complexity (though see *Tainter 1996a; 1996b*). They equate increased complexity with increased social complexity; that is, they see an inevitable trajectory towards ever-increasing social inequality. Brian Hayden (*1993.448–466*) provides the most discomforting example of this, when, in his introductory textbook, he discusses the potential of archaeology to predict the future. He first warns his readers that the "*images may be disconcerting to some people*" and that the archaeology of the future "*requires a total stilling of the self, great objectivity, and complete divorce from the emotional values that structure [one's] daily profane thought*" (*Hayden 1993.448*). He claims that we are heading for ever greater inequality, where the rich get richer and the poor get poorer. There is no way of stopping this, because "*there is no doubt that evolution will continue; if not now, then later; if not here, then elsewhere; if not on this planet, then on another; if not by our hands, then by others*" (*Hayden 1993.466*). Because introductory textbooks are foundational histories (*sensu Leone 2006. 139*), in the sense that they shape the underlying paradigms of whole generations of archaeologists, the ethical consequences of such texts always need to be scrutinized. In Hayden's case, evolution is provided with a purpose, and the only type of human agency that is seen as adaptationally successful in this case is rugged individualism. This is the adaptation to the edge of chaos applied to human societies, whereby catastrophic collapses of complex systems occur, but the complex systems always re-emerge and are more complex (*i.e.*, characterised by greater inequality) each time. This is a very pessimistic view, and one that serves the interests of certain, well-off sectors of modern society. It is not a value-neutral stance. Moreover, it is not necessarily logically valid.

According to Clifford Geertz (*1973.5*), who in turn traces the idea back to Max Weber, humans are essentially cultural creatures, and they function in cultural systems of meaning. These cultural systems constitute larger-scale phenomena that subsume aspects of social organisation. In this sense, then, a diachronic trajectory to greater complexity can be applied to human 'evolution' without implying increasingly differentiated or stratified social organisation. As archaeologists, we observe complex cultural phenomena, such as patterned settlement layouts or monumental architecture, at a 'global' level, and social organisation merely provides the local rules of behaviour followed by people in the past. Agent-based modelling and complexity theory, generally, have taught us that simple rules at the local level suffice to create complex patterns, and no centralised structure characteristic of 'complex' social organisation is necessary. This brings us to the Natufian and to Lepenski Vir, where social complexity has often been assumed rather than demonstrated.

The Natufian example

The Natufian was first discovered in Shukbah Cave, Wadi en-Natuf, in 1928 (*Garrod 1942*) and more extensively investigated at El-Wad in the Wadi el-Mughara (*Garrod and Bate 1937*). It dates to 14 900/14 600 to 12 000/11 700 calBP in the Terminal Pleistocene (*Byrd 2006*), and has received a lot of attention as the period preceding the first appearance of domesticated plants and animals in the Old World (*Valla 1975; 1995; Bar-Yosef and Belfer-Cohen 1989; 1992; Byrd 1989; Bar-Yosef and Valla 1990; 1991b; Belfer-Cohen 1991; Schyle 1996.175–209; Poyato Holgado 2000*). Based largely on its chipped and ground stone assemblages and its erroneous placement within the Holocene, the Natufian was originally interpreted as a Mesolithic industry by Garrod (*1932; 1957*) and Neuville (*1934*). Though it is now considered the terminal phase of the Epipalaeolithic sequence, some authors (*e.g., Clark 1980; Hayden 1993*) have continued to see it as Mesolithic, while others (*e.g., Gilead 1984*) consider it Upper Palaeolithic. Such terminology is about more than mere lithic industries, as each term implies a reconstructed mode of production and differing levels of continuity with preceding and subsequent phases. Because it is closest in time to the Neolithic, the Natufian has generally been assumed to be more complex than the preceding Kebaran and Geometric Kebaran (*e.g., Henry 1989*; but see *Kaufman 1992* for a different opinion).

Very briefly, the Natufian chipped stone industry is characterised by a predominance of lunate microliths and by the microburin technique. Ground stone tools include mortars and pestles and are thought to occur in greater frequency than in preceding periods. The bone industry includes decorative items, such as pendants and beads, shaped by grinding. Artistic expression, although present throughout the Epipalaeolithic (*e.g., Hovers 1990*), now includes a few zoomorphic figurines. Stone-built architecture, in the form of small- to medium-sized circular structures, is present on some sites. Burial customs included decorated burials in the Early Natufian, and secondary burial with skull removal during the Late Natufian.

The Natufian material culture extends over much of the (southern) Levant, though there appear to be diachronic changes in its extent. The differently shaped microliths are generally thought to represent stylistic variation and have therefore been used to identify ethnic groups or cultures in the 'culture circles' sense (*e.g., Henry 1989*). Neeley and Barton (*1994*) have suggested, however, that they might actually represent different stages in reduction sequences. Starting with Henry (*1981*) and Wright (*1978*), the Natufians have frequently been considered complex hunter-gatherer chiefdoms with high levels of social complexity (*Bar-Yosef 2002*). This complexity, according to Henry (*1981; 1985; 1989*) was made possible by intensified wild cereal collection – a type of proto-cultivation that eventually led to domestication in the Pre-Pottery Neolithic. Smith (*1987*), for example, proposes that reduced robusticity and size of mandibles in the Late Natufian, along with evidence for increased dental disease, indicates increased reliance on cereals in the Late Natufian diet, at least at Nahal Oren. Dubreuil (*2004*) comes to a similar conclusion on the basis of an increased reliance on, and improvement of, grinding slabs. This intensification, in turn, was said to have been made possible by the expansion of wild cereals from the Last Glacial Maximum refugia to the highlands of the Mediterranean phytogeographic zone, considered the Natufian 'homeland'. Such an interpretation has, however, never been fully accepted (*e.g. Olszewski 1991; 1993; Kaufman 1992; Byrd 2005; Boyd 2006*). Wild cereals may have played a noteworthy role in Epipalaeolithic diet well before Natufian times (*e.g., Nadel and Hershkowitz 1991; Weiss et al. 2004*), and a broad spectrum of other plants may, in fact, have overshadowed the importance of cereals even during the Natufian (*Olszewski 1993*). On the other hand, on the basis of dental microwear, Mahoney (*2005*) infers an increased reliance on ground plant foods occurring in the Pre-Pottery Neolithic rather than the Natufian.

Natufian settlement patterns include large sites in the core area, for which sedentism is assumed (*e.g., Henry 1985*), medium sites in the hillsides, and small sites in the hillsides and in desert areas. Various explanations of this pattern have been offered, some relying on the socio-economic organisation characteristic of Arnold's (*1996*) complex hunter-gatherers, while many do not (*e.g., Perlès and Phillips 1991; Kaufman 1992; Lieberman 1993*). Henry (*1981*) suggested that Natufian adaptation was significantly different from that of mobile hunter-gatherers' during preceding periods. The expansion of wild cereals into the Mediterranean hill zone (which has better soil than the Pleistocene refugia, *Henry 1989*) allowed for sedentism based on intensified reliance on wild cereals as a dietary staple. This caused the population growth and expansion of the Natufians. Later, claims Henry, climatic deterioration meant that Natufians could no longer support themselves by intensive reliance on wild cereals alone. This lead to two different responses:

1) a change to a food producing economy with the domestication of cereals (Pre-Pottery Neolithic in the 'homeland'), and
2) the 'return' to mobile foraging (Harifian in marginal zones).

Byrd (*2005*) indicates that more reliable palaeoenvironmental data are needed if we want to correlate climatic change with specific cultural changes at the beginning and end of the Natufian; these cultural changes need not have been causally determined by environmental changes.[9] One aspect of complexity theory that differs from processualist linear systems theory is the possibility for change to occur without stimuli external to the system.

Olszewski (*1991*) charges Henry relies too much on sedentism as a necessary component of Natufian social complexity. This social complexity has been inferred from burial data, population density, base camps, local group size, storage, and territoriality. Olszewski (*1991*) debunks all these possible sources of evidence for social stratification and chiefdom organisation. Wright's (*1978*) conclusion for the existence of social stratification on the basis of an analysis of grave goods from El-Wad, too, has been discredited by several scholars (*Olszewski 1991; Belfer-Cohen 1995; Byrd and Monahan 1995; Kuijt 1996*). Hayden (*2004*), while also disagreeing with the idea

9 Despite his apparent environmental determinism, Henry acknowledges the contingency of the Near Eastern trajectory that eventually led to agriculture. Were it not for "*some Neanderthal driven to grinding pigment for ritual purposes*" Henry (1989.236) claims, "*it is unlikely that most of the world would be sustained by agriculture today*" because mortars and pestles would not have been invented and there would therefore not have been a technology for processing cereals several millennia later.

of Natufian chiefdoms, argues that the burial record still indicates a high degree of social complexity with a heterarchical social organisation; here, inequality would exist between corporate kin groups without an inter-settlement political hierarchy. In a circular argument, Hayden (*2004*) reasons that transegalitarian societies are characterised by feasting, and if the Natufian were complex it would have evidence of feasting; despite a lack of 'secure' evidence for feasting (*2004.274*), feasting is then used to reconstruct a complex social organisation for the Natufian (*2004.276*). Bocquentin and Rouais (*2004*) conclude that a differentiation of tasks within sequences of production requiring the use of teeth as tools took place at Ain Mallaha, on the basis of intensive tooth wear on two individuals (out of 306!). This could be an indication of labour specialisation and social complexity, although it could be interpreted in a myriad of other ways.

The very concept of Natufian sedentism has been criticized by several scholars (*Kaufman 1986; 1992; Boyd 2006*). On the one hand, evidence for year-round sedentism during the Natufian is problematic at best (*Boyd 2006*). On the other hand, even during the Early Epipalaeolithic, evidence for a reoccupation of specific locations exists, for example at Ohalo II (*Nadel and Werker 1999*). The huts at Ohalo II had up to three superimposed floors, a number that compares favourably with that of the Final Natufian layers at Ain Mallaha (*Samuelian et al. 2006*). Hardy-Smith and Edwards (*2004*) argue that garbage disposal patterns indicate that the Natufians had not yet 'gotten used to' sedentary living, assuming they were sedentary in the first place. Zooarchaeological analyses indicate a general increase in mobility (and decrease in sedentism) during the Late Natufian (*Munro 2004*). Overall, the archaeological data have been interpreted by different scholars as indicating varying degrees of sedentism and social complexity. While social organisation and other aspects of culture appear to have varied throughout the duration of the Natufian, there is little support for the contention that these were socially complex hunter-gatherers.

The Lepenski Vir example

At Lepenski Vir, we see a similar debate. Srejović (*1966*) initially considered the LV I trapezoidal house floors to be Neolithic, because at the time he subscribed to a Hobbesian worldview that could not imagine attributing such a complex cultural phenomenon to hunter-gatherers. Only when it became stratigraphically apparent that the architecture and art at Lepenski Vir (LV I) clearly predated the overlying layers of Early Neolithic pottery (LV III) did he begin to consider the socio-economic conditions that may have been responsible for this culturally complex hunter-gatherer settlement (*Srejović 1967*).[10] Srejović eventually came to the conclusion that the planned village layout at Lepenski Vir 'presupposes complex socio-economic relationships' (*1969.14; 1972. 12*), even convincing Sir Mortimer Wheeler that hunter-gatherers are indeed worthy of study (*Wheeler in Srejović 1972.8–9*). Although this is hardly ever acknowledged, the discoveries at Lepenski Vir paved the way for the complex hunter-gatherer debates of the 1980s and 1990s. Eventually, several scholars came to reassert that Lepenski Vir was a site of socially complex hunter-gatherers (*e.g., Voytek and Tringham 1989; Radovanović and Voytek 1997*), thus earning the Iron Gates a mention in a North American overview of world prehistory as an example of a European Mesolithic society analogous to the supposed social evolutionary stage that the Natufian occupied in the Levant (*e.g., Fagan 2001*). As Cvekić (*2007, in prep*) has pointed out, however, Banning's (*1996*) insights from complexity theory and the Near East bring into question the necessity of relying on complex social organisation to explain the pattern at Lepenski Vir.

Over the years, several scholars have questioned the idea of social complexity at Lepenski Vir. Kulišić (*1972*), for example, proposed that the large, central houses previously identified as chiefly residences (*Srejović 1969*) were in fact men's houses for unmarried youth who used stone sculptures in rituals of initiation into manhood. This interpretation, however, does not account for the presence of sculptures in smaller houses throughout the settlement, nor does it account for the standardisation of house layout. A more serious threat was presented by Radovanović's (*1996*) reinterpretation of LV I sub-phases on the basis of hearth construction, which suggested only 5–10 houses were occupied contemporaneously at any point in time, meaning that the population of the village would have been only 25–50. Radovanović (*2006*) eventually made explicit that these would therefore have been settlements of egalitarian hunter-gatherers, although her re-phasing of

10 Some researchers have questioned the validity of stratigraphic interpretation at Lepenski Vir (*e.g., Milisauskas 1978; Borić 2002*). Perić and Nikolić (*2004*) point out that these arguments are marred by a rather superficial knowledge of the site, and in any case should not be conflated with debates about the chronometric dating of Lepenski Vir.

LV I has proven faulty on several accounts (*Bonsall et al. 2000*).

My own analyses of variation in house size and content do not indicate the presence of social complexity at Lepenski Vir (*Cvekić 2007, in prep*). Bonsall (*2008*) also came to argue against social complexity in the Iron Gates on the basis of a lack of evidence for year-round sedentism, storage, internal division of houses (*cf. Kent 1990*), and warfare (*cf. Roksandic et al. 2004*). Bonsall suggests that the intensified occupation and artistic elaboration of LV I was due to interaction with Neolithic communities in nearby areas. Radiocarbon dates from nearby Vlasac (*Borić et al. 2008*), however, indicate a more intense occupation at this site beginning several centuries prior to the Contact Period of LV I (8250–7950 calBP). Moreover, the continuities in design between LV I art and earlier Mesolithic art have long been emphasized (*e.g., Srejović and Babović 1983*). Although there is wide agreement that Lepenski Vir was not socially complex, there is no need to conceptualise the Mesolithic inhabitants of the Iron Gates as socially inert prior to the appearance of the first farming communities in the Morava Basin to the south. Rather, social organisation and other aspects of culture varied over time, as in the Levantine Natufian.

In lieu of a conclusion

It has become increasingly apparent that the Natufian and Lepenski Vir may not have been characterised by the social complexity posited in a 'Mesolithic societal type' connecting simple hunter-gatherers and complex farmers. In fact, social complexity might not characterise any part of the European Mesolithic (*Spikins 2008.10; Bailey 2008.369*). However, that Natufian and Lepenski Vir hunter-gatherers were not socially complex does not mean they were egalitarian. Their society could have been characterised by inequality, but not necessarily hereditary inequality. I also do not wish to argue that we should confine ourselves to investigations of non-directional, multilinear, culturally specific social evolution (*cf. Rowley-Conwy 2001*). Studies that have limited themselves to this social aspect of culture have largely failed to move beyond social evolutionism (*Warren 2005a; Cvekić 2006*). Instead, we should consider all aspects of culture taken together as the dynamic, non-linear system that is the object of study in archaeology. When the physical or social environment changes, humans do not need to respond by adapting their social organisation; they can respond equally well by changing technology, religion, artistic expression, or any other aspect of culture. If there is any trend towards greater complexity at all, it is greater complexity in the cultural system as a whole, rather than in its social subsystem. Although I find social organisation a fascinating topic, the other aspects of culture are equally important and equally interesting to study.

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Mesolithic cremations as elements of secondary mortuary rites at Vlasac (Serbia)

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ABSTRACT – *In the course of recent excavations of the Mesolithic-Neolithic site of Vlasac, new light has been shed on the mortuary practices and ritualistic behaviour of the Danube Gorges foragers on the basis of human remains with evidence of diverse treatments of dead human bodies. While the majority of burials from the site were found as articulated and some as disarticulated inhumations, there were also several cremation burials. The aim of this paper is to present the analyses of these burned remains, which were excavated in the course of 2006–2007 field seasons in the Danube Gorges. Some of the cremation pits contained calcified human bones, with charcoal and fragments of broken and burned projectile points. These contexts are compared with similar cremation pits found during the first excavations at Vlasac and other sites in the region in 1970–1971. Finally, we examine a series of plausible interpretations in order to sketch a belief system that was part of these funerary practices at Vlasac throughout the 7th millennium BC.*

IZVLEČEK – *Nova izkopavanja mezolitsko-neolitskega nadišča na Vlascu in sledovi različnih ravnanj z umrlimi ponujajo nove poglede na pogrebne prakse in rituale pri nabiralcih v Donavski soteski. Poleg skeletnih pokopov so bili odkriti tudi žgani grobovi. V članku predstavljamo rezultate analiz žganih ostankov, ki so bili izkopani v letih 2006–2007. V nekaterih kremacijskih jamah so bile odkrite kalcificirane človeške kosti, oglje in prelomljene in ožgane puščične osti. Te kontekste smo primerjali s podobnimi kremacijskimi jamami, odkritimi med prvimi izkopavanji na Vlascu in drugih najdiščih v regiji v letih 1970–1971. Preučili smo verjetne interpretacije verovanj, ki so bila povezana s pokopnimi praksami na Vlascu v 7. tisočletju BC.*

KEY WORDS – *cremations; secondary mortuary practice; Mesolithic; Vlasac; the Danube Gorges*

Introduction

Cremation burials in the archaeological record usually come from later prehistoric periods in Europe, particularly the Bronze Age. Cremations also characterise the later mortuary record of many parts of the Roman Empire in the 3rd century AD. Yet, in some regions of Europe, cremations as a form of mortuary practice date back to the Mesolithic. Among other cases, cremations have been found at Oirschot V in the Netherlands (*Arts 1987*), Franchthi Cave in Greece (*Cullen 1995*) and in the Mesolithic levels of several sites in the Danube Gorges of the north-central Balkans (see *Radovanović 1996.187–219; Srejović and Letica 1978*). In the latter region, most recently, new excavations at the site of Vlasac in the Upper Gorge of the Danube (*Borić 2006; Borić et al. 2008*) revealed several new cremation pits with burned human bones. These instances indicate mortuary rituals focused on secondary burning of defleshed human bones as part of a particular mortuary behaviour of Late Mesolithic-Early Neolithic (*c.* 7500–5900 calBC) settlers in this region. This paper presents evidence that demonstrates the conclusion that still flesh-covered and intact human bodies were not burned and left in these locations *in situ*, and that we are dealing with a specific, previously unrecognised form of secondary mortuary practice, which

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involved burning bones from older burials.

In this paper, we first present the archaeological contexts with burned human remains found in the course of new excavations at Vlasac (2006–2007). Second, we focus on the material from the old excavations of the site (*Srejović and Letica 1978.18–27*) by combining physical anthropology inferences with previously unpublished details of particular archaeological contexts. One should keep in mind that the 1970 and 1971 campaigns were salvage excavations conducted at an accelerated pace over a large area with excavation standards different to those common today. Hence, the observations made in the course of the new excavations at Vlasac serve as valuable guidelines on how to treat comparable instances from previous excavations at the site. In the final instance, these sets of data are compared in an attempt to reconstruct recurring patterns in the evidence and to suggest a range of possible meanings associated with Mesolithic cremations and secondary mortuary practices in general.

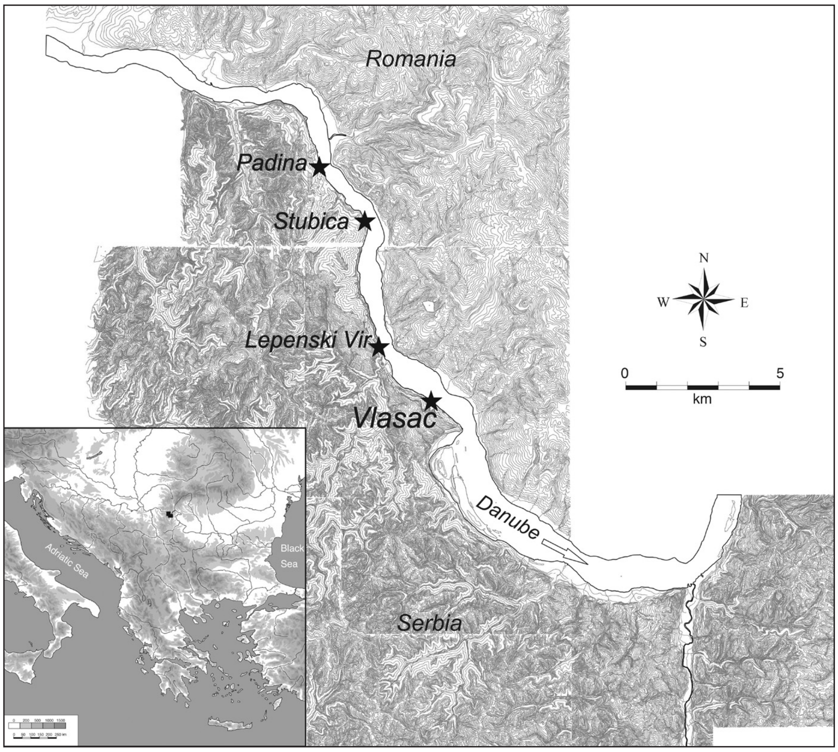


Fig. 1. Map of the Upper Gorge of the Danube, with principal Mesolithic and Neolithic sites.

The site and its setting

Vlasac is situated approx. 3km downstream from the type-site of Lepenski Vir in the Upper Gorge of the Danube, on the Serbian side of the river. It is one of the key settlements among a number of Mesolithic and Neolithic sites found along the Danube banks in this specific landscape zone (Fig. 1). The site was first excavated in 1970–1971 by D. Srejović and Z. Letica (*1978*). New excavations at Vlasac were begun in 2006 and are ongoing (*Borić 2006; 2008; Borić et al. 2008*). The resumed work at the site has covered an area of 326m², investigating a 63m stretch of the new riverbank section created after 1971 in the probably peripheral, southernmost part of the site (Fig. 2). Spatially, this new work takes place upslope from the excavation area that was investigated in 1970–1971. During these first excavations, the zone next to the original riverbank profile, up to a height of around 70 m asl, was sampled for archaeological remains with a number of trenches. Since 1971, the Danube has risen, due to the building of the hydroelectric dam, and largely covered the previous excavation zone. The current riverbank was created by continuous erosion, which destroyed a portion of the site with archaeological remains. In Fig. 2, we show an estimated relationship between the old and new excavation areas, which remains provisional for the time being.

Radiometric evidence suggests that the site was more or less continuously occupied from the Early Mesolithic, from around 9500 calBC, but the intensity of occupation, judging from the number of radiocarbon dates, is greatest from the mid-8th millennium calBC. This Late Mesolithic occupation/use of the site covers the period from around 7500 to 6200 calBC. New research at Vlasac has also indicated that the site was continuously used throughout the transformational/Early Neolithic period (*c.* 6200–5900 calBC). Finally, there is clear evidence from the new as well as the old excavations that human groups also frequented the site in the course of the regional Middle Neolithic (*c.* 5900–5500 calBC). During the Middle Neolithic phase, the first pottery appears in Vlasac, while the evidence of contact with Early Neolithic groups through the acquisition of novel material culture, among other kinds of exchanges, are documented in the period 6200–5900 calBC (*Borić et al. 2008.Ap-*

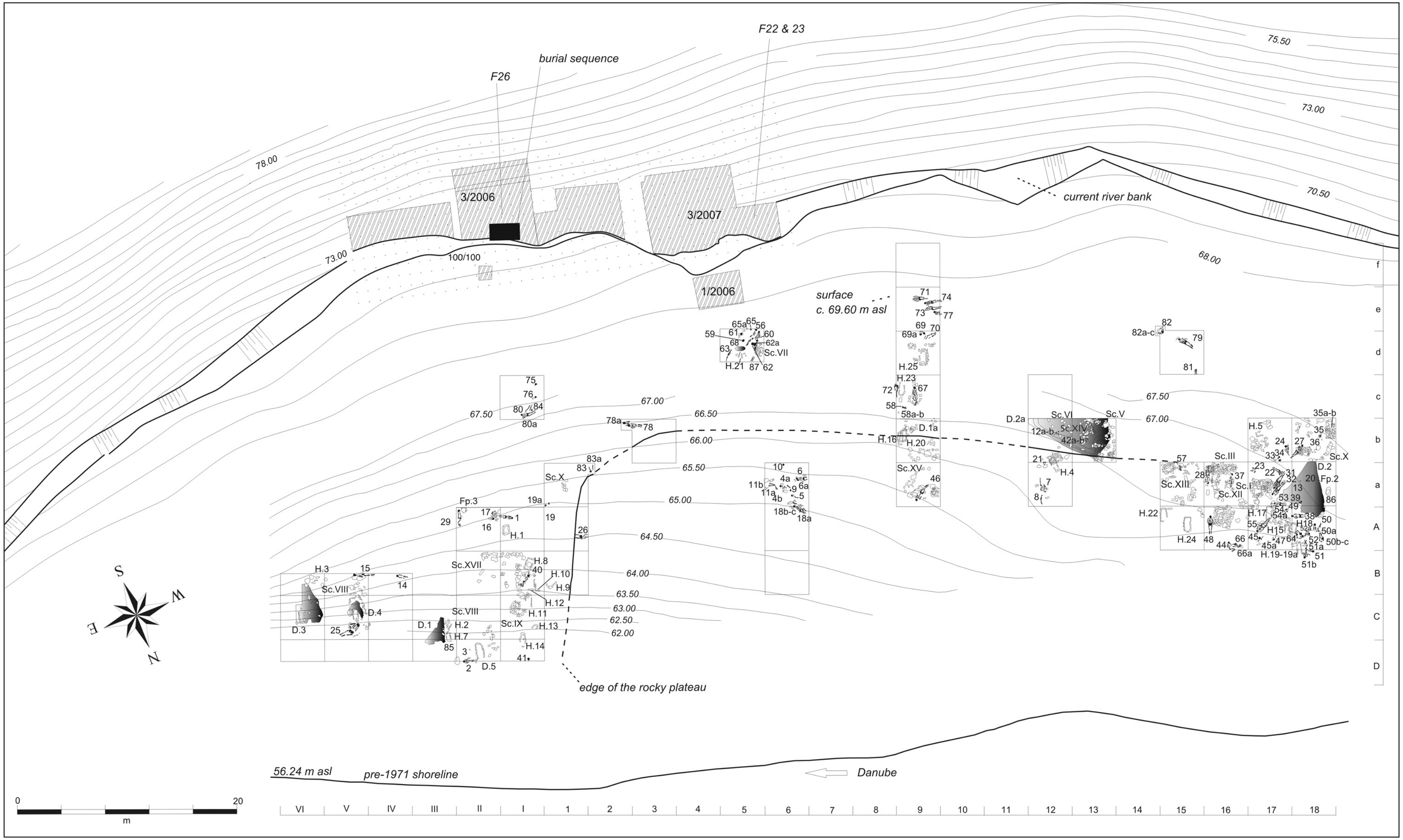


Fig. 2. Vlasac site plan showing an approximate relation between excavation areas excavated in 1970–1971 and areas excavated in 2006–2007 (hatched); D. – dwelling; H. – stone-lined hearth; Fp. – fireplace; Sc. – stone construction; [just number] – burial.

pendix; for a regional chronology see *Borić 2008.Tab. 1; Borić and Miracle 2004; Borić and Dimitrijević 2007; 2009*).

Fig. 3. River bank section of Trench 3/2006, with visible burned cremation contexts 97 and 146 and disarticulated tibia H130 (see Fig. 5).

Apart from numerous burials (see below), domestic features were also recognised at the site, such as trapezoidal dwellings and rectangular stone-lined hearths. Numerous utilitarian artefacts were found across the site, but primarily in relation to dwelling structures. Among several classes of objects found are a typical knapped stone industry characterised by splintered pieces, numerous scrapers and end-scrapers, and (rarely) trapezes, among other typological groups, primarily made of locally available flint, along with a substantial use of quartz implements; a large collection of bone, antler and ivory tools; and, ground stone tools in the form of pestles, mortars and some specific tools such as stone clubs/fish-stunners (see *Antonović 2006; Borić 2002b; Kozłowski and Kozłowski 1982; Radovanović 1996; Srejović and Letica 1978*).

Burials at Vlasac

Numerous burials have been found at Vlasac, shedding light on the complexity of mortuary rites practiced by the communities that inhabited the site over several Mesolithic millennia. The total number of formal burials at Vlasac excavated in 1970–1971 comprises 87 graves, containing either 119 individuals (*Nemeskéri 1978*) or 164 individuals (*Roksandić 1999; 2000*). There are further 17 formal burials which were excavated in 2006–2008, while the minimum number of individuals (MNI) for this assemblage is 16 (*Stefanović n.d.*). There are also a number of disarticulated, scattered human remains found across the site. Among the buried individuals are adults, children and neonates, all buried mostly as extended inhumations, although some semi-flexed and one seated burial in a lotus position were also found (*Borić 2006; Borić et al. 2008; Borić and Stefanović 2004; Radovanović 1996; Srejović and Letica 1978.53–82*). On the basis of the tight body position of some skeletal inhumations, it is possible to suggest that in a number of instances the corpse was wrapped before burial (*cf. Duday et al. 1990; Nilsson Stutz 2003; Roksandić 2001*).

While some burials did not have any associated grave constructions, a number of inhumations were covered or encircled by unmodified blocks of stone, or had somewhat carefully fashioned stone plaques covering the body; in some instances specially selected stones (sometimes of red colour) were placed beneath the head of the deceased. Burials were also frequently associated with dwelling zones and were interred over abandoned buildings or around stone-lined rectangular hearths. However, there are examples of burials found immediately beneath such rectangular hearths (for instance, Burials 51a and 51b underneath Hearths 19 and 19a).

Fig. 4. Articulated remains of Burial H136 and the cut of cremation pit context 115 that damaged this older inhumation.

Possible grave goods, usually in the form of bone implements, are noted

Fig. 5. Refitted fragmented tibia H130 and a burned shaft fragment from context 115. This disarticulated and partly burned bone can be connected with primary articulation H136.

Fig. 6. Burned human clavicle from cremation context 115 in Trench 3/2006. The clavicle might have belonged to individual H136.

in a few burials, while occasional unmodified animal bones found in burials cannot be related to formal burial practices with any certainty (*Borić 2002b.Appendix 6*). On the other hand, body adornment in the form of beads/appliqués accompanied a number of Late Mesolithic/transformational burials, most frequently consisting of a large number of appliqués of pharyngeal teeth of the Cyprinidae family (carp). Such body decoration was also reported for the site of Schela Cladovei (*Boroneanţ 1990*), a site located some 80km farther downstream from Vlasac and belonging to the same Late Mesolithic material culture tradition. Along with Cyprinidae teeth appliqués, another type of appliqués of marine snails, primarily *Cyclope neritea* and sporadically *Collumbela rustica*, were also found in a number of burials (see *Borić 2002b; 2006; 2007a; 2007b*). Most recently, Spondylus and red and white limestone beads have been found in transformational phase burials (*c.* 6200–5900 calBC) (*Borić 2007b: 2008*).

Another particularity of the mortuary practices found at Vlasac is the occurrence of cremated human bones. It is possible to distinguish three basic types of such contexts: (i) oval pits with *in situ* burning of human bones directly associated with skeletal inhumations found a) above cremated remains or b) partly damaged by cremation pits; (ii) oval pits with *in situ* burning of human bones not found directly associated with skeletal inhumations, but in their vicinity; and, (iii) isolated fragments of cremated bones found in the burial fill of skeletal inhumations. Similar instances of cremation 'burials' were found both in the course of old and new excavations at the site, and in the following text, we focus on this type of mortuary practice. We believe that the careful recording of contextual details in the course of most recent excavations at the site enables us to understand the complexity of the particular instances of cremation burials recorded in 1970–1971, and hence we describe the most recent findings first. Before the discussion of contextual associations, we first provide a short guide to the analytical procedure followed when examining burned human remains.

Material and methods

The analyses focused on the number and weight of bone fragments, variation in colour as an approximate indicator of temperature and duration of bone exposure to the heat, and, where possible, identification of the minimum number of individuals, sex and age criteria. Macroscopic bone morphology observation and comparative techniques were used in the examination of bone fragments. The state of preservation of the skeletal material from Vlasac varies significantly. Bones vary from being extremely fragmented, with the majority of fragments being less

Fig. 7. Articulated inhumation Burial H81 and cremated pit context 115.

than 5cm, to some containing almost completely preserved bones. Only in one instance (individual H60 from new excavations), when the deceased was partly burned, were certain burned bones found in their primary anatomical articulation *in situ*. In all other burial contexts, burned bones were disturbed, fragmented and found in piles or in oval burial pits.

Fig. 8.* In situ *cremated remains of juvenile individual Burial H60, with some cremated cranial fragments of an adult individual, most likely the skull of individual H63.

In total, there are 56 contexts with burned human skeletal remains at Vlasac. From the 2006–2007 excavations, there are 38 contexts, while 18 contexts are from 1970–1971 (Appendix 1). Only in few instances was it possible to determine the number of individuals in a particular cremation context (*e.g.* burned remains of both a juvenile and an adult in the cremation pile labelled H60). From the 1970–1971 excavation campaigns, in only one context (Burial 54a) could two adult individuals be distinguished. In all other contexts, estimating the MNI had its limitations. Despite the absence of duplicate skeletal elements, a small number of bones and the nature of their fragmentation made more precise determination difficult. Since in most cases, we examined incomplete skeletal remains with fragments (less than 3cm long) originating from long bones, aging techniques and measurements relevant for determining sex could not be applied. However, burned juvenile bones or bones of individuals under the age of 14–16 were not detected during the examination. In only one burial (H60; 14–16 years old) could age and sex be determined with some certainty on the basis of burned bones.

The assemblage of burned remains demonstrates a variety of colours and bone textures. As Shipman *et al.* (*1984*) point out, colour is not a sole indicator of burning temperature, and should not be the only analytical tool when examining burned osteological remains. However, it can be a rough guideline for establishing an approximate range of temperatures, conditions of bones and/or environmental conditions at the time when a cremation event took place (*Walker et al. 2008*). In our analyses, we took into consideration the surface colours recorded using the Munsell Soil Colour chart (*Munsell Soil Company Inc. 1954*), and we further compared them with five stages suggested on the basis of the research undertaken by Shipman *et al.* (*1984.311, Tab. 2*). Based on the colour of the bones found in Vlasac cremation contexts, it is possible to suggest that bones underwent the first four stages described by Shipman *et al.* Stages II, III and IV apply to most of the dental and osteological remains from Vlasac. According to

Fig. 9. Close-up of the pile of cranial fragments of a juvenile (H60) and an adult (H63). The arrow indicates the proximity of the unburned right humerus of individual H63 found under this pile of cremated bones.

Fig. 10. Close-up of burned bones found directly beneath the legs of skeletal inhumation Burial H53.

a phalanx of red deer from Burial 54a).

Cremated human bones from the 2006–2007 excavation campaigns[1]

There are 17 formal burial contexts with human bones recognised on the basis of the presence of complete or partially articulated skeletons, with a minimum number of 16 individuals (*Stefanović n.d.*), while 30 additional contexts were associated with disarticulated human bones. In total, 38 contexts contained burned human remains. However, cremated human remains were found in two particular zones of the site excavated in 2006 and 2007 (Fig. 2). The two zones also contained clusters of skeletal inhumations. The first zone – with the majority of these contexts – is located in Trench 3/2006 and the other in Extension Trench 3/2007.

these stages, temperatures from 285°C to 440°C produce white, pinkish grey, dark grey, brown and black colours, while temperatures from 525°C to up to approximately 800° can produce light grey, grey, medium blue and bluish grey colours.

After the fire is extinguished, fracture patterns, shrinkage and warping of the fragments should indicate whether bones were flesh-covered, defleshed but not completely dry ('green') bones, defleshed – anhydrous, boiled or baked (*Whyte 2001.438*). We suggest that bones at Mesolithic Vlasac were most frequently burned with no soft tissues on them, since they exhibit longitudinal cracks and fractures (*cf. Whyte 2001.439*). Apart from indications based on the colour and surfaces of the burned bones, such a conclusion is also supported by contextual evidence: the process of preparing bones for burning can be recognised at some locations on the site (see below). Although it is often hard to distinguish among small and heavily burned fragments, among the dominantly human burned remains, there were occasional burned animal bones (*e.g.* occasional fish bones and

Trench 3/2006

At this location there is a complex sequence of skeletal inhumations associated with concentrations of cremated human bones. Similar to other instances

Fig. 11. Skeletal inhumation H232 placed on top of cremation pit F26.

1 New and ongoing fieldwork at Vlasac started in 2006 through a collaborative project between the Departments of Archaeology of Belgrade University, Serbia, and the Department of Archaeology, University of Cambridge, UK, and with Miloš Jevtić and Dušan Borić as principal investigators. We would like to acknowledge the funding received for the archaeological excavations at the site of Vlasac through the British Academy grants (SG-42170 and LRG-45589) and the McDonald Institute for Archaeological Research, University of Cambridge grants in the period 2006–2007.

Fig. 12. Cross-section of cremation pit F26, with stratified fill contexts 260, 249 and 251 (a) and context 249 exposed with a stone slab context 259 (b).

from the old and new excavations at Vlasac, this cluster of burials is found in a depression, which might have been a natural formation, but subsequently adjusted by fashioning its sides. It was first used as a habitation zone, since a flint, quartz and bone concentration was found within a layer of palaeosol (context 222). This layer is currently radiometrically undated, but is probably of earlier Mesolithic date, *i.e.* it must be older than the date for one of the earliest burials, H136, which is dated to the first half of the 7th millennium calBC (see below). On top of this initial habitation zone, there was a red burned dwelling floor (context 149). One can only speculate that the outline of the floored area might have been of trapezoidal shape on the basis of the shape of the preserved floor level and by analogy with such contemporaneous dwellings found at Vlasac in 1970–1971. Here, the first pits with *in situ* cremated bones seem to have been dug into sterile deposits immediately around this Late Mesolithic dwelling floor, which had only a partially preserved rear part, while the Danube has eroded away its front part. These pits might have been dug only upon the abandonment of the dwelling floor and its covering by a sterile layer of soil (context 132). Two oval pits with *in situ* cremated human bones (contexts 97 and 146 [see Appendix 1] found on the eastern gradient of the depression at slightly different levels), as well as the infill of the burial sequence above the dwelling floor, were seen in section on the eroded portion of the riverbank immediately upon the start of work at Vlasac in 2006 (*Borić 2006; 2008; Borić et al. 2008. Figs. 5, 8–10*) (Fig. 3).

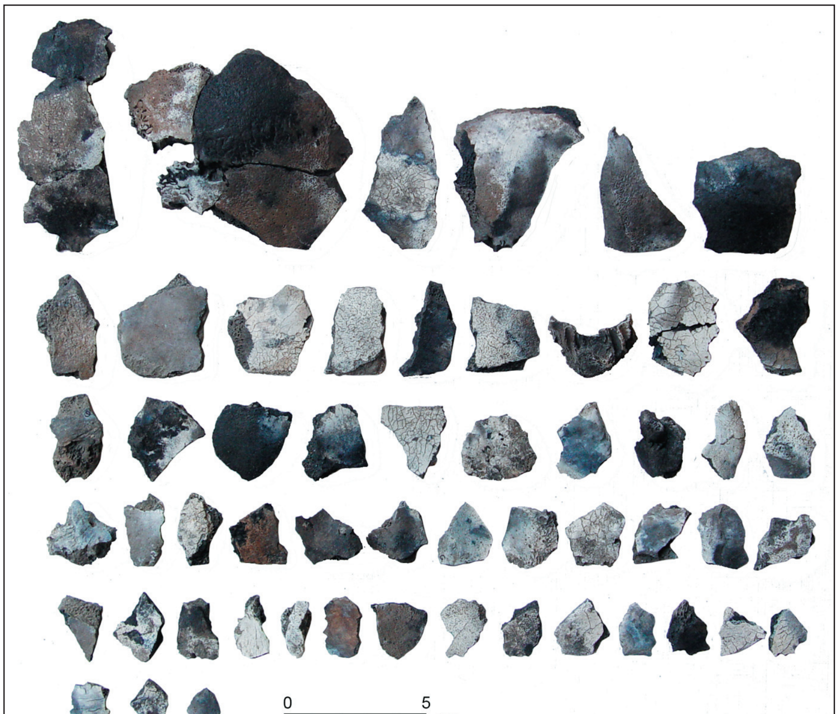


Fig. 13. Burned cranial fragments from cremation pit F26 (Trench 3/ 2006, Vlasac).

Once this floor surface (context 149) had been abandoned, eight inhumations of adults, children and neonates were placed one above the other, with the same body orientation, in supine extended positions. In addition, one of the earliest burials found

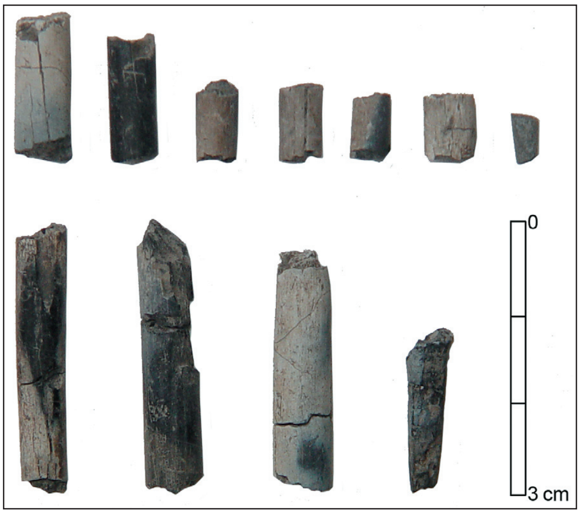


Fig. 14. Burned bone projectiles found in F26 (Trench 3/2006, Vlasac).

here, placed at the south-eastern side of the cut fashioned for the (trapezoidal) dwelling floor, was a child burial (H297; around 1 year old), associated with more than 400 Cyprinidae teeth appliqués modified by making V-shaped cuts on their roots to facilitate easier sewing to the cloths that adorned the deceased, along with 21 appliqués of *Cyclope neritea* marine snails. The knees were covered by a large, specially chosen stone. All these mortuary elements may connect H297 with the first burial discovered in 2006, H2, suggesting these two burials were contemporaneous (H2 is dated to 6775–6475 calBC at 95 per cent confidence, or 6681–6530 calBC at 68 per cent confidence after correcting for the freshwater reservoir effect: for details of all AMS dates, see *Borić et al. 2008.Appendix*). However, H297, although in the immediate vicinity of the vertical sequence of burials, was not in a direct stratigraphic relation with the other burials and was not damaged by subsequent digging. It also had an unusual body orientation, with the head pointing north-east.

Within the vertical burial sequence in Trench 3/2006, older burials had usually been partially disturbed by later digging and the subsequent cremation of the disturbed human remains. While it is difficult to reconstruct with certainty the remains of which burials are found within the earliest cremation pits, partly due to the loss of other burials that might have been destroyed by erosion, one could speculate that these first pits contained the bones of such older burials. On the other hand, it is clear that one of the damaged burials found at the bottom of the vertical sequence of burials, an old adult female (H136) was disturbed by a later pit in which this individual's bones were probably burned *in situ* (context 115). Only the feet and the right tibia and fibula of this individual were found unburned in their primary articulation (Fig. 4). As a consequence of this disturbance, some disarticulated and unburned bone fragments of this individual were probably scattered in the vicinity of the burial's resting place, as is most probably the case with an unburned left tibia diaphysis (context H130) (*Stefanović n.d.*). Burial H136 is directly AMS dated to 6775 to 6473 calBC at 95 per cent confidence, or 6684 to 6530 at 68 per cent confidence (after correcting for the freshwater reservoir effect; see *Borić et al. 2008*). From context 115, the cremated proximal anterior parts of the left and right tibiae, and a fragmented left tibia labelled H130, probably come from Burial H136 (Fig. 5). Other scattered and unburned finds from context 115 might also have come from individual H136: a very gracile clavicle, which is morphologically identical as a cremated fragment in context 115 (Fig. 6). A total of 19 permanent burned teeth were found that also might have belonged to individual H136. Although incomplete, among the burned bones, ribs, carpals and phalanges were recovered with a 5mm sieve and the flotation of sediments from context 115. There were fragments of burned bone projectiles, which seem to have been a recurrent feature of these pits with burned human bones (see Appendix 1), and we will later discuss the possible meaning of such associations (see below).

Fig. 15. Skeletal inhumation Burial H244 (Feature 22) prior to excavation, and pit F23 (fill 242 and cut 243), which contained burned human remains and* Cyclope neritea *marine snails.

The burned teeth in this context do not differ from the burned bones – their surfaces are smooth and glassy, with black colour dominating the crowns and roots, indicating a lower temperature and heat (*Schmidt 2008. 58*), probably about 360–440°C (*Shipman et al. 1984.311*). Slight transverse fracturing on the roots is observed and uniform black colouration could indicate that the teeth were probably burned with no soft tissues around them, since teeth protected in the sockets tend to be multicoloured (*cf. Schmidt 2008.63*). Small maxillar and mandibular fragments among the burned bones of context 115 again suggest that perhaps the whole head of H136 was burned here.

Fig. 16. The upper part of the body of Burial H244 (Feature 22) with the damage done to its torso and the burned humerus left in its supposed* in situ *location.

Above this cremation pit context 115, an adult male individual, Burial H81, was interred. In its primary articulation, only the left half of the pelvis, the whole left leg and the right leg beneath the knee are preserved (Fig. 7). From the position of the deceased's legs, it could be inferred that at least lower limbs might have been wrapped at the time of burial, as the ankles are touching, while the feet were found in the upright position due to the effect of the wall (*Borić 2006*). H81 is now also directly dated by OxA–20 762 to 6639 to 6440 calBC at 95 per cent confidence, or 6590 to 6468 calBC at 68 per cent confidence (after correcting for the freshwater reservoir effect), confirming its stratigraphic position in relation to H136. The bones of this individual were disturbed by the digging of the burial pit for the younger burial, H63, which is above H81, but slightly horizontally displaced to the north along the same axis.

Burial H63 is a young female adult between 25 and 30 years of age (*Stefanović n.d.*). A number of bones were found in the infill of the burial pit of H63. On the basis of morphological and metrical characteristics of these disturbed remains, one can suggest that these body parts are the bones of an adult male, and can be with some certainty connected to H81. Moreover, the presence of particular bones missing from H81 (skull fragments, right femur, left humerus) strongly suggest that these bones are disarticulated body parts of H81. While disarticulated bones of H81 were not burned *in situ*, perhaps some of the unaccounted for bones were burned in Feature 26, found to the south of this main burial area. This oval pit contained cremated human bones and was superposed by a primary skeletal inhumation (H232). We describe this feature in more detail below.

Fig. 17. Hearths 15 and 18 and Burials 45 (AA-57778), 53, 54, 54a, (OxA-5823) and 49 (photo: Centre for Archaeology, Faculty of Philosophy in Belgrade).

The younger burial, H63, found above H81, and containing some of the disarticulated body parts of H81, is directly dated to 6232 to 6018 calBC at 95 per cent confidence, or 6212–6066 calBC at 68 per cent confidence (after correcting for the freshwater reservoir effect, see *Borić et al. 2008*), and is thus at least two cen-

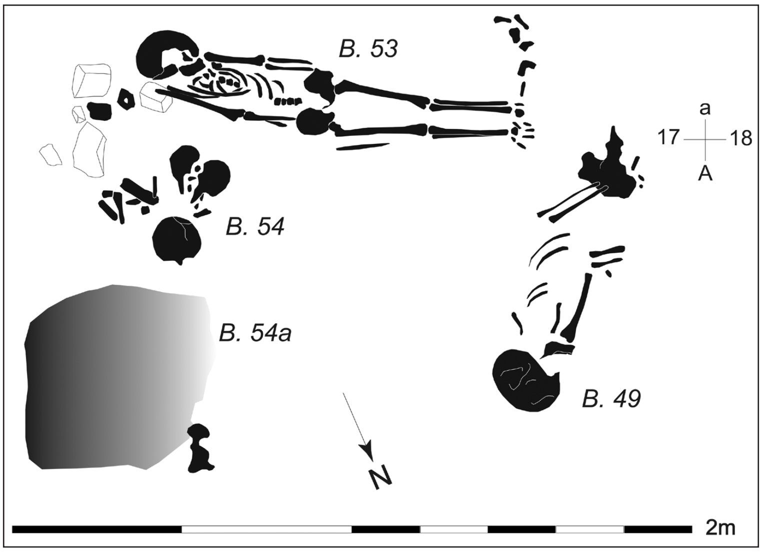


Fig. 18. Sketch of Burial 54, with cremation zone 54a and primary articulations Burials 49 and 53 (redrawn after* Srejović and Letica 1978.70*).

individual (14–16 years old), placed directly on top of H63. H60 was largely burned by cutting another oval pit in this part of the burial place. This was *in situ* burning, which almost completely destroyed the lower limbs and lower torso of H60, while the bones of the upper torso (clavicles, rib cage and cervical vertebrae and scapulae) were found in their primary articulation, although parts of these bones were also affected by fire and appear partly burned (Fig. 8). In the course of the cremation process, some bones (pelvis and lower limbs) of individual H60 were heavily burned. By the content, number and weight of fragments, one could infer a deliberate cremation of the exhumed bones of individual H60 *in situ*. It is of some interest to note that the skull of this individual was detached from its primary location, similarly to the removal of the skull of H63. The disarticulated position of the broken atlas of this individual may suggest that the head was severed while the bones of H60 were still flesh-covered or defleshed but not completely dry.

turies older than H81 (see Fig. 32). This may suggest a restrictive set of criteria for particular individuals to be buried in this location over a long period of time, while, at the same time, there seems to have been a clear recognition of this particular burial place by a social group within a larger community that repeated several times the same set of burial customs (see *Borić in press*). The skull of H63 was removed possibly after the decomposition of the soft tissues, since neither the cervical vertebrae nor the atlas were disturbed. H63 bears no traces of exposure to fire, and is much more complete than both H136 and H81. Parts of the primary articulations of a juvenile (H153) and a sub-adult individual (H60) were found over H63, while her left ulna, radius, femur, part of left pelvis and lumbar vertebrae were removed when a burial pit was dug here for the interment of two neonate burials (H62 and H69). All these disarticulated body parts of H63 were subsequently placed in the infill of the last inhumation in the group burial – H53 (see below). Modified Cyprinidae teeth appliqués were found on both sides of the neck and partly below the left scapula of H63, suggesting some sort of headdress adorning the deceased. A large Spondylus bead and red and white limestone beads found associated with this burial (*Borić 2006; 2007b; 2008*) confirm its radiometric date, placing it in the transformational phase in the Danube Gorges, parallel with the Early Neolithic time span of the wider region of the north-central Balkans (see *Whittle et al. 2002; 2005*).

An important discovery for the theme of this article is the subadult Burial H60, possibly a young female

In this last pile of burned bones, of which most belonged to H60 in this location, closer to the area where the heads of H63 and H60 should have been found, there were also cranial fragments of an adult individual as well as of a juvenile (Fig. 9). It is likely that these fragments indicate that, after the removal of the heads of H63 and H60, these skulls were burned here, the remains of which are found in the pile of cremated remains. The following bones of young female (?) individual H60 were present: twelve cranial fragments with unobliterated coronar and sagital sutures, and two fragments of occipital bone with external occipital protuberance and unfused sutural edges. The following fragments comprised the cranium of individual H63: four fragments of frontal bone, with parts of orbit; a fragment of the right temporal bone with zygomatic process; two fragments of the petrous part of the temporal bone, with internal auditory meatus; the apex of the right mastoid process and incomplete left mastoid process; a fragment of the lingual surface of left mandible with teeth sockets; a left fragment of a mandible with the third molar, and one fragment of the body of a mandible, with the part of a socket for the third molar and visible mylohyoid line and groove. Although most of the fragments are incomplete, their

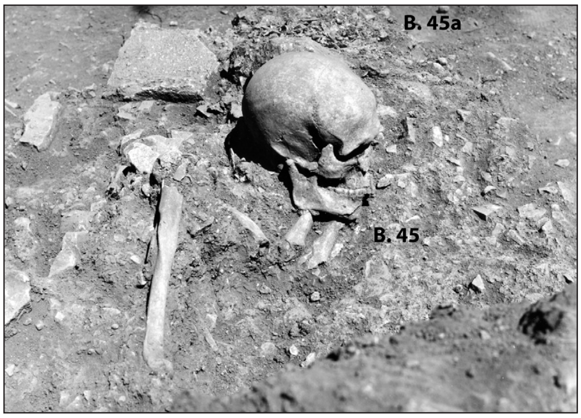
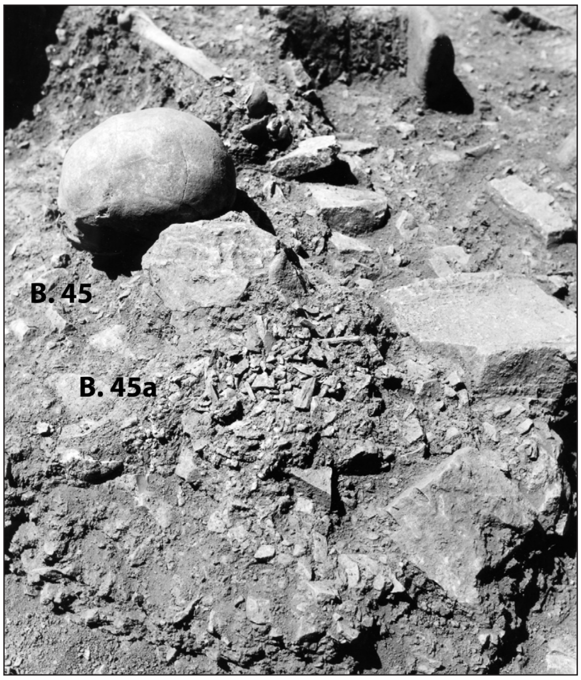


Fig. 19. Skeletal inhumation Burial 45 and cremated Burial 45a found behind the head of Burial 45 (photo: Centre for Archaeology, Faculty of Philosophy in Belgrade).



general appearance indicates that they belong to an adult female.

On the other hand, the individual in Burial H21, represented by an isolated skull with mandible and the upper portion of the torso of a smaller child (2 years ± 8 months), on the basis of its age and the general condition of the bones, probably belonged to the postcranial bones found as a partially preserved primary articulation marked as H153, also placed on top of H63. If this is the case, the upper torso and head of this child were also removed but not burned, and placed in the form of a structured deposit, probably upon closing the whole burial location (see below; *Borić 2006*). This removal of body parts probably took place when the skulls of H63 and H60 were removed and subsequently burned. All these actions were probably undertaken immediately before a new skeletal inhumation was buried here.

The old adult individual Burial H53 is placed along the same axis as other, older burials in this location, but in the opposite direction to all other burials, *i.e.* with the head pointing upstream the Danube, instead of the previous rule of orienting the deceased with heads pointing downstream. As mentioned above, the interment of this burial might have directly been connected with the series of events just described – of detaching the skulls of earlier burials and the burning of H60 and probably parts of H63 (the head) and possibly also parts of the child, H153. The legs of the old adult individual, H53, were found lying directly on the pile of burned bones designated as H60 (Fig. 10). The burial fill of this last inhumation, H53, at this location also contained a number of bones from previously disturbed contexts, but primarily the complete left femur, fragments of the left pelvis and the lumbar vertebrae of individual H63. On top of one thin stone plaque that covered the pelvis of H53, a red deer skull with antlers was found as part of the ritualistic/structured closing of this location. This red deer skull was placed symmetrically with the already mentioned skull of child individual H21 (probably equivalent to the articulated post-cranial remains labelled as H153) (see *Borić in press*). The red deer skull has directly been dated in the range 6006 to 5838 calBC at 95 per cent confidence, or 5984–5891 calBC at 68 per cent confidence (*Borić et al. 2008*). After this burial, the whole location was covered by large blocks of stone and 'closed'. The final infill of this burial location beneath the stone blocks, *i.e.* its uppermost layer, contained a number of burned human remains, which must have originated from the disturbance of older contexts with burned human remains, along with disarticulated unburned fragments of human bone.

Feature 26 in Trench 3/2006

On the southern side of the described depression, 1.5m to the south of the vertical sequence of burials, another skeletal inhumation, H232 (young female adult, Feature 21), was discovered in 2007. The orientation of this burial followed the same general orientation as the rest of the burials in the vertical sequence. Due to the gradient of the terrain in the southernmost part of the depression, the position of this burial was semi-seated, while its pelvis was placed directly on top of a zone with intensely burned human remains found in an oval pit lying directly beneath H232 (Fig. 11). The pit (Feature 26) had an East-West orientation. The cut (context 252) was 100 by 60cm in diameter and 50cm deep. Three distinct fills were separated in the cross-section of this feature (contexts 249, 251 and 260). These differences mark the intensity of burning in the pit, from the trampled layer (context 251) on top of which H232 was placed – the most intense zone of burning found in the middle layer (context 249) and the diffused burning (context 260) that affected the surrounding sediment on pit's edges (Fig. 12). While some burned bones from this pit were recorded *in situ*, most were hand-collected or picked up by sorting the heavy residue after the flotation of the sediment from this feature. The flotation procedure also allowed for the recovery of a concentration of palaeobotanical remains, primarily stones of cornelian cherry (*Cornus mas*), which were also noted in relation to some burials during the first excavations at Vlasac (*e.g.* Burial 49; *Srejović and Letica 1978. 55*). This concentration of cornelian cherries found in F26 probably occurred accidentally, being still attached to branches used for firewood, but one should not exclude the possibility that the fruit was deliberately thrown into this feature. Their presence probably indicates the autumn for the timing of the cremation event. Most recently, one of these cherry stones from context 249 was directly AMS dated by OxA-20 702 in the range 6636–6476 calBC at 95 per cent confidence, or 6596–6502 calBC at 68 per cent confidence. This date could be taken as the date for the cremation pit, but also for the burial of H232, if one assumes that the interment of this individual took place immediately after the cremation of bones, which their stratigraphic superimposition suggests. Comparing the heights of burials H81 (*c.* 7.25 m asl) and H232 (*c.* 7.30 m asl), which were both found at approximately the same level above cremated contexts, as well as the completely overlapping dates obtained for the likely interments of these two individuals, one may suggest that these events possibly took place around the same time, utilising an older burial, H136, as the substance for burning in cremation pits beneath both burials.

Total recovery of the burned human remains from cremation pit F26 was attempted, and these include: 511 fragments of burned bones weighing almost 600 grams that were hand collected; 199.6 grams from a 5mm sieve; 647.8 grams from a 3mm sieve; and 47.8 grams from the flotation of sediments. The length of fragments recovered by flotation ranged between 0.5mm and 20mm (Appendix 1). Multiple colours on the burned bones are noticeable – varying from black to light blue and grey, to partially burned bones. It is possible that not all the bones were exposed to the same temperature, probably due to their different positioning within a pyre and fluctuations in temperature that occur naturally. Also, bones could be partly burned or differ in colour due to draft and lack of fuel (*Walker et al. 2008.129*). Since the dimensions of cremation pit F26 do not suggest that a whole adult body could have been buried in it, it is most likely that some already defleshed bones were dug up from their primary position and then burned here.

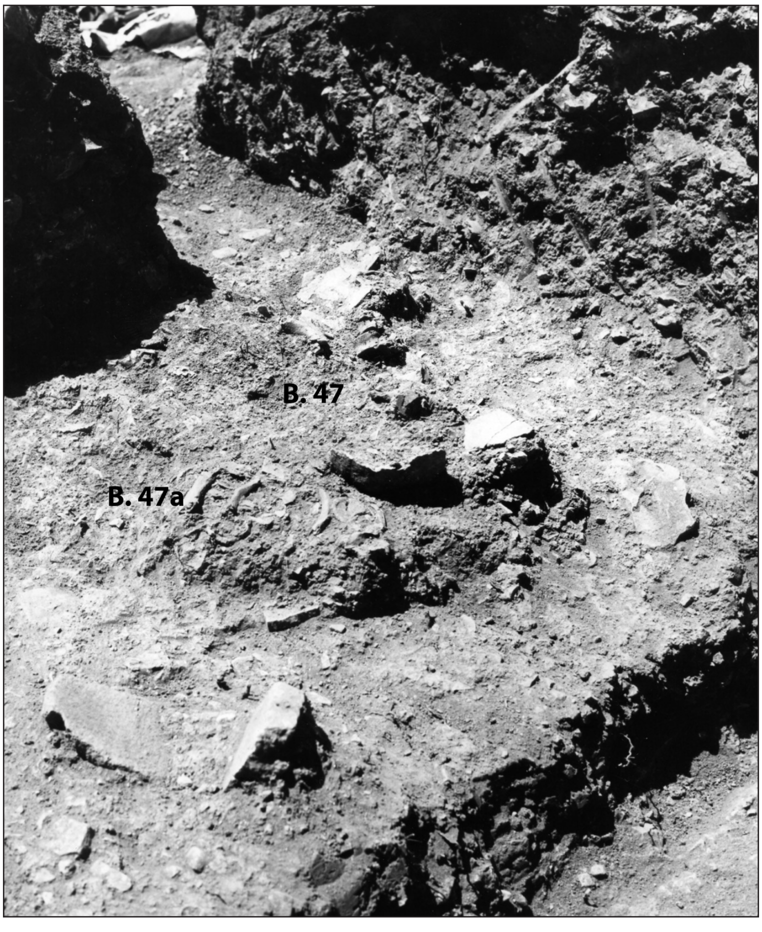


Fig. 20. Skeletal inhumation Burial 47 and cremated bones Burial 47a (photo: Centre for Archaeology, Faculty of Philosophy in Belgrade).

On the basis of the anthropological examination of the burned remains

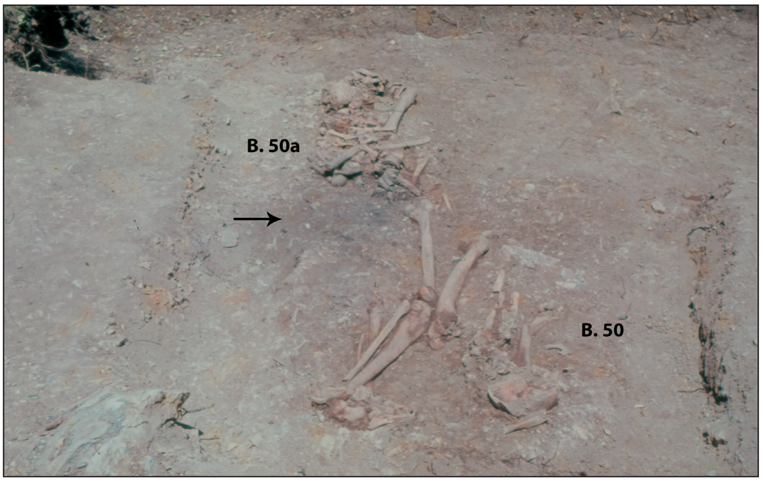


Fig. 21. Skeletal inhumation Burial 50a, with dislocated right femur and traces of burning in this zone of disturbance; next to it, the disturbed skeleton of Burial 50.

from this feature, it is possible to conclude that there are no duplications of skeletal elements to indicate the presence of more than one person, although the high fragmentation of bones might be misleading in this respect. The majority of fragments originate from long bones, but three fragments of vertebrae and more than 60 cranial fragments are also present, indicating that almost the whole skeleton or at least all the parts of a human skeleton might have been cremated here. Also, one mandibular fragment, 28mm long, is present, with preserved lingual surface and with mental spines and sockets for both canines and all incisors, indicating an adult person. However, the cranial fragments were the best preserved and are the best for sex and age determination. Cranial suture closures, observed on four fragments, indicate that the individual was of adult age, over 50 years old (Fig. 13). Due to high fragmentation and the absence of diagnostic anatomical features on the post-cranial skeleton for sex determination, the gracility of bones was the only indicator to suggest a possible female. In an attempt to answer the question about whose bones were burned in F26, one may thus recognise the possibility that the disturbed bones of adult female H136 might also have found their way into this cremation pit and not only into the previously mentioned context 115. This conclusion is corroborated by the stratigraphic positions of these burial features, their proximity, anthropological observations on the burned human remains and their comparisons with the preserved skeletal inhumation of H136, which was found in its primary articulation.

Among the recovered fragments are an ulna and a radius that can be articulated. It is important to note that the fracture patterns observed are not those originating from the bone shattering prior to burning (*Mays 1998.214*). Furthermore, a post-depositional disturbance could not result in either such traces or in the high degree of fragmentation. One bone fragment shows cutting traces made while the bone was still heated, while others show traces of blunt force trauma on the edges, which may indicate that the bones were first cut and then smashed. In this particular case, we suggest that the mechanical breakage of the bones was done when the bones were being prepared for cremation. Thus, we could assume that some time after the initial inhumation, defleshed bones of the deceased were taken from the primary burial and intentionally fragmented in order to be subsequently burned in the pit. J. Kinley (*1994.342*) states that high fragmentation of burned bones in cremations cannot be taken as an indication of the state of burned remains at the time of deposition. Any movement while they were hot, their interment, as well as the subsequent excavation and post-excavation conditions would affect the bones and most likely increase their fragmentation. For a small quantity of bones we could say that they suffered some very limited fragmentation in the course of the excavation and through their post-excavation treatment, but deliberate pre-incineration fragmentation in a number of cremation burials at Vlasac is very likely. Some instances of burials from the 1970–1971 excavations at Vlasac support this conclusion (see below).

Eleven fragments of burned bone projectiles (Fig. 14) were found in the same feature, commingled with burned human remains. One fragment was found beneath an unworked stone slab (context 259) placed within the cremation pit, while nine other fragments came from the most intense zone of burning in the middle of the pit.

Extension Trench 3/2007

There is only one instance in the part of the site where another cluster of skeletal inhumations was found with the evidence of, first, post-mortem damage to a skeletal inhumation and, second, subsequent burning of the disturbed human remains and associated finds. It relates to Burial H244 (Feature 22) and pit Feature 23 (fill 242 and cut 243) (Fig. 15), found in close proximity to two other skeletal inhu-

Fig. 22. Distal tibia fragment that refits with a burned shaft fragment from Burial 50.

mations, Features 25 (H254) and 27 (H267). The individual labelled as H244 is a female, around 40 years old. This skeleton was damaged by a disturbance that damaged most of the torso, leaving only distal parts of the arms and parts of the lumbar vertebrae. The mandible was also not found, and one could suggest that perhaps the retrieval of the mandible of this individual was the cause of the disturbance. Curiously, a black burned and fragmented right humerus was found in a place where it would be expected anatomically, but no other traces of *in situ* burning were noticed in this location (Fig. 16). Further, a pit with a dark grey deposit and some burned human remains was recognised as Feature 22 (fill 242 and cut 243) in the immediate vicinity of H244, *i.e.* behind its head, but at a somewhat lower level. In total, 236 fragments weighing 64.4 grams were collected from the pit. Apart from six cranial fragments (longest fragment 28mm), with no sutures, all other fragments come from long bones. Due to the high degree of fragmentation (the longest post-cranial bone is 22mm) and the absence of anatomical features for sex and age determinations, matching these fragments with the mentioned skeletal inhumations in the vicinity is very difficult. Pit F22, with remains that do not indicate intense burning *in situ*, also contained 9 burned *Cyclope neritea* marine snails. It is possible that these appliqués, along with burned bone fragments, originate from disturbed burial H244, and that some of these remains ended up in this burial pit by secondary redeposition, while the primary location for their burning might have been outside the currently preserved riverbank, on the edge of which this concentration of burials was found.

Summary of findings for the 2006–2007 cremated remains

Previously described instances of cremation 'burials' discovered in the course of the 2006–2007 excavation seasons suggest both some recurrent patterns in the appearance of cremated human bones, but also indicate a certain degree of variability that does not allow for a single interpretive scenario. The recurrent pattern found in the burial zone within Trench 3/2006 suggests disturbances being made only to certain parts of older burials, frequently the head and torso, while legs and feet were occasionally preserved. Disturbed bones were probably deliberately broken in smaller portions prior to burning. Given the degree of burning and the presence of charcoal in these pits, the fire must have been burned for a relatively long period, perhaps several days

Fig. 23. Burned cranial fragments from cremation pit Burial 35.

(*C. A. I. French, pers. comm.*). Such events of digging through and disturbing previous burials and the subsequent fragmentation and final burning of these bones might have taken place as a required practice of (ritual) preparation for the interment of the newly deceased, since the skeletal inhumations seem to have been placed directly on top of burned remains. Only in one case (Burial H60) was it possible to unequivocally determine that bones of more than one individual were jointly cremated. The superimposition of these cremation pits with skeletal inhumations and their vertical stratigraphic relations with other features in Trench 3/2006, further aided by a number of radiometric dates now available, suggest that the basic elements of the same mortuary/ritualistic practice might have remained unaltered for at least the last 800 years of the 7th millennium calBC. In the course of this period, this burial location was used for interments of a selected number of community members, which might have belonged to a particular social (kin?) group. Some changes seen in the appearance of ornament novelties around 6200 calBC did not alter the basic mortuary ritual of secondary re-burial and cremation (see below).

Cremated bones from the 1970–1971 excavation campaigns

In the course of 1970–1971, 19 burials with cremated human bones were recorded across the excavated area as i) piles of bones (Burials 35, 45a, 47a, 65a, 58a and 68), ii) contents of oval pits (Burials 11b, 54a, 85 and 86, while the last two were marked as found in 'fireplaces'), or iii) as isolated bones found within the burial fills of some skeletal inhumations (Burials 36, 45, 50, 50a, 50b, 51a, 52, 55 and 67) (see Appendix 1). A number of physical anthropologists have examined the human remains from the 1970–1971 excavations at Vlasac (*Nemeskéri 1978; Nemeskéri and Lengyel 1978; Nemeskéri and Szathmary 1978; Menk and Nemeskéri 1989; Mikić 1981; 1992; Roksandić 1999; 2000*). Although these authors comment briefly on the cremation burials, detailed analyses of these remains have never been undertaken, leaving this phenomenon with neither an adequate description nor an appropriate interpretative framework.

There are some problems with the collection of cremated bones excavated at Vlasac in 1970–1971. One burial (Burial 85) with cremated remains is missing from the collection. Also, the labelling for Burials 65 and 65a is confused: Burial 65a was originally de-

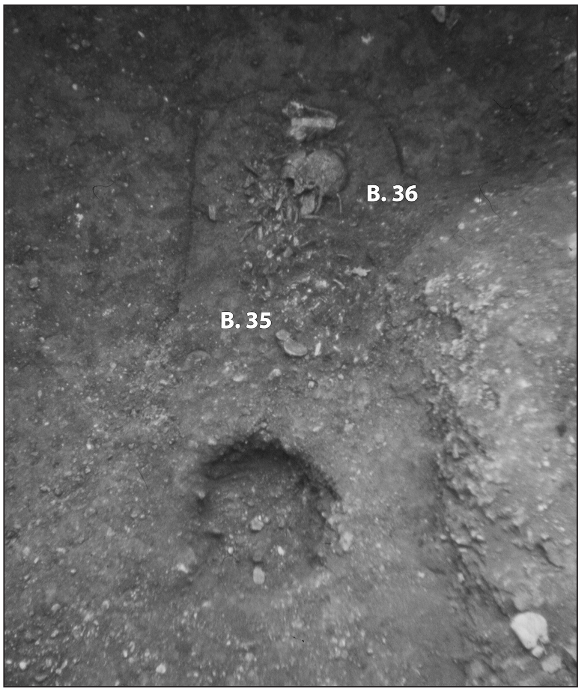


Fig. 24. Excavated cremation pit of Burial 35 and the pile of bones with the head on top labelled as Burial 36 (photo: Centre for Archaeology, Faculty of Philosophy in Belgrade).

scribed in the source publication as a round pit, 0.25m in diameter, with calcified human bones (*Srejović and Letica1978.61*), while in the preserved collection the label 'Burial 65a' is used for adult unburned human bones, and the label 'Burial 65' is used for cremated remains. The source publication also fails to mention cremation bones found in the burial fills of skeletal inhumations.

The cremated remains excavated in 1970–1971 could also, slightly differently, be divided into another three groups. The first group would comprise defined cremation contexts (pits or piles) containing only burned human bones (Burials 11b, 35, 45a, 47a, 54a, 58a, 65, 68 and 86). The second group comprises burials where burned bones are found associated with primary articulated skeletons (Burials 50 and 50a). The third group is made up of sporadic bone fragments (less than five per burial) that might have accidentally come to rest in burial fills from disturbed cremations nearby (Burials 36, 45, 50b, 51a, 52, 55 and 67). The observations presented below are made on the basis of published information (*Srejović and Letica 1978*), as well as re-examined material and documentation available at the Faculty of Philosophy, Belgrade University. We will not use the original excavator's phasing of burials for phases Vlasac I–III, since it has recently been shown that, bearing in mind the colluvial character of formation processes at Vlasac, one could not sustain the excavator's stratigraphic understanding of the site, and a thorough revision of all associated features is required. Such a new understanding of formation processes and the stratigraphy of the site is based both on new field research and an increasing suite of new radiometric measurements dating secure contexts from old excavations (*Borić et al. 2008*).

In a number of cases, we were able to connect the defined cremation pits and piles that contained burned human remains with nearby disturbed skeletal inhumations, the bones of which were burned. However, we could not be absolutely sure in each particular case that the cremated bones were from skeletons in the vicinity of which they were found. Even when diagnostic parts exist, due to the shrinkage when exposed to fire and the high degree of fragmentation of burned and unburned bones, it was hard to find fragments that can be refitted. However, in a small number of instances, we were able to conjoin unburned bone remains from the inhumations with burned fragments of bones found in cremations.

In the following, we describe particular contextual associations. While piles or pits with cremated human bones were found in different parts of the area excavated in 1970–1971, their presence is prominent in the area where a number of other habitation and mortuary activities were also concentrated, *i.e.* in the western part of the site, in front of, behind and on the western side of Dwelling 2 (see Fig. 2). We shall describe these instances first.

Fig. 25. Section above Burial 11b in square a/6 (photo: Centre for Archaeology, Faculty of Philosophy in Belgrade).

Space around Dwelling 2 (Western sector)

In square A/17, located in front of the wider side of trapezoidal Dwelling 2 and overlapped Hearths 15, 17 and 18, a complex sequence of overlapped and truncated skeletal inhumations was found (Fig. 17). Among these burials are some of those that the excavators recognised as cremation burials, frequently in association with, or in relation to skeletal inhumations. We describe each of these features below.

Burial 86 (Dwelling 2)

At the same level as the floor of Dwelling 2 and next to the western side of this floor (0.4m away from the floor), there was an oval pit (0.8 by 0.35m) marked as 'Fireplace 2'. It contained a thick layer of charcoal and ash, as well as calcified human bones. These bones were marked as Burial 86. This feature contained 464 post-cranial fragments, the majority of which originate from long bones of the lower extremities, but the head of a radius, a glenoid cavity (scapula), three fragments of ribs, one vertebra and two phalanges indicate that bones from the upper part of the body were burned here. There were also 75 very fragmented cranial (calotte) fragments, and only one fragment of the mandible ramus (46.4mm). Cranial as well as post-cranial fragments do not show diagnostic criteria for aging or sexing of these skeletal remains. Among the burned human bones, one burned unmodified Cyprinidae tooth appliqué was found.

The excavators indicate that this oval pit must have been dug only after the construction of Dwelling 2 (*Srejović and Letica 1978.22*). This is similar to the case of the so-called 'Fireplace 1', which contained Burial 85 associated with Dwelling 1 at the Eastern sector of the site (see *Borić et al. 2008.Fig. 14*). In both cases, it could be problematic to assume that these were the actual fireplaces of these dwellings. Instead, it is more likely that, similarly to the described instances from the new excavations at the site found in Trench 3/2006 (see above), Burials 85 and 86 associated with Dwellings 1 and 2 are cremation pits connected primarily with the burning of human bones. For the absolute dating of these first trapezoidal dwellings at Vlasac, new radiometric dates indicate the first two centuries of the 7th millennium calBC, while the cremation pits might have been somewhat later. For instance, a roe deer skull with antlers found at the floor of Dwelling 2 was dated in the range of 7047 to 6699 calBC at 95 per cent confidence, or at 7033–6821 calBC at 68 per cent confidence (*Borić et al. 2008*). Although found approximately at the same level as the floors of these two dwellings, it is likely that these cremation pits were created after these dwelling spaces had ceased to be used for everyday activities.

Burial 54a
Cremation Burial 54a was found in an ellipsoidal pit containing burned human bones next to Burial 54 (Fig. 18). Burial 54 is a disarticulated inhumation of an adult male, over the age of 50, whose bones were placed in a pile above Burial 53 (see Fig. 17).

The total of 336 burned bone fragments, weighing 527 grams, were recovered from Burial 54a. There were 32 cranial and 304 post-cranial bones exhibiting similar colours: from blue, dark grey to white and black. However, some bones were also reddish in colour, not caused by the fire, but possibly due to the treatment by ochre. Fragments of calotte, vertebrae and some long bone fragments have a thin layer of reddish dust and direct red pigmentation on the surface. A mandible condyle, part of the mandible body, and one premolar indicate that this cranial fragment belonged to an adult. Among the burned bones in Burial 54a, part of a scapula (glenoid cavity) was found. The left scapula of the individual in Burial 54 is missing this part of the bone, and the fragmented part of the glenoid cavity is probably the one found among burned bones in the cremation pit of Burial 54a. In the cremation pit infill, an unburned flint, an unmodified third phalanx of a red deer, and a burned bone projectile were found.

On the edge of cremation pit of 54a, there was a right pelvis of another adult (male), over the age of 30 (Fig. 18). One of the fragments missing from the pelvis was found inside the pit, partly burned. After a close examination of the content of Burial 54a and comparisons with surrounding skeletal inhumations, we conclude that the bones of two different individuals can be identified. One of these individuals could be connected to the disturbed bones found in the secondary position and labelled Burial 54. This assumption is likely on the basis of the close spatial connection between these two burials and the bone fragments that can be conjoined. The other individual is identified by the presence of burned bone fragments and parts of the unburned pelvis, but to no other

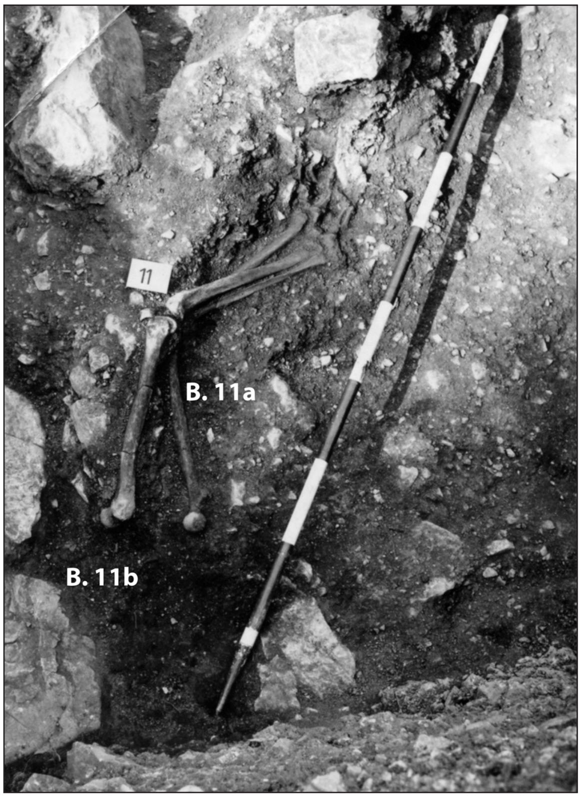


Fig. 26. Partly preserved skeletal inhumation Burial 11a and cremation pit Burial 11b, which damaged the upper part of the body of individual 11a (photo: Centre for Archaeology, Faculty of Philosophy in Belgrade).

articulated or disarticulated skeleton in the vicinity can this additional pelvis be assigned, and we must assume that this individual was not preserved in any articulated primary position in this zone of the site.

Burial 54 is dated in the range of 7024 to 6394 calBC at 95 per cent confidence, or 6678 to 6454 calBC at 68 per cent confidence (after correcting for the freshwater reservoir effect), and the whole sequence could possibly be assigned to the mid-7th millennium calBC (*Borić et al. 2008*).

Burial 45a
A heap of cremated bones – labelled Burial 45a – was found just above the head of Burial 45 (Fig. 19); 45a also had a burned bone fragment in its infill along with 410 unmodified Cyprinidae teeth appliqués around the head of the deceased. Only the head, a clavicle, right humerus and some vertebrae of this individual were found in their primary articulation. Burned human bones along with burned Cyprinidae teeth appliqués were found in the pile defined as Burial 45a, next to the head of Burial 45 (*Srejović and Letica 1978.58*). Burned post-cranial fragments belong to long bones, and only two frag-

ments of ribs and one of a phalanx were present. Cranial fragments do not show any suture closures, and like the post-cranial fragments, the absence of any identifiable features prevents us from providing sex or age determinations. At this stage we could only speculate that some of the disturbed and missing bones of Burial 45 might have been burned and placed in this pile behind the deceased's head, while the presence of cranial fragments among these bones would indicate that the head of some other individual must also have been burned here. Burial 45 is dated in the range of 6654 to 6411 calBC at 95 per cent confidence, or 6591 to 6462 calBC at 68 per cent confidence (after correcting for the freshwater reservoir effect) (*Borić et al. 2008*).

Burial 55

Two burned bones were found, placed in virgin soil, in the burial fill of skeletal inhumation Burial 55 (*Srejović and Letica 1978.60*). One fragment is unidentifiable and less than 10mm long. The other is a calcified fragment of a long bone, 39mm long, probably part of a radius. These fragments might have come from Burials 45 and 45a – since the interment of Burial 55 considerably damaged Burial 45 (Fig. 17) – and possibly also the burned remains of Burial 45a. On the other hand, some of these burned bones might also have come from Burial 54a (see above), since the feet of Burial 55 were beneath this cremation pit, so the burned human remains in the fill of Burial 55 might have been intrusions from the later burial.

Burial 47a

Burial 47a exhibits a pattern that is almost identical to the one found in Burial 45a. Again a pile of burned bones marked as Burial 47a was found behind the head of skeletal inhumation Burial 47 (Fig. 20). This pile was 0.25m in diameter, and among traces of charcoal and ash, burned human bones as well as burned Cyprinidae appliqués were found. The assemblage contains highly fragmented and unidentifiable fragments of twenty-four cranial and 105 post-cranial long bones. While it is difficult to link the burned bones with the skeleton of Burial 47 – which consisted only of the head, vertebrae and pelvis – traces of ochre on one of the fragments of burned bones were detected. At the same time, the vertebrae of the skeleton of Burial 47 were also coloured with ochre (*Srejović and Letica 1978.59*).

Burials 50 and 50a

Burial 50a consists of a partially disturbed skeletal inhumation, with legs crossed at the ankles (*Srejović and Letica 1978.59–60*). In one of the previously unpublished photos of this burial, one notices that the right leg and the right arm had been disturbed, *i.e.* dislocated from their primary position, and that precisely in the location of this disturbance one can follow dark traces of burning (Fig. 21). This instance indicates that the disturbed bones of Burial 50a were probably burned, even including the bones of Burial 50, which was only partially preserved. Among the burned bones found in the fill of Burial 50a, 138 post-cranial fragments are from long bones only, with the longest bone fragment being 45mm long. One left metatarsal and tarsal, and one hand phalanx were found complete and unburned. Two fragments of a burned mandible and a calcified tooth were recovered, as well as one fragment of a cranial bone with observable suture. Although very fragmented and with no criteria for sex determination, all the bones are robust and it is possible to suggest, therefore, that they belonged to an adult. In the burial fill, one burned unmodified Cyprinidae tooth was found along with traces of ochre.

Fig. 27. Burned and fragmented projectiles from Burial 11 (after* Borić 2002b.Appendix 6*).

In the case of Burial 50, the partly preserved leg bones found in articulation had traces of breakage. In the fill of Burial 50, 147 fragments of post-cranial burned bones show traces of intentional breakage. A distal fragment of a tibia can be refitted with a burned fragment from Burial 50 (Fig. 22). Although burned fragments are partly mixed and calcified with fragments of other bones, the dimensions and morphological resemblance of the burned tibia shaft and the unburned tibia from Burial 50 suggest that the skeleton of Burial 50 was partly burned here. Other burned bones, however, are highly fragmented, with the largest bone fragment being 52mm long, and cannot be used for sex or age determinations. Among the burned bones, besides fragments of long bones of lower extremities, one phalanx and a fragment of a radius were found. A fragment of an epiphysis shows a red pigmentation that could be from ochre. The legs of the skeletons in Burial 50a and 50b had traces of ochre, and Burial 50 was reportedly found in 'reddish soil' (*Srejović and Letica 1978.59–60*).

Burials 52, 51a and 50b had fewer than five burned bone fragments, and these could perhaps be interpreted as intrusions from disturbed contexts of burning now located in Burial 50a. One fragment from Burial 50b shows traces of ochre.

Burial 35

Burial 35 is in the area behind Dwelling 2 (*Srejović and Letica 1978.55*). It was in the vicinity of another fire installation marked as 'Fireplace 4'. In this circular pit (0.39 by 0.34 m), 32 cranial and 372 post-cranial fragments were recovered, exhibiting variations in colour due to different degrees of exposure to fire. Post-cranial skeletal material differs from the rest of the cremated bones from Vlasac since there are more calcified bones (white predominates), indicating exposure to higher temperatures or longer exposure to heat. The assemblage of bones consists of fragments of vertebrae, ribs, a left ulna, a pelvis, a scapula, metacarpals, metatarsals, a humerus, sacrum, right talus and left patella, and unidentifiable fragments of long bones. Such a composition indicates that different bone elements from both sides of the skeleton were burned. Cranial fragments show an uneven intensity of burning on the inner and outer sides of the skull, and even different intensities of burning on specific parts of the skull (Fig 23). Eleven fragments belonging to the occipital and parietal bones on the outer lamina are burned (black in colour), while their inner lamina is untouched by fire. One occipital fragment (57x56mm), with an external occipital protuberance, shows a fine borderline of burning on the outer lamina. Fragments of frontal bones, two maxillar and three mandibular fragments are completely burned (light brown, grey and blue) and even calcified (white). On those calcified frontal bone parts, the separation of external and internal laminae can be observed. Given the colours observed on the bone fragments, it is reasonable to suspect that part of the preserved (not broken) cranium with mandible was placed upside-down on the pile of post-cranial bones which were more consumed by fire. Thus, the lower temperature changed only the outer parts of skull bones.

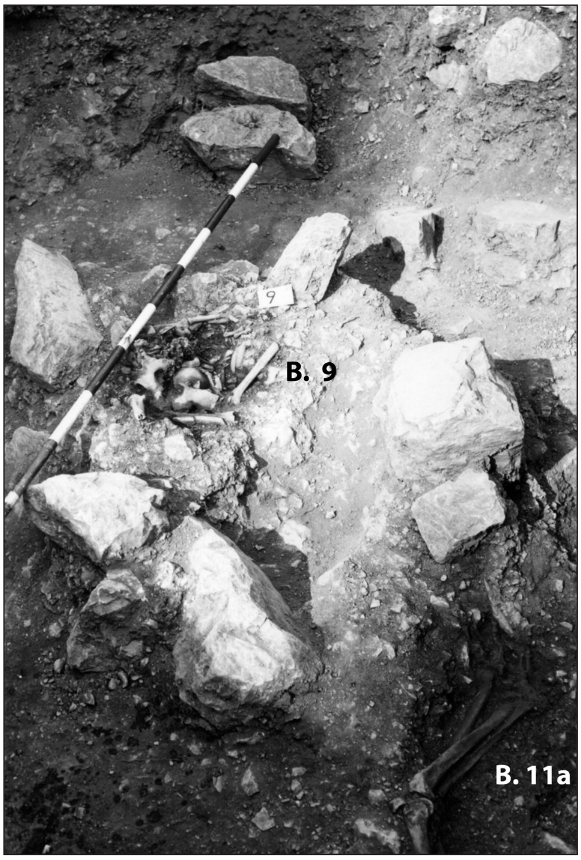


Fig. 28. Burial 9 in square 6/a: fragmented bones were placed in a pile encircled by several long bones and stones; Burial 11a in the foreground (photo: Centre for Archaeology, Faculty of Philosophy in Belgrade).

This cremation burial was found in the immediate proximity of Burial 36 (Fig. 24), which contained a pile of disarticulated broken bones over an area of 0.5 by 0.4m with a head being placed on top of this pile. It is possible to assume that some of the bones from secondary Burial 36 were burned in the pit of Burial 35, although due to their fragmentation, it was not possible to ascertain this connection.

Central sector

Burials 11b and 9 (square a/6)

Cremation Burial 11b (the diameter of the cremation pit was 0.7m, depth 0.4m, associated with lumps of ochre) is found in the central part of the Vlasac terrace, where the layer of sediments is rather thin, since it is located on the border of the rocky plateau (see *Borić et al. 2008.4–5, Fig. 2*). The thickness of sediments in this square, as well as the cross-section of this burial pit, are visible in the previously unpublished section above Burial 11b (Fig. 25). There are a number of skeletal inhumations of articulated and disarticulated burials in the vicinity: Burials 4a, 4b, 6, 6a, 5, 9, 10, 11a, 18a, 18b and 18c. One of the burials in this group, Burial 6, has been AMS dated in the range 6600 to 6235 calBC at 95 per cent confidence, or 6558 to 6266 calBC at 68 per cent confidence (after correcting for the freshwater reservoir effect). By analogy, the remainder of the burials in this location could also be dated to this general chronological framework (*Borić et al. 2008*).

Next to the cremation zone of Burial 11b, partly articulated Burial 11a was found. In fact, the cremation pit of Burial 11b damaged the upper part of Burial 11a, of which only the lower limbs were preserved (Fig. 26). Due to the general morphological resemblance of cranial fragments and those of upper limbs present in Burial 11b, with the preserved lower limbs of Burial 11a, we can suggest that the bones of Burial 11a were burned inside the cremation pit of Burial 11b (similarly to previously described contexts from Trench 3/2006: Burial context H136, which was cut by a cremation pit context 115 or H60, see above). Besides the legs of Burial 11a, fragments of burned projectiles were found (*Borić 2002b.Appendix 6; Srejović and Letica 1978.69*), as well as some other discarded artefacts, among which was one unburned broken tool made from wild boar tusk. It is not unlikely that the burned projectiles (Fig. 27) were actually burned in the cremation pit of Burial 11b. The practice of burning projectile points has been attested in several other cremation burials at Vlasac.

In the context of cremation burials, it is of interest to mention Burial 9, found in the same quadrant as Burials 11a–b. Burial 9 was found in a natural rocky depression, encircled by larger stone blocks (Fig. 28). The excavators suggest that the spinal column of this individual had been twisted so that the pelvis rested on the skull. In Fig. 28 one can notice the disarticulation of this skeleton, with the longer bones encircling those that were intentionally fragmented and placed in the middle of this pile. We have suggested already that once the bones were taken out of their

Fig. 29. High fragmentation of bones found on a pile labelled as Burial 9.

primary inhumations, they were frequently deliberately fragmented and placed in a pile before being burned. Thus, burial 9 can be considered as an example of such preparation of defleshed (dry) bones, either for burning or simply for burial in a fragmented state (Fig. 29). In this case, parts of long bones were heavily fragmented, never burned, but buried on the pile alongside some of the remaining complete long bones of this individual. This case, like the previously described Burial 36, may also indicate ways of preparing bones for cremation.

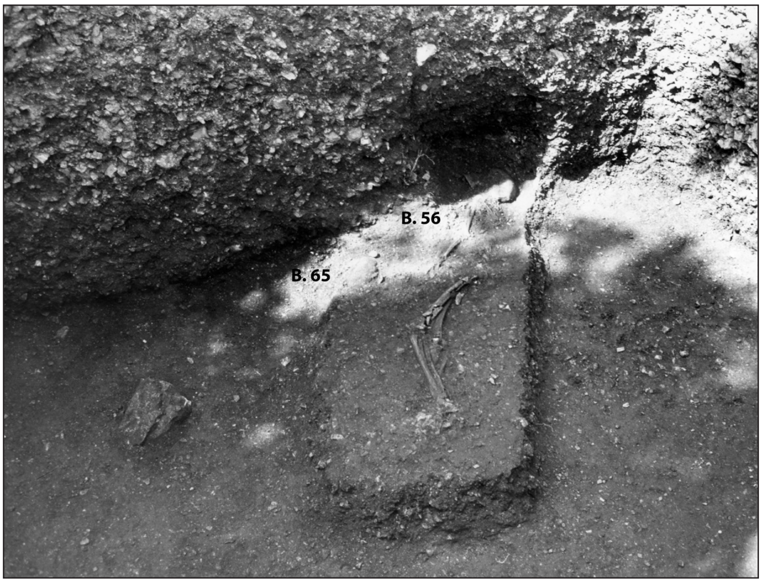


Fig. 30. Burial 56 and cremation zone Burial 65 next to section e4–e5 (photo: Centre for Archaeology, Faculty of Philosophy in Belgrade).

Burial 58a (square b/9)

Burial 58a (0.62 by 0.4m of dark burning) comprises another concentration of cremated bones found beside partly preserved skeletal inhumation Burial 58. Burial 58 had its legs preserved, in articulation beneath the knees and crossed at the ankles (similar to Burial 50a, see Fig. 21), while only the left femur was preserved, and was extended into section b8–c8, such that the rest of the potentially preserved body remained unexcavated. Beside the right femur of Burial 58, cremated Burial 58a was found, suggesting that some of the bones of Burial 58 might have been burned here. In addition, the skeletal remains of a neonate, Burial 58b, were found next to the right side of Burial 58 in the proximity of Burial 58a (*Srejović and Letica 1978.64, Fig. 93*). These burials were found approximately at the same level (64.83m), with neighbouring Hearth 20 (at 64.81m asl), which was overlapped by Hearth 16. Such a position may indicate that these burials were placed at the rear of a possible dwelling structure, of which these hearths were part, upon the dwelling's abandonment. A bone and charcoal samples from the layer between the two hearths have provided overlapping ranges: 6638 to 6479 and 6634 to 6474 calBC at 95 per cent confidence, respectively (*Borić et al. 2008.15–16*). Burial 58a contains very fragmented calcified cranial and post-cranial bones. Among nineteen fragments of cranial bones, two were recognised as temporal, two as occipital and two are unidentifiable fragments with observable sutures and visible traces of sutura metopica. These characteristics, along with the presence of one fragment of the inner part of a mandible, with open sockets but no teeth or roots present, indicate the presence of an adult. All the cranial fragments differ in size, with the longest fragment being 41.6mm long. Among 153 post-cranial bone fragments, apart from one unburned phalanx, two fragments of ribs and two pelvic fragments (non-indicative for sex or age determinations), all other fragments come from long bones. The longest fragment is 50mm long. These fragments can not be reliably connected with the skeletal remains of disturbed Burial 58 or 58b.

Burials 65 and 68 (square d/5)

Burials 65 (circular surface 0.25m in diameter) and 68 (0.9 by 0.4 m) had smaller amounts of the calcified burned bones of two adult individuals found in the vicinity of Burial 56 (*Srejović and Letica 1978. 61*). We have already indicated that there was an error in the labelling of the disarticulated bones marked in the source publication as Burial 65 and the burned bones marked as Burial 65a, since on the original labels of this material in the collection we examined, these burials are inversely marked. Here, we are being true to the original labelling of the material and hence use label 'Burial 65' for the cremation and 'Burial 65a' for the unburned skeletal parts, thereby differing from the source publication. In a previously unpublished photo of Burial 56, on the right, next to section e4–e5 where Burial 65a was found, one notices a surface with dark burning that can be related to the *in situ* burning of Burial 65 (Fig. 30). Due to the high fragmentation of burned bones, it is not possible to draw any firm conclusions about where these burned bones might have originated, but it is very likely that they could be connected to the disarticulated bones of Burial 65a found in their immediate vicinity. Burial 68, on the other hand, cannot be easily connected with any partially articulated skeleton in its immediate vicinity. These features were found in the vicinity and beneath the level of neighbouring stone construction VII and Hearth 21 (see Fig. 2).

Burial 67

One fragment of burned human bone was found in skeletal inhumation Burial 67 (square c/9) (Appendix 1). It is likely that this fragment was accidentally deposited in the burial by the re-deposition of soil that contained burned bones in the vicinity of this burial.

Burial 85 and Dwelling 1 (Eastern sector)

Burial 85 (ellipsoidal, 0.75 by 0.4 by 0.25m) was not found in the preserved collection of osteological remains from the 1970–1971 excavations of Vlasac. As previously mentioned when discussing Burial 86, found beside Dwelling 2, after the examination and review of the numerous contextual instances related to the cremation burials at Vlasac, Burial 85 is also probably not a fireplace of Dwelling 1. It should rather be interpreted as yet another cremation pit that might have been cut after the construction and use of Dwelling 1. However, one should notice that the excavators mention a lot of charcoal, ash, fish bones, fragments of a human skull, and other calcified bones associated with this feature (*Srejović and Letica 1978.18*). Since these bones were not preserved, it is impossible to comment on the fact noted in the source publication that these remains represent a 3–5-year-old child (*Srejović and Letica 1978.57*). Two dates obtained on animal bones found on the floor of Dwelling 1 give ranges of 7163 to 6818 and 7042 to 6699 calBC at 95 per cent confidence respectively (*Borić et al. 2008.12–14, Fig. 14*).

Summary for 1970–1971 cremation burials at Vlasac

The absence of cranial sutures, epiphyses and, in most cases, dental material, reduced the possibility for exact age estimations. An exception to this pattern was Burial 54a, with two male individuals identified on the basis of their pelvic bones. In the source publication of Vlasac, the authors state: "*...cremated remains always have the opposite sex from the skeletal inhumations beside which they were found*" (*Srejović and Letica 1978.76*). However, diagnostic criteria for the determination of sex were often lacking in the examined assemblage of cremated bones. Hence, only the robustness of the preserved bones could be taken as an indicator. However, this is further complicated by the shrinkage of bones, since the exposure to temperatures affects bones, causing them to lose from 15 to 30 per cent of their mass and thus to become smaller (*Mays 1998.215*). In this light, we must reject the suggested patterning of opposite sex regarding cremated remains and the skeletal inhumations where these cremations were found.

Unlike the previously described 2006–2007 cremation 'burials', in the examples from 1970–1971, cremations were not superposed by skeletal inhumations. However, there are obvious similarities in the practice of partially or completely disarticulating older burials through secondary mortuary rites and the subsequent *in situ* burning of such disarticulated bones. The practice of intentionally fragmenting the disarticulated bones of older burials seems to have occurred prior to their burning, as in the case of the unburned but intentionally piled and fragmented bones of Burials 9 and 36 in the vicinity of which other burned burials were found – Burials 11b and 35 respectively (see above). Charcoal, dark layers of soil and ash were present in most of the cremations. The ritualistic nature of burning human bones might be the main reason for performing this practice near skeletal inhumations. There are also two examples of ellipsoidal cremation pits with burned remains la-

Fig. 31. Burned cranial and postcranial fragments of Burial 81 from Lepenski Vir.

belled as Burials 85 and 86, previously interpreted as Fireplaces 1 and 2 and associated with Dwellings 1 and 2, respectively, in each case found along the dwelling's longer, western sides. We suggest that these features were not fireplaces related to the day-to-day use of these spaces, but more probably cremation pits similar in nature to those found in association with skeletal inhumations as described in a number of instances in this paper. However, one should be cautious in this respect and allow for the possibility that, although similar in form and content to other cremation pits, the association of these features with the two dwellings might have signified a slightly different kind of secondary mortuary ritual from other described instances. Moreover, among the described instances of secondary mortuary practices involving the intentional cremation of human bones, one could suggest several different types of mortuary and/or ritualistic behaviours. Such a variety of practices – underlined by a very similar material signature – may indicate individual choices made in adjusting an existing burial and or ritual custom to momentary circumstances and needs. On the basis of the existing radiometric evidence, this type of mortuary/ritualistic practice characterised the Late Mesolithic at Vlasac in the course of the 7th millennium calBC.

Comparative examples and possible meanings

The closest comparative examples for cremations from Vlasac are from neighbouring Lepenski Vir. A number of burials had occasional fragments (no more than four small fragments per burial) of burned bones in the burial fill (Burials 32a, 45a, 54d, 87 and 93). However, there is only one example, Burial 81, which contains a burned mandible and several cranial and post-cranial bones, which might be evidence of a possible *in situ* burning of human bones similar to the described instances from Vlasac (Fig. 31).

In the course of the early prehistory of Eurasia, cremation burials were occasionally reported from sites found from the Near East to western Europe and Scandinavia. The earliest known cremations come from Natufian culture contexts in the Levant. In the back of Kebara Cave, the remains of twenty-three cremated individuals were excavated by Turville-Pitre in 1931 (*Bar-Yosef and Sillen 1993.205–208*). The examined material demonstrates a high state of fragmentation, but as the authors point out, the burning of the bones was preceded by their desiccation and fragmentation. The authors suggest that the burning temperature might have been between 200 and 600°C (*Bar-Yosef and Sillen 1993.207*). Also in the context of the Natufian culture, at Wadi Hammeh 27, in Jordan, sixteen burned human cranial fragments were found scattered among the refuse of Structures 1 and 2 (*Webb and Edwards 2002.117*). At this site, a single, semi-flexed burial was found on top of what turned to be a collective burial containing five other individuals. This last burial in the sequence, Homo 1, was laid over an oval pit containing burned sediments, while limestone plates had been deliberately placed on the deceased's thorax. Five individuals found in a small pit beneath Homo 1 were the remains of secondary burials. One of these, Homo 3, had a necklace with 27 Dentalium shell fragments under the mandible, and traces of ochre on the bones (*Webb and Edwards 2002.109*).

The most relevant comparative example in the wider region of the Balkans for the cremations found in the Danube Gorges is the Lower to the Upper/Final Mesolithic sequence at Franchthi Cave in Greece (*Cullen 1995.277–278; Jacobsen and Cullen 1981*). The total of the examined human remains from Franchthi indicate between 15 and 34 individuals for Mesolithic levels, represented by both fully articulated burials, as well as many human bone scatters. A Mesolithic primary inhumation of a male, Fr 1, was found above a group burial location containing five inhumations (Fr 2–6) and two cremations of young adults (Fr 7 and Fr 8) in Trench G1, near the present entrance to the cave, next to the cave wall. The male individual, Fr 1, was buried in a shallow pit with an ashy deposit, in a semi-contracted position, with the pelvis and chest covered by stones (*Cullen 1995.275*). Below Fr 1, five inhumations (Fr 2–6) were found, having probably been placed in semi-contracted positions. They were found in a reddish sediment with shells, animal bones, and associated with a hearth (*Cullen 1995.276*). Radiometric dates (P–2096: 8710±100 BP; P–2106: 8730±90 BP; P–2107: 8530±90 BP) from the wood charcoal at this level indicate a period between *c.* 8000–7600 calBC. However, due to the problem of 'old wood' and the uncertain association of charcoal and burials, it is possible that the burials are somewhat younger than this date. Among these remains, two individuals, a male and female (Fr 7 and Fr 8), were recognised as deliberately cremated at high temperatures (400–1100°C). Cullen and King suggest that the bones were burned while still articulated and with the bones still covered with flesh (*Cullen 1995.277*). Cullen points out that the cremations at Franchthi yielded a small percentage of cremated bones, but

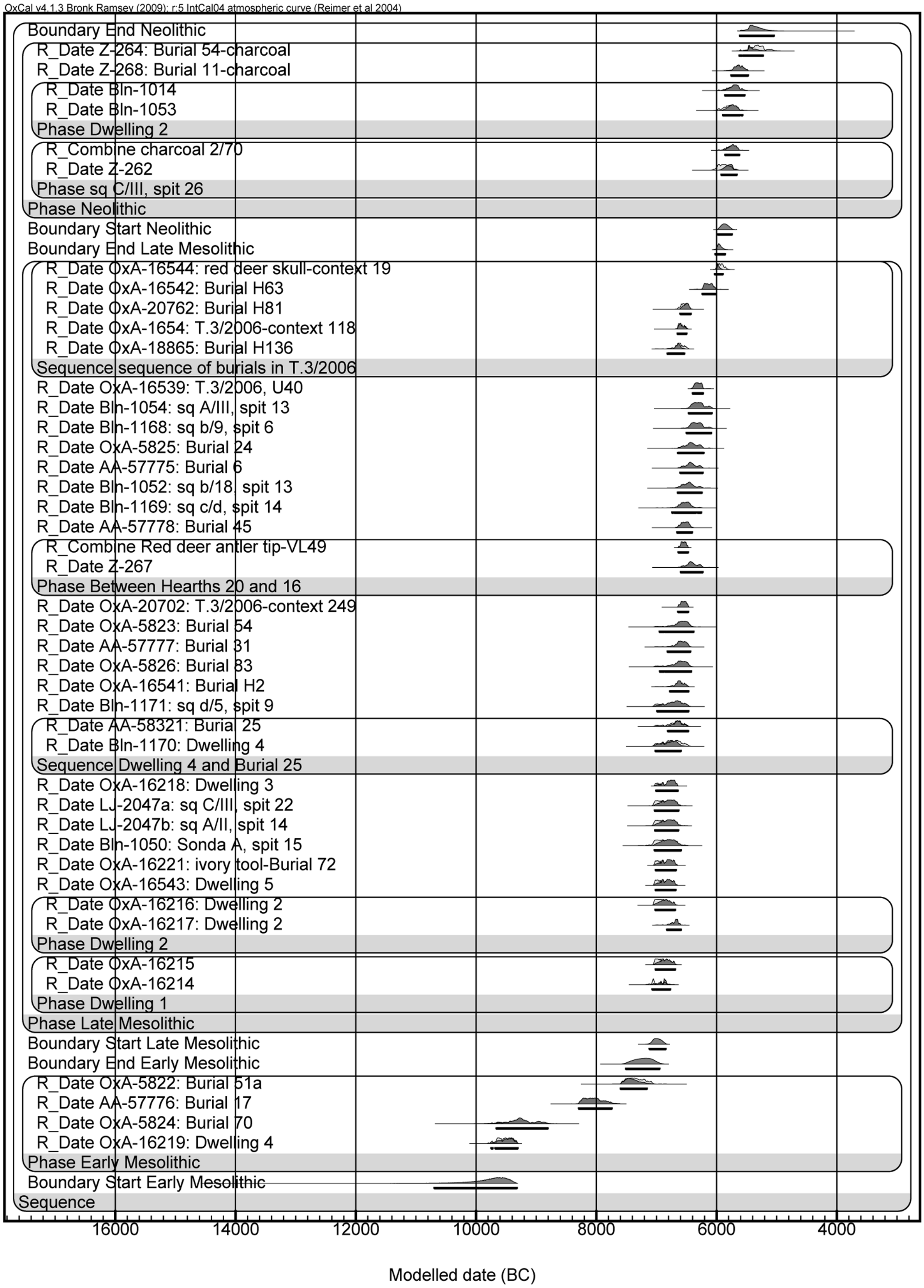


Fig. 32. Probability distributions of dates from Vlasac. The outline distributions show the likelihoods derived only from the calibration of dates. The solid distributions show results when stratigraphic constraints are imposed. The bars under distributions show the 68.2 and 95.4 per cent ranges from the analysis (see Appendix 2 for details). Dates were calibrated using OxCal v. 4.0.5 (**Bronk Ramsey 1995; 2001*****) and modelled within the Bayesian statistical framework (*****cf. Bayliss et al. 2007; Buck et al. 1996*****).***

that very small fragments might have been lost through excavations or even flotation of the sediment. Hence it is suggested that possibly whole bodies might have been cremated in these instances (*Cullen 1995.278*). Besides cremations and inhumations, scattered human bones were found in the Mesolithic levels of the cave. Apart from the presence of cremations, one aspect that further connects the Mesolithic sequence at Franchthi with previously described examples from the Danube Gorges, and also with some other contemporaneous sites across the Balkans, is the type of ornament found in the burials. In one of the Upper Mesolithic units at Franchthi, 67 *Cyclope neritea* and Dentalium beads accompany an infant and a 3–6-year-old child (*Cullen 1995. 277*). Probably as the type of personal adornment favoured in the Mesolithic, *Cyclope neritea* and Dentalium beads were also found with individuals Fr 1–8. These species were in use at Franchthi until the end of the Mesolithic period, when they were replaced by *Cerithium vulgatum* (*Cullen 1995.282*).

Two Mesolithic sites in northern Europe, Pomorsko 1 and Wieliszew VII, yielded several cremated remains (*Sulgostowska 2006.193–203*). At Pomorsko in western Poland, the remains of a child and some additional burned fragments were recovered, while at Wieliszew in north-eastern Poland, only a single male individual was cremated. Discussing Mesolithic mobility in this regional context, it was suggested that cremations might have been practiced during seasonal expeditions, and that easier transportation of the deceased over long distances might have been facilitated in this way (*Sulgostowska 2006.197*).

Nicolas Cauwe (*2001.147–163*) mentions cremated human remains from the Early Mesolithic site of Abri des Autores in southern Belgium. In this rockshelter, a collective tomb consisting of five adults was found. Underneath this group burial, the remains of six children were found, alongside the cremated bones of an adult. All of the deceased, including the secondary burial of the cremated individual, had undergone a selection and manipulation of skeletal remains. Fragments or whole bones were removed from and moved within the tomb, suggesting the making of complex links between the deceased and the living (*2001.157*).

The burned human bones of an individual, aged 10–13, buried next to and also within the pit where the cremation took place were found at the Middle Mesolithic settlement of Oirschot V, the Netherlands (*Arst and Hoogland 1987.172–189*). Also, at the Late Mesolithic site of Dalfsen, only a small amount of human calcinated bones were excavated from pits containing domestic refuse (*Smits and van der Plicht 2009.55–85*). In Vedbaek Fjord, in eastern Denmark, one deposit at Gøngehusvej 7 revealed the remains of five cremated bodies; this has been interpreted as a collective burial during an annual gathering, since the deceased were in different stages of decay by the time of cremation (*Fowler 2004.134*).

In southern Sweden, burned human bones were found at the Late Mesolithic site of Skateholm I (Graves 11 and 20) as well as at Skateholm II (Grave XVIII) (*Fahlander 2008.29–45; Nilsson Stutz 2003. 327–328*). Of the total of 87 excavated burials from both sites, damage inflicted upon older burials, possibly including secondary mortuary practices, is described for Burials 4, 7, 13 and 28. In addition, in the case of Grave 13, arrowheads pointing towards the deceased were found in the burial fill. This instance has been interpreted as an act of aggression directed at the dead individual (*Fahlander 2008. 38*).

Conclusions

Considering the combined data from old excavations with data from new excavations in Vlasac, it appears that cremations were elements of secondary mortuary rites, very often directly related to the interment of the newly deceased. The burning of the bones rarely involved just one deceased. At Vlasac, contexts in which burned bones are found demonstrate direct exposure to fire and intentional burning. Burials from the new excavations, but also reanalyses of instances from the 1970–1971 excavations, suggest that the majority of burned bones are found burned *in situ*, near the complete or partly preserved skeletal inhumations. Only small concentrations of burned bones were found scattered with no traces of burning *in situ*. On the basis of the current radiometric dating evidence for a number of contexts associated with cremation burials (see Fig. 32 and Appendix 2), we must reject previous conclusions that cremation practices were restricted to the so-called 'early phase' burials at Vlasac (*Radovanović 1996.218*), or phase I as defined by Srejović and Letica (*1978*). Our current evidence suggests that the practice was prominent throughout the 7th millennium BC (*Borić et al. 2008*; see Appendix 2).

There are some remaining questions: how and why did the community at Vlasac make choices with regard to what part of the body of the deceased to burn or which individual would undergo such a cremation process? Although whole skeletons might have sometimes been cremated, it seems that in a number of instances where one finds a clear association of a cremation with a particular disturbed skeleton, it was the torso and head that were more frequently disarticulated and burned than the lower limbs or, at least, all parts of lower limbs (*e.g.* Burials H136, H244, H81, 11b). Burial 50a may be a possible exception to this pattern. There are no elements to suggest that either the sex or age of the deceased played an important role in decisions about which individuals should be exhumed, disarticulated and burned, since individuals of both sexes and all ages, including older juveniles, were chosen. Perhaps only neonates did not undergo this process, but the patterning here may be skewed due to the issue of the preservation of neonate bones in cremations, or because the small number of neonate bones were not considered sufficient for such secondary mortuary practices of burning.

We could ask whether such particular choices mattered at all. For instance, the chronological sequence of overlapped cremations found in the course of new excavations at the site may be suggestive of a long period between particular burials (see Fig. 32). Here, the issue of people's memory of particular individuals buried at a particular location becomes important. For instance, can we expect that people would remember a particular individual and would dig into an old burial due to their continuing social contact with the deceased (her/his character, remembered biography, virtues and/or vices), or does the deceased become a rather anonymous person from the past who, through such acts of disarticulation and burning, are transformed into even more anonymous entities (*e.g.* spirits, ghosts, enemies, etc.), and their disarticulation and possibly also their burning triggering a 'happy forgetting' (*cf. Borić in press*)?

One could speculate that purification before the newly deceased was interred was a reason to burn human bones. This could be an explanation for instances recorded in 2006–2007 in Trench 3/2006, when skeletal inhumations were often found placed on top of cremation pits that disturbed and burned bones of older burials. However, in Trench 3/2007 in relation to F22, we recorded an instance in which a skeletal inhumation Burial H244 had been disturbed by digging into its upper torso and by removing and burning the deceased's bones, which were probably placed in nearby pit F23, behind the head of the deceased. The pit contained burned bones and burned *Cyclope neritea* appliqués. Hence, disturbing older burials and the burning of bones in the latter case suggests a different type of motivation from those instances where a newly deceased was interred over a cremation. What, then, could be a reason for the partial or complete disturbance and disarticulation of older burials, or for creating patches of small surfaces with burned human remains left beside skeletal inhumations (*e.g.* Burials 47 and 45a), as evidenced in most of the instances from the 1970–1971 excavations at Vlasac? One could suggest two different speculative positions, which are not mutually exclusive. First, as the simplest interpretive solution, the burning of older, probably already defleshed burials (sometimes only parts of older skeletons) or of intentionally fragmented heaps of bones of one or several individuals in the vicinity of new burials might have related to the ritual practice of purifying a place needing preparation for a newly deceased individual, since many burials were not interred in virgin soil, but in places where there had already been a number of other interments. The issue of ritual purity in the choice of the resting place of the deceased in this case might have been paramount, if one assumes that the burial ground was considered 'polluted' by the remains of previous burials.

The second position would go a step further in speculative interpretation. We could assume that such acts of disarticulation and burning were intended to restrict the remaining powers of defleshed, but still articulated bodies, which might have been understood as dangerous and still possessing voluntariness. There are other elements of mortuary practices at Vlasac that suggest the placing of restrictions on the physical capacities of the deceased: possibly by tying (especially the legs) or wrapping bodies prior to burial, or the placing of large rocks on the knees of the deceased (*Borić 2006; Srejović and Letica 1978.passim; cf. Roksandić 2001* for the site of Padina), as if such acts were meant to restrict the possible resurrection and movement of the dead. In a world in which the dead might have been understood as changing the terms of their alliance and affinities with the living community over the passage of time since their death, as many ethnographic instances indicate (*e.g. Taylor 1993; Vilaça 1992; 2000*), it might have been important to assure the intentional forgetting of the dead and the restriction of their powers through specific ritualistic practices, which involved, first, the disarticulation of bones, and, second, their fragmentation and thorough destruction through burning. If one accepts such an interpretive framework, one could explain why in certain instances the damage was done to a particular burial by disarticulating and partly fragmenting the bones of some of the deceased even without burning them (*e.g.* Burials 9 and 36), or in those instances where the disarticulation procedure was followed by burning, with no obvious association of burning with the interment of a newly deceased (*e.g.* Burials H244/F. 22, 11, etc.). In addition, while the presence of broken and burned projectile points in a number of cremation pits might have been related to primary grave goods of articulated burials that were eventually disarticulated and cremated and thus commingled with human bones, it is also possible that bone projectiles were intentionally placed in secondary mortuary contexts, perhaps supporting the offered interpretation of a 'predatory' move against the dead. However, should we assume, by the same token, that if some of the older dead turned into dangerous, hostile spirits that required mastery, and the exercise of the force of disarticulation and burning of their physical remains, that those left untouched in their primary articulations were the 'unproblematic' dead? Moreover, why were only parts of their physical presence damaged and subsequently left in particular, formally designated cremation contexts next to articulated burials? Finally, who was being protected by these practices of burning – the living or the newly deceased placed buried with older burials?

It is exceptional that the clearest examples of the described secondary mortuary practices, which involved the burning of old burials, are seen at the site of Vlasac and not at other contemporaneous sites in the Danube Gorges. Some elements of the same mortuary ritual could perhaps be observed in currently unpublished mortuary evidence from Lepenski Vir, but perhaps also in instances of burning found at the site of Hajdučka Vodenica in the Lower Gorge of the Danube (*Jovanović 1984*). It is possible that the communities inhabiting each of these sites, although sharing general attributes of the material culture and worldview characteristic of the period, also had their particular ways of going about their everyday business, which also involved specific burial customs, rituals and beliefs. A fascinating point remains, however, in that the form of these practices, if not their 'original' meanings, remained unaltered throughout the 7th millennium calBC at Vlasac, surviving the great culture change that brought elements of the Neolithic world to the Danube Gorges' foragers.

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Appendix 1. Contexts with cremated bones from Vlasac.

Context	Context description	Area/ quadrant	Number of fragments	Weight (g)	Colour of burned bones	Associations
VLASAC 1970–1971 excavation campaigns						
B. 11b	Burned bones found in oval pit, 0.70m in diameter, 0.40m in depth; pit cut Burial 11a above lower limbs; surrounded by limestone blocks/large rocks.	a/6	193 Cranial: 14 Postcranial: 179	327 Cranial: 22 Postcranial: 305	Light blue and grey	5 burned animal bone fragments; charcoal
B. 35	Surface with burned bones 0.39 by 0.34m; beside the rear of Dwelling 2 and Fireplace 4.	b/18	464 Cranial: 92 Postcranial: 372	1110.9 Cranial: 220 Postcranial: 890.9	Black; light black and gray; partly burned bones	Unio sp.
B. 36	On the surface of 0.50 by 0.40m skull of Burial 36 was placed on a pile of smashed human bones among which also burned bones were found.	b/18	Postcranial: 3	Postcranial: 3.2	Grey	–
B. 45	Partly preserved skeletal inhumation	A/17	Postcranial: 1	Postcranial: 1.4	Light reddish-yellow	Cyprinidae teeth; ochre
B. 45a	Burned bones were discovered surrounded by limestone blocks on the surface of 0.30m in diameter; located behind the skull of Burial 45.	A/17	100 Cranial: 15 Postcranial: 85	227.5 Cranial: 32.2 Postcranial: 195.3	White; light blue and grey	410 burned Cyprinidae teeth
B. 47a	Burned bones located behind the skull of Burial 47; round surface (0.25m in diameter)	A/17	128 Cranial: 24 Postcranial: 104	111 Cranial: 30 Postcranial: 81	Light blue and grey; light red	Charcoal; ash; Cyprinidae teeth; 8 burned animal bone fragments
B. 50	Partly preserved skeletal inhumation	A/18	Postcranial: 147	Postcranial: 379	Light blue and grey	One unburned human tooth; 13 burned animal bone fragments
B. 50a	Partly preserved and damaged skeletal inhumation; Cyprinidae teeth and ochre underneath the skeleton.	A/18	145 Cranial: 7 Postcranial: 138	245 Cranial: 12 Postcranial: 233	White; light blue and grey	Cyprinidae teeth; 10 burned animal bone fragments; ochre
B. 50b	Partly preserved skeletal inhumation underneath Burial 50a with traces of ochre on feet.	A/18	Postcranial: 4	Postcranial: 13.4	White; blue; light reddish	Ochre
B. 51a	Disturbed and partly preserved skeletal inhumation	A/18	Postcranial: 2	Postcranial: 2.8	Grey	–
B. 52	Upper part of skeletal inhumation; Hearth 19 cut the lower limbs and pelvis of the deceased.	A/18	Postcranial: 1	Postcranial: 1.2	Black	–
B. 54a	Ellipsoidal pit (0.70 by 0.55 by 0.20m) with bones of two adult individuals; Burial 54 beside it found in secondary position and the other individual is identified by fragments of burned bones and unburned pelvis that was found at the edge of the pit	A/17	336 Cranial: 32 Postcranial: 304	527 Cranial: 66 Postcranial: 461	White; light blue and grey	Burned bone projectile; third phalanx of red deer; flint
B. 55	Skeletal inhumation with its feet beneath Burial 54a	A/17	Cranial: 2	Cranial: 5	Light reddish-yellow	–
B. 58a	Burned bones on the surface of 0.62 by 0.40m beside disturbed Burials 58 and 58b, above Hearth 23.	c/9	172 Cranial: 20 Postcranial: 152	280 Cranial: 48.2 Postcranial: 231.8	Black; light black and grey; light reddish-yellow	Charcoal

Appendix 1. Continued ...

Context	Context description	Area/ quadrant	Number of fragments	Weight (g)	Colour of burned bones	Associations
B. 65	Surface 0.25m in diameter with burned bones located beneath Dwelling VII and Hearth 21.	d/5	Postcranial: 14	Postcranial: 63.8	Black; light black and grey	–
B. 67	Skeletal inhumation beneath Hearth 23	c/9	Postcranial: 1	Postcranial: 0	Black	–
B. 68	Located beneath Dwelling VII and Hearth 21, surface with burned bones (0.90 by 0.40m).	d/5	Postcranial: 75	Postcranial: 80.8	Black; light black and grey	–
B. 86	Burned human bones found in Fireplace 2 (ellipsoidal pit 0.80 by 0.35m, 0.15m in depth).	a/18	539 Cranial: 75 Postcranial: 464	626 Cranial: 103 Postcranial: 523	Black; light black and grey; light red	One burned Cyprinidae teeth
VLASAC 2006–2007 excavation campaigns						
13	Fill over the stone construction on top of which Early-Middle Neolithic Starčevo pottery was found.	T. 3/2006	Cranial: 1	Cranial: 2.2	Light blue	Flint
19	Dark fill of Burial H21 and of the upper layer of the burial sequence (likely equivalent to contexts 24 and 44).	T. 3/2006	Cranial: 2	Cranial: 2.6	White	Flint; beads; pottery fragments; antler tool
24	Upper infill of burial sequence underneath large blocks covering child skull H21 and red deer skull (likely equivalent to contexts 19 and 44).	T. 3/2006	Cranial: 2	Cranial: 9.6 + 4 from sieve	Black	Burned and unburned human bones; flint; Cyprinidae teeth; fragment of deer jaw
29	Layer covering the structured deposition of red deer skull	T. 3/2006	Postcranial: 2	Postcranial: 6.2	White	Burned and unburned human bones; antler beam fragment; flint; flint in red deer skull
44	Context 44 is fill of dark soil in the upper layer of the burial sequence (likely equal to contexts 19 and 24).	T. 3/2006	47 Cranial: 6 Postcranial: 41	850.2 Cranial: 30 Postcranial: 50.2 + 72 from flotation	Black; light black and gray; light reddish-yellow	Spondylus; limestone beads
50	Fill of Burial H53	T. 3/2006	Postcranial: 113	Postcranial: 110.4	White; black; light blue	Limestone beads
51	Layer of fill of F2 covering the surface south from burial Feature 3 and enclosed by context 65.	T. 3/2006	Postcranial: 83	Postcranial: 37.5	White; black; light blue	Cyprinidae teeth; burned animal bone; yellow mineral
54	Layer of soil beneath the fill of Feature 2	T. 3/2006	Postcranial: 34	Postcranial: 14.1	White; black; light blue	Pebble
55	Layer of soil beneath the fill of Feature 2	T. 3/2006	Postcranial: 211	Postcranial: 71.6	White; black; light blue	–
59	Layer beneath Burial H53	T. 3/2006	Postcranial: 54	Postcranial: 20.4 + 124.8 from flotation	White; black; light blue	Cyprinidae teeth and beads disturbed from Burial H63
B. H60	Partly cremated juvenile (14–16 years) placed over individual H63	T. 3/2006	919 Cranial: 196 Postcranial: 723	1173 + 447.8 from flotation Cranial: 425 Postcranial: 748	Black; light black and grey; partly burned bones	Limestone beads; Spondylus bead; perforated Cyprinidae teeth

Context	Context description	Area/ quadrant	Number of fragments	Weight (g)	Colour of burned bones	Associations
64	Layer above legs of H63 and beneath Burial H53; containing burned human bones.	T. 3/2006	38 Cranial: 5 Postcranial: 33	6.8 Cranial: 2 Postcranial: 4.8	White; black	Cyprinidae teeth; carnivore canine; burned rock; flint
87	Layer between the northern boundary of Burial H63 and the edge of the eroded riverbank north-facing profile	T. 3/2006	Postcranial: 8	Postcranial: 5.4	Black	Perforated Cyprinidae teeth
97	Fill with burned bones visible on the eroded north-facing profile	T. 3/2006	Postcranial: 3	Postcranial: 1.8	White; light blue	–
109	Ashy soil beneath layers of dark soil labeled as contexts 54 and 55	T. 3/2006	Postcranial: 5	Postcranial: 1.4	White	Ash; limestone; fish bones
110	Layer of olive-brown soil beneath Burial H81	T. 3/2006	Postcranial: 55	Postcranial: 53.2	White; black; light blue	Flint
111	Layer connected to Feature 2	T. 3/2006	Postcranial: 2	Postcranial: 1	White	Cyprinidae teeth; fish bones; bird bone
115	Fill with burned bones	T. 3/2006	1052 Cranial: 66 Postcranial: 986	769 Cranial: 83 Postcranial: 686	White; black; light black and grey	Fragments of human unburned fibula; antler tool; animal phalanx; cut Cyprinidae teeth; flint; burned rock; burned bone projectile
118	Layer of compact brown soil; bottom of Feature 2	T. 3/2006	115 Cranial: 4 Postcranial: 111	47.2 Cranial: 6 Postcranial: 41.2	White; black; light black and grey	Bone projectile; fish bones; quartz; flint
132	Layer of soil next to the eroded north-facing profile; dark soil	T. 3/2006	34 Cranial: 4 Postcranial: 30	16.6 Cranial: 3 Postcranial: 13.6	Black; white	–
137	Sediment of burned wood beneath context 118, possibly part of context 115	T. 3/2006	Postcranial: 33	Postcranial: 12.7	Black	Burned wood; two burned rocks
138	Brown-greyish soil just under and around the rocks found in context 115	T. 3/2006	Postcranial: 19	Postcranial: 18.3	White; black	Flint
142	Layer of light brown yellowish soil which is part of the fill surrounding Burial H136	T. 3/2006	Postcranial: 13	Postcranial: 6.4	White; black; light blue	Fragments of red deer antler; quartz; lime-stone; red rock
144	Layer with charcoal beneath context 142	T. 3/2006	11 Cranial: 1 Postcranial: 10	9 Cranial: 3 Postcranial: 6.4	Black; light black and grey	Cyprinidae teeth; burned animal phalanx; one carnivore canine
146	Fill with burned bones visible on the eroded north-facing riverbank profile	T. 3/2006	40 + 13 unburned frag. Cranial: 7 Postcranial: 33	22.4 + 77.2 from sieve Cranial: 4.8 Postcranial: 17.6	Black	two fish bones; burned clay soil

Appendix 1. Continued ...

Context	Context description	Area/ quadrant	Number of fragments	Weight (g)	Colour of burned bones	Associations
147	Layer associated with stone plaque within context 145 (yellow largely sterile soil above dwelling floor context 149)	T. 3/2006	296 Cranial: 9 Postcranial: 287	84.2 Cranial: 7.2 Postcranial: 77	White; black; light black and grey	–
230	Feature 21; fill of Burial H232	T. 3/2006	Cranial: 8	Cranial: 21.4	Black	Cyprinidae teeth
237	Feature 20; fill of pit context 241 containing disarticulated bones of dog and red deer and stone	T. 3/2007	Cranial (?): 1	Cranial (?): 1.8	White; blue	Fragments of dog and red deer bones
242	Greyish fill of a pit (Feature 23); in the vicinity of burial Feature 22	T. 3/2007	236 Cranial: 6 Postcranial: 230	64.4 Cranial: 14.2 Postcranial: 50.2	White; black; light black	Worked bone; marine shell; Cyprinidae tooth; stone
B. H244	Skeleton in Feature 22 with the damaged torso; skeletal inhumation within fill 235 and cut 263	T. 3/2007	Postcranial: 12	Postcranial: 59.6	Black	–
249	Part of Feature 26; charcoal-rich fill containing burned human bones	T. 3/2006	221 Cranial: 60 Postcranial: 161	465 + 847.4 from sieve and 47.8 from flotation Cranial: 162 Postcranial: 303	White; black; light black and grey	Charcoal; fish bones; burned bone projectile
251	Part of Feature 26; trampled layer beneath Burial H232 (Feature 21)	T. 3/2006	Postcranial: 1	Postcranial: 1	White; light blue	Charcoal
253	Part of Feature 25; fill of a skeletal inhumation visible in the riverbank section in T. 3/2007 with skeleton H254	T. 3/2007	Postcranial: 42	Postcranial: 7.6	White; blue	Cyprinidae teeth; worked bone; red stone; flint
256	Artificial spit within quadrants 73/101 and 74/101 containing mixed material from burial Feature 25 and surrounding sediment context 257	T. 3/2007	Postcranial: 46	Postcranial: 7.8	White; blue	–
260	Part of Feature 26; lower layer of burned deposit within the cremation pit	T. 3/2006	299 Cranial: 21 Postcranial: 278	133 Cranial: 26 Postcranial: 107	White; black; light black and grey	Burned bone projectiles
261	Brown grey gravelly silt fill found above dark grey material with burned bones (context 242)	T. 3/2007	232 Cranial: 5 Postcranial: 227	94 Cranial: 4.6 Postcranial: 89.4	White; black; light black and grey	–
262	Layer of apparently sterile gravelly silt; small amount of finds from sieving sediment from quadrant 73/101 probably represent material from context 261 in front of pit context 243	T. 3/2007	Postcranial: 6	Postcranial: 2	White; blue	–
273	Pale grey silt and very abundant limestone rubble on the riverbank section	T. 1/2007	Postcranial: 1	Postcranial: 1	White	–

Appendix 2. Modelled and unmodelled radiometric dates from Vlasac at 68 and 95 per cent confidence and probability. Dates were calibrated using OxCal v. 4.0.5 (*Bronk Ramsey 1995; 2001*) and modelled within the Bayesian statistical framework (*cf. Bayliss et al. 2007; Buck et al. 1996*). For the source of dates, see *Borić et al. 2008*; OxA–20702 (charred cornelian cherry stone from F 26) and OxA–20762 (H81) are published here for the first time.

Name	Unmodelled (BC/AD) from	to	%	from	to	%	Modelled (BC/AD) from	to	%	from	to	%	A	C
Boundary End Neolithic							–5480	–5240	68,2	–5610	–5050	95,4		98,3
Interval Duration Neolithic							350	640	68,2	200	870	95,4		99,7
R_Date Z–264: Burial 54–charcoal	–5470	–5210	68,2	–5490	–5060	95,4	–5490	–5330	68,2	–5620	–5230	95,4	83,6	99,5
R_Date Z–268: Burial 11–charcoal	–5720	–5550	68,2	–5770	–5480	95,4	–5720	–5560	68,2	–5760	–5480	95,4	101,6	99,8
R_Date Bln–1014	–5800	–5620	68,2	–5970	–5530	95,4	–5780	–5620	68,2	–5860	–5530	95,4	107,3	99,8
R_Date Bln–1053	–5870	–5660	68,2	–5990	–5610	95,4	–5810	–5650	68,2	–5890	–5570	95,4	108,8	99,7
Phase Dwelling 2														
R_Combine charcoal 2/70	–5810	–5660	68,2	–5890	–5620	95,4	–5790	–5660	68,2	–5860	–5620	95,4	106,2	99,8
R_Date Z–262	–5990	–5790	68,2	–6040	–5710	95,4	–5860	–5730	68,2	–5920	–5670	95,4	86,1	99,8
Phase sq C/III, spit 26														
Phase Neolithic														
Boundary Start Neolithic							–5930	–5800	68,2	–5980	–5750	95,4		99,8
Boundary End Late Mesolithic							–6000	–5920	68,2	–6020	–5860	95,4		99,9
Interval Duration Late Mesolithic							950	1120	68,2	870	1200	95,4		99,8
R_Date OxA–16544: red deer skull–context 19	–5990	–5890	68,2	–6010	–5830	95,4	–6010	–5950	68,2	–6030	–5900	95,4	89,5	99,9
R_Date OxA–16542: Burial H63	–6220	–6060	68,2	–6240	–6010	95,4	–6220	–6060	68,2	–6240	–6020	95,4	100,3	99,9
R_Date OxA–20762: Burial H81	–6590	–6460	68,2	–6640	–6430	95,4	–6560	–6450	68,2	–6600	–6430	95,4	106,1	99,9
R_Date OxA–1654: T.3/2006–context 118	–6650	–6530	68,2	–6660	–6480	95,4	–6640	–6530	68,2	–6650	–6500	95,4	103,8	100
R_Date OxA–18865: Burial H136	–6690	–6520	68,2	–6780	–6470	95,4	–6690	–6590	68,2	–6820	–6540	95,4	104,7	99,8
Sequence of burials in T.3/2006														
R_Date OxA–16539: T.3/2006, U40	–6370	–6240	68,2	–6400	–6220	95,4	–6370	–6240	68,2	–6400	–6220	95,4	99,9	99,9
R_Date Bln–1054: sq A/III, spit 13	–6420	–6220	68,2	–6470	–6080	95,4	–6420	–6220	68,2	–6470	–6080	95,4	100,1	99,8
R_Date Bln–1168: sq b/9, spit 6	–6430	–6240	68,2	–6500	–6090	95,4	–6430	–6240	68,2	–6500	–6090	95,4	99,9	99,8
R_Date OxA–5825: Burial 24	–6510	–6250	68,2	–6650	–6220	95,4	–6510	–6250	68,2	–6640	–6220	95,4	100	99,7
R_Date AA–57775: Burial 6	–6560	–6260	68,1	–6600	–6230	95,4	–6560	–6260	68,2	–6610	–6230	95,4	99,9	99,7
R_Date Bln–1052: sq b/18, spit 13	–6590	–6390	68,2	–6650	–6250	95,4	–6590	–6390	68,2	–6650	–6250	95,4	100	99,6
R_Date Bln–1169: sq c/d, spit 14	–6610	–6430	68,2	–6750	–6250	95,4	–6610	–6430	68,2	–6740	–6250	95,5	100,4	99,6
R_Date AA–57778: Burial 45	–6600	–6460	68,2	–6660	–6410	95,4	–6600	–6460	68,2	–6660	–6410	95,4	100	99,7
R_Combine Red deer antler tip–VL49	–6600	–6500	68,2	–6640	–6470	95,4	–6600	–6500	68,2	–6640	–6470	95,4	99,8	99,9
R_Date Z–267	–6500	–6260	68,2	–6600	–6230	95,4	–6500	–6260	68,2	–6600	–6230	95,4	99,8	99,7

Appendix 2. Continued ...

Name	Unmodelled (BC/AD) from	to	%	from	to	%	Modelled (BC/AD) from	to	%	from	to	%	A	C
Phase Between Hearths 20 and 16														
R_Date OxA–20702: T.3/2006–context 249	–6600	–6500	68,2	–6640	–6470	95,4	–6600	–6500	68,2	–6640	–6470	95,4	99,9	99,9
R_Date OxA–5823: Burial 54	–6680	–6450	68,2	–7030	–6390	95,4	–6660	–6450	68,2	–6950	–6380	95,4	102,1	99,7
R_Date AA–57777: Burial 31	–6650	–6480	68,2	–6830	–6430	95,4	–6650	–6490	68,2	–6820	–6440	95,4	100,9	99,7
R_Date OxA–5826: Burial 83	–6690	–6470	68,2	–7030	–6430	95,4	–6680	–6470	68,2	–6940	–6420	95,4	102,4	99,7
R_Date OxA–16541: Burial H2	–6690	–6520	68,2	–6780	–6460	95,4	–6690	–6520	68,2	–6780	–6470	95,4	100,4	99,8
R_Date Bln–1171: sq d/5, spit 9	–6900	–6500	68,2	–7040	–6470	95,4	–6830	–6530	68,2	–6990	–6470	95,4	104,1	99,8
R_Date AA–58321: Burial 25	–6810	–6530	68,1	–7030	–6480	95,4	–6710	–6510	68,2	–6810	–6470	95,4	111,2	99,8
R_Date Bln–1170: Dwelling 4	–7000	–6530	68,2	–7040	–6490	95,4	–6920	–6640	68,2	–7020	–6590	95,4	103	99,9
Sequence Dwelling 4 and Burial 25														
R_Date OxA–16218: Dwelling 3	–6990	–6680	68,2	–7030	–6650	95,4	–6900	–6680	68,2	–7010	–6640	95,3	105,2	99,8
R_Date LJ–2047a: sq C/III, spit 22	–7030	–6680	68,2	–7050	–6640	95,4	–6920	–6660	68,2	–7030	–6630	95,4	102,1	99,8
R_Date LJ–2047b: sq A/II, spit 14	–7030	–6690	68,2	–7050	–6640	95,4	–6920	–6680	68,2	–7030	–6640	95,4	101,8	99,9
R_Date Bln–1050: Sonda A, spit 15	–7030	–6690	68,2	–7090	–6570	95,4	–6920	–6660	68,2	–7030	–6590	95,4	103,1	99,8
R_Date OxA–16221: ivory tool–Burial 72	–7030	–6690	68,2	–7040	–6680	95,4	–6920	–6690	68,2	–7010	–6680	95,4	102,1	99,9
R_Date OxA–16543: Dwelling 5	–7030	–6700	68,3	–7040	–6690	95,4	–6920	–6690	68,2	–7020	–6680	95,4	100,2	99,9
R_Date OxA–16216: Dwelling 2	–7040	–6820	68,2	–7050	–6690	95,4	–6960	–6760	68,2	–7020	–6690	95,4	96,6	99,9
R_Date OxA–16217: Dwelling 2	–6760	–6630	68,2	–6900	–6590	95,4	–6760	–6630	68,2	–6830	–6590	95,4	101,1	99,9
Phase Dwelling 2														
R_Date OxA–16215	–7030	–6770	68,2	–7050	–6690	95,4	–6950	–6710	68,2	–7020	–6690	95,4	97,1	99,9
R_Date OxA–16214	–7080	–6830	68,2	–7170	–6810	95,4	–6970	–6820	68,2	–7070	–6770	95,4	71,6	99,8
Phase Dwelling 1														
Phase Late Mesolithic														
Boundary Start Late Mesolithic							–7070	–6910	68,2	–7120	–6850	95,4		99,6
Boundary End Early Mesolithic							–7370	–7050	68,2	–7510	–6950	95,4		99,9
Interval Duration Early Mesolithic							2150	2790	68,2	1910	3560	95,4		99,7
R_Date OxA–5822: Burial 51a	–7520	–7180	68,2	–7580	–7080	95,4	–7550	–7320	68,2	–7600	–7160	95,4	104,4	99,7
R_Date AA–57776: Burial 17	–8260	–7950	68,2	–8290	–7740	95,4	–8260	–7950	68,2	–8290	–7740	95,4	100	99,7
R_Date OxA–5824: Burial 70	–9650	–8920	68,2	–9760	–8800	95,4	–9450	–8920	68,2	–9660	–8810	95,4	105,3	99,6
R_Date OxA–16219: Dwelling 4	–9660	–9390	68,2	–9760	–9320	95,4	–9630	–9330	68,3	–9750	–9310	95,4	100	99,8
Phase Early Mesolithic														
Boundary Start Early Mesolithic							–9910	–9400	68,2	–10690	–9320	95,4		97,4
Sequence														

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Representing people, constituting worlds: multiple 'Neolithics' in the Southern Balkans

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ABSTRACT – *This paper considers the diverse iconographic landscapes of the southern Balkans, especially those populated by human figurines. The main premise is that material culture is a resource upon which agents draw to situate themselves in the world. In this way, regional traits are deemed particularly important for the constitution of specific subjectivities, in contrast to a generic 'Neolithic individual', and at the same time, for the constitution of specific local worlds as opposed to an all-encompassing world that is merely experienced differently. I attempt to provide an example of such regional traits that would have constituted different contexts for agency during the Neolithic and focus on the differences between two regions within the southern Balkans, regions that do not remain the same in the course of time.*

IZVLEČEK – *Članek preučuje različne neolitske ikonografske krajine južnega Balkana, zlasti tiste, ki jih poseljujejo človeške figurine. Glavna predpostavka je, da je materialna kultura vir, s katerim se delovanja umeščajo v svet. Na ta način so regionalne poteze posebej oblikovane v posebne subjektivitete, ki delujejo kot nasprotja generični 'neolitski individualnosti'. Oblikujejo tudi posebne lokalne svetove kot nasprotek drugače doživetemu vse-obsegajočemu svetu. Poskušam predstaviti primer takšnih regionalnih potez, ki v neolitiku oblikujejo različne kontekste delovanja in se osredotočiti na razlike med dvema regijama na južnem Balkanu, ki sta se skozi čas spreminjali.*

KEY WORDS – *representation; figurines; regionalism; materialization*

Introduction

The usual approach to prehistoric imagery is essentialist in character. Figurines and other representations of humans, animals and other entities are considered products of an inner 'ideological' or 'non-practical' behaviour, which is separated from the rest of social life and is presumed to illuminate the mental activity or even capacity of the people that used the artefacts. Representations of any kind are still approached as an inherent facet of humanity, albeit of a certain stage of humanity's evolution. It is not fortuitous that the earliest representations made by humans are still equated with art and, consequently, are taken as an index of civilization, of people ascending to the next level of their long walk toward the present (see for instance Renfrew's (*2003.13*) recent argument: 'We [sapiens ancestors of 40 000 years ago and modern humans in Europe today] are pretty much the same. This is partly illustrated by the remarkable cave art that appeared in France and Spain').

The equation of certain artefacts with a certain stage and, therefore, with a certain 'economic' behaviour characterizes all sorts of periodizations and classifications. Although making representations is not a trait of each and every society, attempts to gather different societies under a common denominator are still considered valid (*e.g. Renfrew 2007.xv*). Yet, in these cases, even though representations were the very criterion for assembling the different societies under the same roof, the distinctive trait refers again to other fields ('sedentism', 'hierarchy', *Ren-*

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frew 2007.xvi). As far as the Neolithic is concerned, here too the common agricultural regime presupposes that material culture, and that includes representations as well, performs the same functions across the regions where they are found. Representations are considered a by-product of the evolution of humanity, of its capacity, that is, to reify abstract ideas which are bound to be part of its parcel at some point in time. Irrespective of when each and every trait appears in the 'archaeological record', the inescapable conclusion is that a common 'economic' background would mean a common range of 'beliefs' incarnated in the representations of the period: Neolithic representations are first and foremost Neolithic, which means that the Neolithic is already constituted before representations enter the scene. When they do, they appear merely as representatives of the common regime, with no power over it. It is as if they were made solely to inform others of people's intentions, to serve as mirrors of one's inner self.

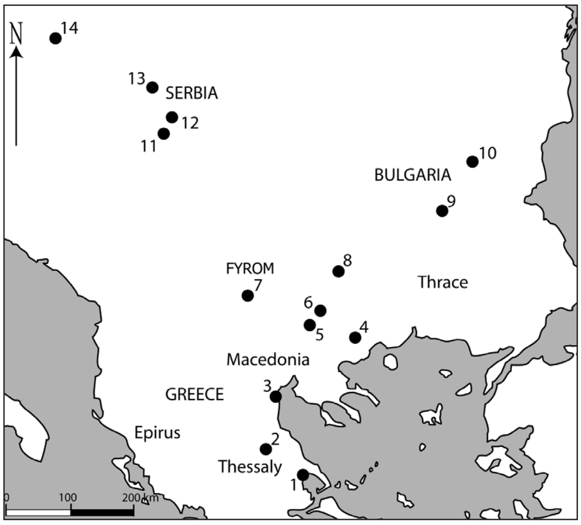

Fig. 1. Map with areas and sites discussed in the text: 1. Dimini; 2. Platia Magoula Zarkou; 3. Makriyalos; 4. Sitagroi; 5. Promachon-Topolniča; 6. Kovačevo; 7. Anza; 8. Rakitovo; 9. Karanovo; 10. Ovčarovo; 11. Divostin; 12. Selevac; 13. Vinča; 14. Donja Branjevina.

Contrary to this view, I make a plea to change the order and consider the 'Neolithic' as the by-product of the use of representations. It is time to abandon the implicit idea that artefacts are reflections of past intentionalities and, instead, interpret material culture as a resource upon which agents draw in order to situate themselves in the world (*Barrett 2005*). In each and every case where artefacts that represent people, animals or other entities are used, they are constitutive of the framework which guides people's actions, and are not merely a manifestation of it. In this way, regional traits are deemed particularly important for the constitution of specific subjectivities in contrast to a generic 'Neolithic individual'. If representations are different, then their world is different, not because they bear witness to different beliefs, but because they are part of the materials that built that world. In this paper, I try to provide an example of such regional traits that would have constituted different contexts for agency during the Neolithic, and take up the case of the southern Balkans, from northern Greece to Serbia.

How to do things with figurines

How is it that representations constitute a way of life for their users? There is much debate over the relation of people with material culture, a debate usually formed around the idea of the mutual constitution of people and things. Even though this debate began with some very powerful theoretical propositions, admittedly with an extremely careful articulation, in order not to reify the two parts of the equation (*Miller 1987*; see also *Miller 2005; Meskell 2004*), usually in archaeology, and indeed in the subfield of representational practices (usually called 'art'), the theoretical exposition takes the form of a simple to-and-fro relation between the two parts, whereby people make things and things have an effect on people. In this formulation, people are affected by artefacts only after their production, their ascension to full-fledged things. Meanwhile, the process is rather absent from the discussion, as are artefacts that have not successfully reached the end of the process. Infelicitous actions do not count, since they are not 'imbued with the intention of the producer' (*Mina 2008.116; citing Knappett 2006.240*, who, however, focuses on the process of manufacture and speaks of imbuing with mindfulness, rather than intention). And yet, arguably all production is infelicitous, for nothing can be said to correspond exactly to some predisposed intentions of the producer (*Butler 1993; Barrett 2005; Felman 2003*)[1]. Products are bound to fail to materialize an intention, and this makes change possible. In a nutshell, separating the formation of intentions from the actual manufacture of things hardly suggests the mutual constitution of people and things. Contrary

1 For the concept of felicitous and infelicitous (speech) acts, see *Austin 1962*, from which the section title is evidently borrowed, and *Derrida 1982, Felman 2003, Butler 1997*.

to that, the constitution of intentions should be situated within the manufacturing process (*Joyce 2000; Nanoglou 2008a.2–3*). As Miller points out, 'our humanity is not prior to what it creates' (*Miller 2005. 10*; see also *Nanoglou 2008b.314*), and thus our constitution as subjects is coextensive with the constitution of other entities such as animals, plants or things, *etc.* This is an unceasing process, but it 'stabilizes over time to produce the effect of boundary, fixity, and surface we call matter' (*Butler 1993.9*, emphasis removed). In this, it draws upon earlier processes, earlier stabilizations, earlier boundaries and surfaces, which it rearticulates into new, yet conditioned ones.

Representations are such entities that stabilize over time in a certain form. Their materialization is an endless process (*Meskell 2007*), but one which, as a result of the discourses structuring each context, produces different 'matters'. The very categorization of artefacts today is the result of specific discourses that dominate the field of archaeology, and we can imagine that figurines might have not been a coherent or intelligible category of artefacts in the past (*Meskell 1995; Ucko 1996*). Again, we should not conceptualize discourses as pre-existing structures that produce simple manifestations of themselves. Discourses are entirely coextensive with their being practiced and performed, which is why they never attain closure (*Nanoglou 2008b.314*). In this vein, representations are performative articulations, *i.e.* they do not stand merely for an abstract set of rules, but actually materialize discourses, which on the other hand cannot exist outside this materialization.

In the process of constituting themselves, then, people draw upon such articulations, performing and materializing discourses that also inform and govern the materialization of entities such as figurines, anthropomorphic and zoomorphic vessels, or any other relevant artefact. By studying the patterns of the production and use of all these artefacts we can reconstruct (at least partially) some of the discourses that governed the production of human subjects, focusing on their performative power – their capacity to produce what they describe, be it a human body or a certain animal, in flesh or in clay.

This process always takes place in specific conditions, it is always local (*Whittle 2003; citing Latour 1993*) and produces particular 'fields of time-space' (*Barrett 1994.72*) or 'spacetimes' (*Munn 1986.9–11*, see *Nanoglou 2006.157*), because the circumstances in which people, animals, actions and material culture converge are unique, and so are the rearticulations of these moments. These moments are reference points for the configuration of people's lives; the practices that were performed there acted as guidelines for new ones. This means, of course, that in each case a different set of practices was called upon as reference matter; a new world was constituted, a world anchored in and conditioned by the references, but still a world that had broken away from these reference points. The more faithful the reiteration of the referent, the more powerful became both the referent and the referring act. On the one hand, commemorating moments in various fields, extending the spacetime (*Munn 1986*), amounted to reinforcing their position as reference points, raising them to the level of dominating discourse. On the other hand, this made the reiteration of the moments intelligible and acceptable, even desirable.

Within this framework, representations both commemorate and are commemorated. They reiterate previous practices, whether the manufacture of another artefact, someone's action or disposition *etc.*, and they stand as reference points for practices to come, be they the manufacture of another artefact, someone's action or disposition *etc.* They do this from specific positions, having a specific materiality, a specific material presence. Figurines are small and handy; vessels in the form of a human or an animal serve as containers too; big statues are relatively immovable and easier to see and so forth. They take part in various social fields in different ways and are brought to bear upon people's lives according to specific biographies, both their own and their users'. From this point of view, the lives of their users are bound to be similar – having to draw upon interconnected spacetimes – and different, having always to choose and fail to reiterate identically specific spacetimes.

In this paper, I am going to pursue this line of thought in considering the representational practices of the middle and southern Balkans during the Neolithic, *i.e.* the area of Greece, particularly northern Greece (primarily the areas of Thessaly and Macedonia, as there is not much information on Epirus or Thrace), the former Yugoslavia, and Bulgaria (but not northeastern Bulgaria in the later Neolithic, which follows a different trajectory). I will focus on the ways humans are represented in these areas during the Neolithic and the consequences that any similarities or any differences might have had for the lives of their respective inhabitants. The exploration will focus on the differences between two regions, a northern and a southern one, which will include different modern areas during time. Although the paper is about regional differences, in the course of this text I will leave out of the discussion any variability within each region and treat them generically. This is due to space and research limitations, and I fully acknowledge that this variability is essential to any fuller understanding of the life of the inhabitants of the regions (see also *Nanoglou 2006*). I hope that the approach advocated here will remain valid in any prospective examination of smaller or greater regions. For similar reasons, I will explore the case within a two-phase timeframe, distinguishing between an earlier and a later Neolithic. The former will refer to the Early Neolithic of the central Balkans (or 'Starčevo culture') and the Early and Middle Neolithic of northern Greece (or 'Protosesklo' and 'Sesklo culture', respectively) and the latter to the Late Neolithic of the central Balkans ('Vinča culture') and northern Greece ('Dimini culture')[2]. In calendrical years, the earlier Neolithic more or less spans the seventh and the first half of the sixth millennium BC, and the later Neolithic, the second half of the sixth and the fifth millennium BC (*Andreou et al. 1996; Reingruber and Thissen 2005*).

Diversified beginnings: the earlier Neolithic

Although hardly constituting a beginning per se, like any other period for that matter, the earlier Neolithic will serve here as the beginning of my exploration. On an analytical level, the changes observed during this time have been given much credit, to the point of even talking about a revolution. I do not mean to suggest that there were not profound changes taking place during this time in the area under consideration. On the contrary, there were significant departures from earlier traditions: new types of settlement, new types of artefacts, new types of resources (see *Bailey 2000*). But the important issue is not to see these novelties as exhibiting new technologies, that is, as the dissemination of some kind of new knowledge, but as the emergence of new relations between the inhabitants (*Whittle 2001*), relations that included animals, plants and things. Among those things, there were many objects that represented humans: figurines, vessels in the form of humans or with human-shaped add-ons, pendants and other items. Figurines, *i.e.* objects that represent humans, but which are not pendants, receptacles, or attached to receptacles, constitute by far the largest category, and I will concentrate on them in the remainder of the paper.[3] They seem to be omnipresent, even if their distribution is not without variation. There are sites that have produced thousands, and sites that have produced a mere handful (*Nanoglou 2006* for Greece, but the same applies to the North).

Admittedly we are somewhat at a disadvantage regarding any knowledge of their context of use (see *Nanoglou 2008a.3–4* for a discussion). There are not many publications with detailed information on the context of discovery. Most of the objects found in an undisturbed layer come from refuse deposits, which at least tell us something about the end of their life. In northern Greece, there are a few occurrences of figurines deposited in groups, but there is no way of knowing whether this was a widespread practice (but see below). Thus iconography remains the most promising avenue of investigation and, interestingly, the area where differences between regions emerge most clearly.

During the earlier Neolithic, almost all figurines were made from clay (*Nanoglou 2008b*). However, there are two major differences between the assemblages excavated in the central Balkans and those excavated in Greece: the first has to do with the ratio of humans versus animals, and the other with the way humans were represented in the two regions (for a fuller discussion see *Nanoglou 2008a*). Although my main concern rests with human figures, the two differences are interconnected, and both need to be taken into consideration. In both areas, human figurines predominate, but while in the assemblages from the central Balkans ('Starčevo' assemblages) we find a ratio of humans to animals fluctuating from 2:1 to 4:1, in northern Greece the ratio rises to fluctuate from 10:1 to 15:1, and in certain cases animal figurines are non-existent (*Nanoglou 2008a.5*). Thus in the central Balkans, there is a significant concern with animals, whereas in northern Greece the iconographic landscape is overtly anthropocentric, at least when it comes to figurines.

2 The equation of the Greek Late Neolithic with the 'Dimini culture' is not wholly accurate any more. In fact the so-called 'Dimini phases' correspond to the second half of the Late Neolithic. The first half is called 'pre-Dimini phases'. It should be borne in mind that many of the traits of the 'Dimini phases' continue in use in the ill-defined Final Neolithic period.

3 There are reasons, besides the presence of a hole, to differentiate between figurines and pendants, at least in Neolithic Thessaly (*Nanoglou 2005.144* and especially *Nanoglou 2008b.317*). The differentiation between anthropomorphic figurines and vessels is for the moment mostly an analytical one.

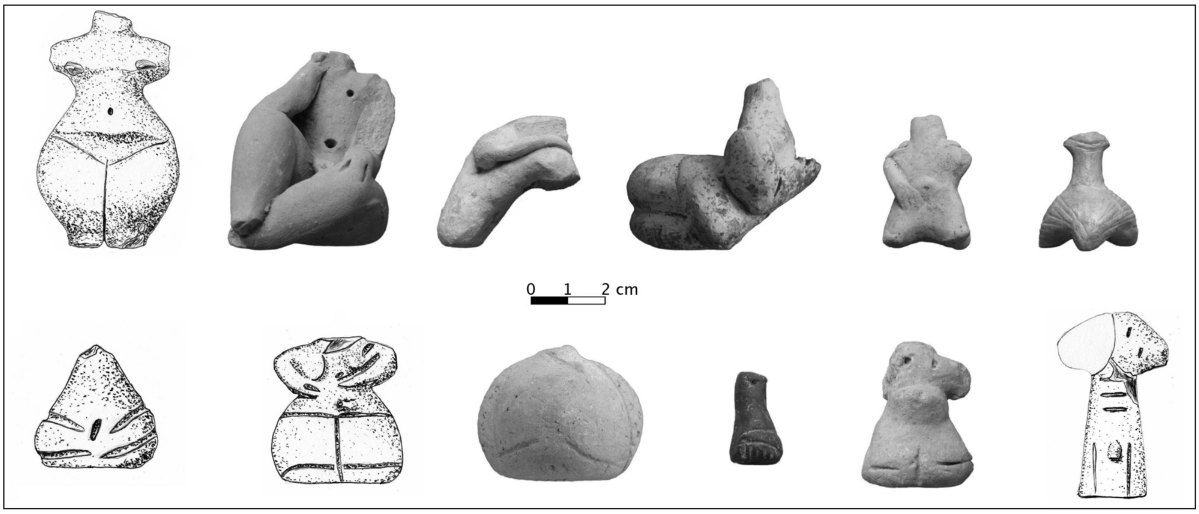

Fig. 2. Characteristic types of figurines from earlier Neolithic sites in Thessaly. (Photos and drawings by the author.).

Relevant to this point is the way humans are represented in the two regions. In the central Balkans, figures are mostly rendered without detail (see *Gimbutas 1976* for Anza; *Demoule and Lichardus-Itten 1994* and *Lichardus-Itten et al. 2002* for Kovačevo; *Radunčeva et al. 2002* for Rakitovo; *Hiptmair 1997* for Karanovo, *Vajsov 1998* for northeastern Bulgaria; *Letica 1988* for Divostin; and *Karmanski 2005* for Donja Branjevina). Legs and hands, when present, seem to be there only to make their existence apparent (*Nanoglou 2008a.9*). In contrast, in northern Greece, legs and hands are always present and doing something. Nearly all the figures have their legs and hands in a specific posture/gesture. There is enough variation to suggest that they are not manifestations of a single type, and at the same time, there is enough repetition to suggest that groupings can be made (see *Nanoglou 2005*). Specific gestures and postures are more frequent in some regions than others, but there are no gestures or postures exclusive to any region (*Nanoglou 2006*). This might indicate that these gestures and postures were meaningful in relation to each other, a point that resonates with the fact that some figurines are found in groups (see above), suggesting that this variety can be interpreted as connoting different actions on behalf of the figures (*Nanoglou 2005; 2008a.8*).

So people in the central Balkans were brought to life and socialized in a landscape with generic images of humans and animals, whereas in northern Greece they encountered a landscape populated with active human figures. However the artefacts were used and discarded, they provided a different framework in each region for social life to continue. Their contexts of use and discard are, of course, critical for an understanding of the exact way they were brought to bear upon people's lives, and the lack of information on them is a great loss, but in any case their differences can be informative as such. To say the least, these different frameworks would have enabled and compelled their users to attain a different ontological status in each region. In the central Balkans, the body was invoked as a generic form and in conjunction with animals, highlighting perhaps humanity as such or a certain group identity, which also included animals (see also *Bailey 2000 and 2005* for the idea that figurines negotiated the boundaries of the community). In northern Greece, however, the body was always in action, in a way making activity the normal case, naturalizing this particular body. Even if figurines were used only in specific instances, their effect on people would have exceeded their boundaries, and each time, these instances served as reference points (even negative ones) for other activities (*Nanoglou 2005.147; 2008a.10*). So, even if active bodies were the norm for the contexts where figurines were used and these contexts were specific and limited, figurines would have evoked certain responses from their users (conscious or not) even outside these contexts, if only to define such an exterior. In any case, these contexts would have formed scenes, where people and other entities (animals, plants, stones, artefacts, *etc.*) would have converged, and where people would have addressed all the rest in ways conditioned – at least to a certain extent – by the figures. That does not mean necessarily that people would have imitated the movements depicted by the figures. But the materiality of the figurines would have certainly been taken account of; their presence would have been accounted for.

It is a completely different thing to account for figures that bring forth generic notions of humanity and animality (or a combination of these, see *Nanoglou 2008a.5*) and figures that focus on what people do. They evoke different questions: on the one hand: 'What or who are you to expect a certain position in this world?' (a 'what or who' that evidently concerns animals, too); on the other hand: 'What do you do, to attain such a position?' (*Nanoglou 2008a.9*). These questions, these accounts, are not merely explanations after the fact. They are not present to inform on an already achieved condition. They are rather constitutive of the ontological status of the people that engage in such scenes and, by correlation, of the people that do not. This means that people in the two regions would have been constituted as subjects in different ways and in a different world. Can we be more specific on the issue? Perhaps, up to a certain point, and considering the generalizing level of this exploration, we could suggest that, trying to cope with animals, plants, their built and unbuilt environment, the land and its resources or whatever, people in the central Balkans paid special attention to the position of humans and animals within this web of relations. This might resonate with the somewhat loose architectural definition of community space in the central Balkans (*Bailey 2000; 2005. 4–5*) and the suggestion that in flat, extended settlements, animals were held inside the occupation area (*Chapman 1989; Andreou & Kotsakis 1994*). Perhaps both of these practices, the incorporation of animals in the occupation area and in the representational field, could be interpreted as part of their incorporation in a common identity, as Bailey has already suggested (*2000*). Yet, rather than expressing such an identity, figurines constituted it, bringing together diverse entities (at least from our point of view) and normalizing their fusion. In northern Greece, such a fusion does not seem to have been in the foreground. Figurines seem concerned with the actions of people, especially actions performed collectively, and this again might resonate with the way the built environment was organized, resulting in settlements with packed buildings and limited open air space (*Kotsakis 1999*).[4] Perhaps, then, architecture and representational practices instigated the constitution of a communal identity different from the one in the central Balkans, which was centred on the relation of humans and animals, focusing instead on the relations between humans and realizing a community whose distinctive trait was to perform certain actions. The distinctiveness of this process in each case and the specific identities it constituted need to be explored on a more local level, bringing forth the particularities of each context of use, but for the moment it seems unavoidable to conclude that the inhabitants of the two regions did not live in the same world.

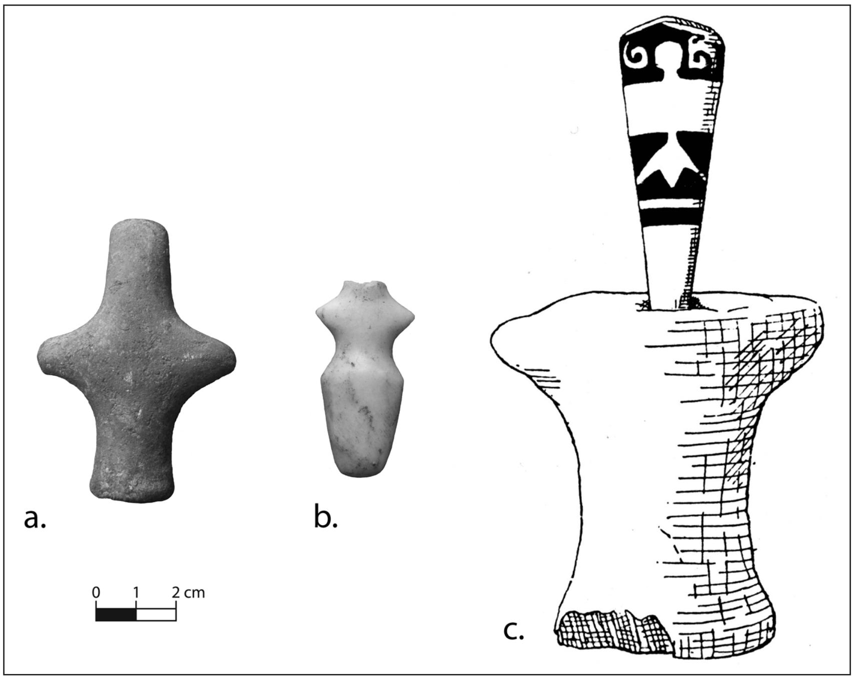

Fig. 3. Characteristic types of figurines from later Neolithic sites in Thessaly. (a and b: photos by the author; c. after Wace and Thompson 1912.fig. 25b.).

Rearticulating the tradition: the later Neolithic

In both regions, there are many changes observed in the assemblages of the later Neolithic. To follow these changes gradually is difficult, both in view of the space available and the danger of presenting a

4 An important caveat: there are still no published assemblages from earlier Neolithic flat extended settlements in northern Greece, which might prove to be inconsistent with this suggestion. All figurine assemblages known to me during the writing of this paper come from settlements with intensive habitation, regardless of their turning to tells or not (see *Nanoglou 2008c.146* for this matter and a call to focus on the process of rebuilding, rather than the final outcome of this process).

circular argument as long as we rely on these very changes as chronological markers. So, rather than trying to present what came first and second, I will focus again on the general traits of the period and especially the first half of the fifth millennium BC. In the case of northern Greece in particular there is a further reason to do so. Regarding Thessaly, published data from Late Neolithic assemblages dating to the second half of the sixth millennium BC (the 'pre-Dimini phases', see note 2) are not that common and, indeed, most of our information on the later Neolithic comes from assemblages dating to the first half of the fifth millennium BC (the proper 'Dimini phases', see note 2). In the rest of northern Greece, namely Macedonia and Thrace, most of the assemblages show a remarkable similarity to the ones from the northern areas (the 'Vinča culture') and so in this period the comparison is between Thessaly and the areas to the North, rather than northern Greece and the central Balkans.

There are certain traits that seem to be present in both areas. Hands are rendered as mere stubs (*Tringham 1971.112; Nanoglou 2005.150*) and the size of the head is big in relation to the body (*Tringham 1971.184* for Vinča and *Nanoglou 2008b.323* for Greece), which seems to suggest an emphasis on the head (along with other features, at least for Thessaly, *Nanoglou 2005.150–1*). Another similarity is a trend towards the standardization of forms: in both areas and despite the variety in a range of details, most of the figurines can be categorized into just a few different types (*Pavlović 1990; Nanoglou 2008b. 324*), evoking more generality than particularity. Certain other features are not so easily comparable. In the first half of the period, figurines from Serbia to Macedonia are mostly standing, and rarely seated (*Tringham 1971.112; Milojković 1990.415; Nanoglou 2006.164*), a feature that we cannot discern in Thessaly, due to the lack of contemporary assemblages.[5] Towards the second half of the period, it seems that figurines with a solid lower part proliferate in the North (*Milojković 1990.412; Nanoglou 2004*), though standing and seated ones continue (*Tringham 1971.184*), whereas in Thessaly, figurines with a solid lower part definitely predominate (*Nanoglou 2005.150*).

The major changes introduced in this period are:
a) for Thessaly:
 i) the dominance of figures that (like the ones in the earlier Neolithic central Balkans) show only a generic human form (*Nanoglou 2005*), and
 ii) the proliferation of stone as a material for the manufacture of figurines (*Nanoglou 2008b*); and
b) for the northern areas, the use of incisions on many figurines (*Tringham 1971; Chapman 1981; Srejović 1988; Milojković 1990; Pavlović 1990*).

So, in this period, both areas have figurines that at first sight focus on a generic human form; but this is not exactly the case. First of all, in Thessaly, the generic form comes from the re-articulation of a tradition that focused on specific bodies, which suggests that there was a repudiation of previous practices, a move against them. This move, in conjunction with the proliferation of stone figures, suggests that the interest is no longer in what a body does, but what a body is made of (*Nanoglou 2008b.326*). Rather than simply generic, the new form is primarily static, and the various figurines are differentiated through their material. Meanwhile, in northern areas, the body remains generic in its form, but is particularized through incisions. A further difference lies in the use of perforations. During the course of the period, figurines with perforated arms seem to multiply in the North (*Tringham 1971.185; Nanoglou 2008b.320*), whereas in Thessaly they are not that common.

The ratio of human to animal figurines remains relatively unchanged in Thessaly and certain areas with a strong connection to Thessaly during this period (*e.g.* Makriyalos, Pieria, see *Nanoglou & Pappa forthcoming*), whereas to the North, animal figurines are again more frequent than in Thessaly, but not as frequent as in the earlier Neolithic (as evidenced at sites like Sitagroi, *Gimbutas 1986*; Selevac, *Milojković 1990*; or Divostin, *Letica 1988*). This could be explained partly as a continuation of the previous tradition. On the other hand, animals are very much represented in other media, especially vessels, suggesting that animals were invoked in a quite different manner in this period (*Nanoglou 2009*).

So, there are certain features that reiterate the traditions of the earlier Neolithic and there are other features that introduce radical changes into the iconographic landscapes of the areas under examina-

5 It is interesting to note that most of the few figurines definitively dated to this phase are either standing (*Wace and Thompson 1912.Fig. 71b and 76l* from Tsangli) or seated (*Gallis 1985* from Platia Magoula Zarkou, which also are very early in the period). But they are not enough for a stronger argument.

tion. As already said, there is variation within the regions I have been comparing in either period, but I am going to focus on practices that seem to be found over wider areas. As I will argue further below, this does not mean that the differences described here correspond to the essential character of two 'cultures' that occupied two neighbouring areas. The differences I describe and the areas constituted by them are partly conditioned by the level on which I have chosen to study the whole area. That said, it seems significant that on this level certain differences do emerge and these point again towards the existence of different worlds.

In Thessaly, the break with the previous tradition seems more radical. The denial of movement and preoccupation with the materials one is made of suggests a major change in the way people understood themselves. The ontological questions posed by these artefacts, in the contexts they were used, were concerned not with the actions of people, but with their making (*Nanoglou 2008b*; see also *Nanoglou 2005. 152*). In the northern areas, changes seem radical on a different level. The proliferation of incisions suggests that the generic form of the body is no longer adequate for the contexts where figurines were used. These bodies needed further features in order to be of some use in the various scenes where they were invoked. Even though not all figurines were marked with incisions, those that were incised rearticulated the whole field of representation. At least these called for a change in the way bodies were constituted, not least by setting up an 'opposition' to those that were not incised. The act of incision suggests, perhaps, that the focus was on the surface of the body. That what was significant was the appearance of an incised body, a body that looked a certain way. The discussion on whether the incisions should be interpreted as clothing or something else is old (*Milojković 1990.412–3*) and not yet resolved, but the focus on the surface was meaningful, regardless of what the incisions referred to.

So we can discern changes in both areas. On a certain level, these changes have resemblances. A more or less static image is projected, and an interest in appearances and the head can be detected. On another level, though, differences prevail, both on account of the specific history that representation as a practice had in each region and on account of the specific materiality of the objects in question. Thus, we can suggest that the Thessalian figurines emanate a preoccupation with the substances of which they were made. But this preoccupation should not be interpreted as a move to distinguish between interior and exterior, as the use of the material as a differentiating feature could suggest a conflation of our epistemological categories of substance and appearance, with their material being their form (*Nanoglou 2008b.326, 329*). So, the interest seems to have lain in the construction of these entities, and we could perhaps suggest that this also reveals a concern with the past, with the way things came to be what they were (*Nanoglou 2008b.325*, for pertinent ethnographic material see *Ingold 2000.113* and *Descola 1996.88*), something that resonates with processes seen in other social fields in later Neolithic Greece (*Nanoglou 2001.313; 2008b.325*). In this vein, the figures from Thessaly constituted an iconographic landscape whereby people would have been able, and perhaps compelled, to identify themselves with reference to their making and their origins.

The figures to the North of Thessaly do not seem to share these concerns. First of all, they seem to have rarely used stone as a material. It seems that clay continued to be seen as the appropriate material for their manufacture. Second, they are static and perhaps generic, but they are particularized through the use of incisions (at least some of them). Incision (and its fellow concept, inscription) has at present some very powerful connotations of an act exercised from outside. It is no accident that this notion is in the middle of discussions pertaining to the meaningfulness of bodies (for the most comprehensive and thorough study yet, see *Meskell 1999*). Incision/inscription is considered a process whereby meaning is inscribed on an already formed body, as if matter preceded mind. I would suggest that, to a certain extent, incision/inscription is an action upon something, but this something cannot be considered already formed. It is not an act upon a body, but the rearticulation of something into a body. Furthermore, this very practice is what constitutes a surface, as long as we understand inscription/incision as acting on a surface. More importantly for our case, this surface does not need to invoke an underground, even less an underground where this essential character remains hidden (as in the body, which behind appearances is purportedly always the same biological entity). What seems significant is that these figures had to carry certain insignia in order to be appropriate for their use (whatever that was). Their material and their generic form were no longer enough, as they probably had been in the earlier Neolithic. These insignia were part of the body and, as such, they presented a particular body, one that had to be covered with them, one that had to carry them and

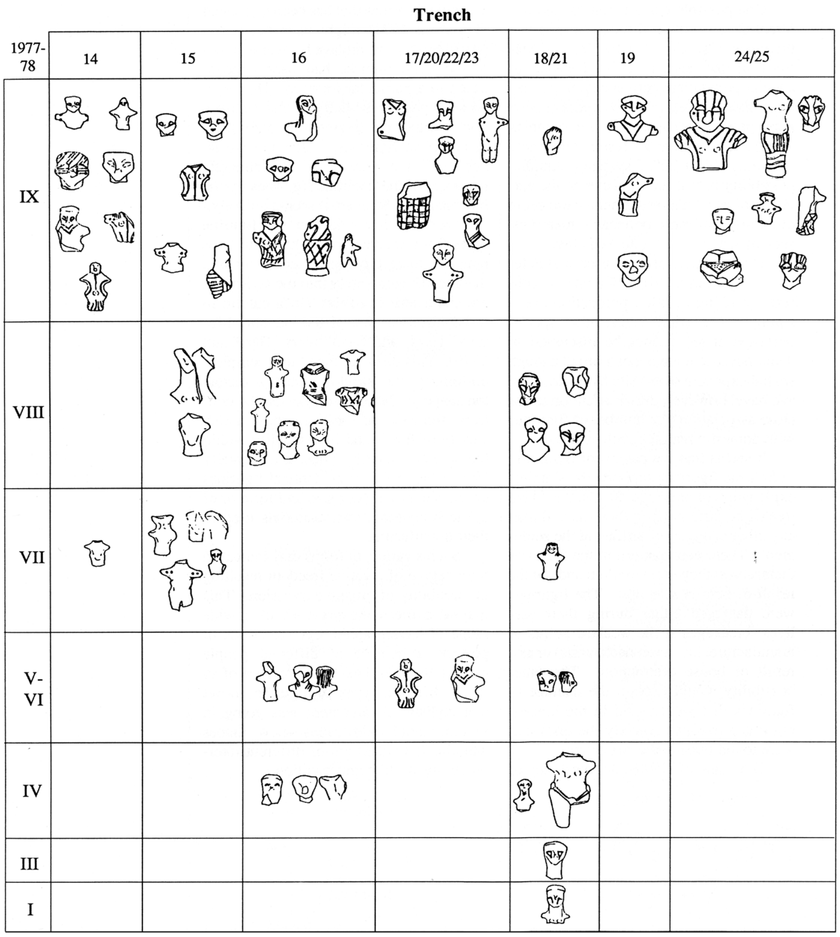

Fig. 4. Chart with characteristic figurines from each phase in the 1977–1978 excavation area at Selevac. (Reproduced with permission from R. Tringham and D. D. Krstić (eds.) 1990. Selevac: a Neolithic village in Yugoslavia (Monumenta Archaeologica 15). The Cotsen Institute of Archaeology, UCLA. Los Angeles (CA): Fig. 11b.).

reveal them so as to be meaningful. It is perhaps not incoherent to suggest that within the context of their use these figures invited the presence of 'incised' persons, of persons covered with relevant insignia, and their place in the social network of the community was recognized and acknowledged with reference to these insignia.

Information about the contexts where these figurines were invoked is scarce indeed. In the area North of Thessaly, there are occasionally groups of figurines found in pits (*Tringham and Conkey 1998*), but these seem to be assemblages formed through the clearing of areas, rather than purposeful depositions of sets of artefacts as in the above mentioned earlier Neolithic cases in Greece. Whenever we have information, it seems that figurines were not deposited in large numbers (*Letica 1988* for Divostin; *Nanoglou and Pappa forthcoming* for Makriyalos). Even in cases of figurines discovered in large numbers in some features, their deposition corresponds to a gradual accumulation of layers, rather than a single event (*e.g.* Makriyalos pit 212, *Pappa 2008* and Promachon-Topolniča pit 4, *Koukouli-Chrysanthaki et al. 2007*). Their deposition in fragments (*Tringham and Conkey 1998; Chapman 2000; Chapman and Gaydarska 2007*) and usually in refuse pits (*Tringham and Conkey 1998*) suggests that their final disposal was different from that reserved for the earlier Neolithic figurines from Greece (at least for some of them, see above). There are, of course, exceptions (*Letica 1988.179* for Divostin, where a group of seven intact figurines was found in House 23).[6] The extensive use of perforations, from which they could presumably be hung, points to a different use-life for these artefacts. We do not need to interpret them as amulets hung from someone's neck (although this is a valid suggestion), for the perforations could serve to fasten many together. But in this case, their fastening was deemed unnecessary for their final deposition.

The information on the contexts of figurine use from Thessaly is even more frustrating, for there is virtually nothing to rely on apart from the case of Platia Magoula Zarkou, where a building-model with eight figurines was found under a floor (*Gallis 1985*) and two figurines were found in the area of the cemetery (*Gallis 1982*). But this find is actually dated very late in the earlier Neolithic or very early in the later Neolithic and can be included in the earlier tradition (see *Nanoglou 2005.149* for a discussion). Most of the studies are too old and they provide only catalogues of the finds, with only general information on contexts of discovery. Moreover, even stud-

6 Compare also the group of figurines found in a house of phase IX in Ovčarovo, northeastern Bulgaria (dated around the middle of the fifth millennium BC, *Todorova 1982.67*).

ies which are supposed to focus on the distribution of the figurines provide no details that could help determine the process of deposition (*e.g. Skafida 1992*; see *Nanoglou 2005.151*).

So other than suggesting that these artefacts would have provided points of reference for the deployment of practices in various social fields, there is not much to go forward. Even at this non-specific level, the iconographic landscapes constituted through these artefacts were different in the two areas, and so was the inhabitation of these landscapes. People would have been enabled and compelled to account for themselves by drawing upon different resources. As long as people needed to situate themselves within their community, this would have been possible only through invoking the particular representations present at hand. So, asking about and accounting for one's making would have been essential, at least in certain instances, for someone to go on living. However this was translated (*e.g.* origins, kinship, *etc.*), the consequences would have been paramount for someone's life and place in the community. It would have affected the ontological status of the person in question, the way s/he understood herself/himself and others and the way s/he was understood by others. The same applies to asking about and accounting for in terms of insignia. This would have also been significant for someone's life and place in the community. It would have also touched upon the ontological status of the person in question. But the persons would have been different – one constituted in relation to concerns about her/his past, about the process that brought her/him in that position, the other constituted in relation to concerns about the visibility of her/his marks. As different persons, they would also have inhabited different worlds.

One Neolithic, two Neolithics, three Neolithics...

That the Neolithic is nothing more than an analytical concept, a heuristic device, should be a commonplace by now (see especially *Whittle 2003*), although many studies still reify the period, attributing to it an essential character, longing for a hard core to emerge, which can be observed, described and followed through regions (*Kotsakis 2002*). If we agree that the Neolithic was not a stage in the evolution of mankind, an essential economic background upon which social life was built, but a modern concept helping us to grasp our history and our place in the world, constituting in the process the very world we are inhabiting, then the question is: what kind of world did the people of the past inhabit and what kind of concepts did they use to understand it and position themselves within it? In this process, artefacts are and were the co-producers of the world (*Meskell 2008.375*, following *Latour 1993*). As long as these artefacts are different and in different associations, in different assemblages (*Latour 2005*), the worlds produced are bound to be different. There are many Neolithics (as products of our own endeavour to understand our past and our present) and there were many 'Neolithics' (as products of their endeavour to understand their past and present).

People in the southern Balkans inhabited a landscape populated with other people, animals, plants, rocks, rivers, mountains and other entities and features and were called upon to account for them and for themselves as they encountered other beings (human or not). Drawing upon previous practices, they were called to make choices and reiterate certain practices that were deemed appropriate for contingent events. During the earlier Neolithic in the Balkans, people manufactured clay figurines, clay objects citing human and animal beings, and used them on occasions that cannot be adequately described. Yet, whatever these occasions were, figurines would have been points of reference for the conceptualization of themselves and others. Communities living in Thessaly focused significantly on citing humans and their actions in clay. Growing up in these communities, someone would have been compelled to focus on exactly these features and define herself/himself according to relevant criteria. This defining process was conditioned by the circumstances, the contexts of use of the artefacts. Reiterating the artefacts would entail commemorating to a small or large extent these circumstances, the spacetimes where the artefacts were articulated and re-articulated within the fabric of social life. This commemoration would have ensured that the spacetimes would have been extended (*Munn 1986*) and similarities would have covered greater regions. In fact, this commemoration would have constituted regional identities, as it would have served as a defining trait for a group of people and a group of communities (see *Nanoglou 2006*). So, people to the North probably focused on different features, citing both people and animals in clay and concentrating on their generic images, rather than on their actions. They were commemorating different instances, different scenes where people, animals and other beings (animate or inanimate) engaged with each other. In these instances their relation to animals was probably deemed quite important. Extending different spacetimes, each group of people and communities constituted two different regions where a distinctive world was produced. In the first case, a world assembled with reference to human actions; in the second, a world revolving around the relation between humans and animals, or perhaps something that transcended the two categories as we moderns understand them (see *Nanoglou 2008a.5* and *Meskell 2008*). It is perhaps no coincidence that in the first case people lived in densely populated settlements (*Kotsakis 1999*), whereas in the second, the organization of settlements was somehow looser (*Bailey 2000; 2005.4–5*; see *Nanoglou 2008a.8* and the caveat *ibid note 9*). What constituted a viable or desirable community would have been contingent on the practices that focused on what constituted a viable or desirable body. If the reference points for the community included animals, then animals should probably have been present in the community space (*Chapman 1989* for the interpretation of flat extended settlements as inclusive of pasture areas). On the contrary, if the focus was on people's actions and their monitoring, then an appropriate spatial arrangement should have been provided.

For the people in these two regions, carrying out everyday tasks would have differed. Even though agricultural regimes no longer seem so different in the two regions (*Bogaard 2004*), it does not mean that representational practices were mere variations on a common theme. On the one hand, figurines in Greece do not seem to delve into the subject of domestication (*Nanoglou 2009*). The artefacts seem to cite practices pertaining to other facets of life in these communities. Consequently, these facets were defined as separate social fields through their citation by figurines. They were constituted and conditioned by these artefacts, which at the same time constituted and conditioned these fields. There people would have been requested to focus on their actions in the presence of others. And their life and their world would have revolved, at least to some extent, around these spacetimes, allowing them and perhaps compelling them to define themselves as participants or not, or as successful or unsuccessful contributors, *etc.* Meanwhile, figurines to the North touch upon the subject of human-animal relations. This does not mean that they probe the issue of domestication, but it is evident that in fields defined by the use of these artefacts the interest was not just in people. It is not clear whether people and animals were considered opposed or not in these scenes (*Nanoglou 2008a.5*). We could see it as the negotiation of a certain hybridism (see *Meskell 2008* on Çatalhöyük), but that must remain purely hypothetical for the moment. The important thing is that they were concerned only with the generic image of the human and animal body, with their presence as such, and thus people would have been guided to define themselves accordingly. Actions were perhaps irrelevant – what really mattered was the position one held in this spectrum of possible relations between persons and animals. Consequently, people were constituted along different trajectories in the two regions. Their ontological status – who they were, what they were – was contingent on their understanding of these artefacts and the definition of a place for themselves according to this understanding. In order to act socially it was necessary that their very being was intelligible and sanctioned, which was only possible through adherence to the discourses materialized by the figurines (among others, of course), even in order to subvert them.

Following upon these distinct traditions, the inhabitants of the two regions rearticulated them in the centuries that ensued. Yet again, two regions were defined by the very reiteration of practices over space, by the extension of specific spacetimes. That the regions were not the same as before underlines the argument that these regional identities had to be performed in order to persevere. The changes in the artefact assemblages of a certain region can be explained as changes in the commemoration of the spacetimes that were valued and deemed important for the social life of the inhabitants. People were starting to invoke different practices and different artefacts in their various encounters with each other or with other creatures and entities. The same process that allowed material culture to change over time allowed it to change over space too. In each new encounter a rearticulation of the previous moments was bound to happen, and yet it was contingent on the choices made.

These changes suggest a radical break with the past in Thessaly. The concern with acting bodies was dropped, and people focused on the material of the figures. I have argued that this could be interpreted as a concern with the making of the figures and, by extension, with the making of their users. So, from a discourse that focused on the actions that were presented and, consequently, the present, we turn to a discourse that focused on origins and the past. This resonates with changes occurring in other social fields, especially the manipulation of the form of a settlement to resemble a long-lived tell (*Nanoglou 2001; 2008c*). This does not mean that tells were exclusively related to such constructs, since this was obviously not the case (Vinča being an excellent example). It does mean that a certain concern with the origins of people and of their communities was acquiring a central position in the social life of the inhabitants of Neolithic Thessaly, and that they would have experienced this life through such a pervasive prism.

To the North of Thessaly, such concerns are not evident, at least to us. Appearance seems to have been a major classificatory principle for figurines and consequently for people too. This could have been anchored in the past, namely in the way appearances were inherited and reproduced. But the significant feature here seems to be the need to monitor someone's place in the community. Seen this way, it is not opposed to the previous tradition of the region, but it does certainly rearticulate it to a great extent, directing attention to a particular plane of the body, its surface (again: not necessarily opposed to a deep core). This concentration on the surface and its incision resonates, perhaps, with relevant practices in the production of pottery. Vessels were widely incised and, indeed, the relation between the incisions on pottery and on figurines has been noted (see *Milojković 1990.413 citing Srejović 1968*). It is perhaps significant that in communities sharing this type of figurines, vessels with human and animal features are common (*Pileidou 2006*; see *Nanoglou 2009*). It seems that there existed a strong relation between figurines and pottery, one that focused among other things on the organization of their appearance through incision. It is perhaps equally significant that in this region figurines continued to be made almost exclusively of clay, reinforcing the relation between the two classes. There are, of course, differences between them: first of all it seems that the ratio between humans and animals was inverted in pottery, where vessels with animal features outnumber vessels with human features (*Nanoglou 2009* for northern Greece). So, in an expanded field of representation, which includes both figurines and vessels, it seems that humans and animals are indeed again a major theme, continuing from a previous tradition. But in this case, humans and animals are constrained to a great extent within a subfield of their own: figurines predominantly for humans, vessels predominantly for animals. Humans and animals continue to be paired when it comes to representations, but they are constituted as different sub-species through the artefacts that cite them. Animals seem to be defined as containers (*Nanoglou 2009*), whereas the use of perforations might allow us to suggest that humans were considered, at least in some instances, as something to be carried around.

So people drew upon different material resources and produced themselves as diverse persons, as diverse kinds of persons. In the same process, they were producing different worlds, not just different worldviews, but different entities, different creatures. It was one thing to be a human or an animal in Thessaly, and another to the North. It is important to insist on the matter: the issue is not about a Neolithic regime that is understood and felt differently by various agents, but about the production of different regimes and different constituents (different animals, different plants, different people, different resources, *etc*.), even different kinds of constituents (taxonomies different from 'animals', 'plants', 'people', *etc*.). In each region, people, animals or any entity had a different presence in their world. They were able to be present, to situate themselves and others in the world, to act and react as something different.

There was, of course, no rigid boundary between regions. Boundaries were performed as people commemorated specific spacetimes and reiterated specific practices. The two regions I have been describing in this paper are to a large extent a product of my own research. The case of Makriyalos is eloquent: from a community sharing many similarities with the northern area in the first half of the Late Neolithic, it turned into a community sharing many features with Thessaly in the second half of the period (*Pappa and Besios 1999; Pappa 2008*). Yet this was not a case of changing sides, but a rearticulation of the community's own past, since many of the traits encountered in the first phase are present in the second. In Makriyalos, as in any other case, people did not merely join or leave a 'culture', but produced an inhabitable place by citing previous experiences. The very context of citation was conditioned by these experiences and people's ability to reiterate them, and at the same time, fail to reiterate them.

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Palaeolithic art in Slovenia

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ABSTRACT – *This article is a review of Slovenian Palaeolithic 'art' objects. Most were found quite some time ago and were described as 'art' by their excavators, who undertook no further examination and authentication. More recent finds, like the Mousterian 'flute', were thoroughly examined, but in the case of the flute, there is still no uniform agreement on whether it was used as musical instrument or not. The only objects which are definitely artificial are engraved bone points, two engraved stones and three pieces of jewellery from Late Palaeolithic sites.*

IZVLEČEK – *Članek je pregled slovenskih paleolitskih 'umetniških' predmetov. Večina izmed njih je bila najdenih pred dolgo časa in so jih kot umetniške izdelke opisali njihovi najditelji, ki pa niso opravili nobenih nadaljnjih raziskav in overitev teh predmetov. Mlajše najdbe, kot je mousterienska 'piščal', so bile temeljito preiskane, vendar v primeru piščali še vedno ni enotnega sporazuma ali so jo uporabljali kot glasbeni inštrument ali ne. Edini predmeti, ki so zagotovo delo človeških rok, so gravirane koščene konice, dva gravirana kamna in trije kosi nakita iz mlajšepaleolitskih najdišč.*

KEY WORDS – *Slovenian Palaeolithic; Palaeolithic art; flute; engravings; jewellery*

Majority of the Palaeolithic art objects in Slovenia require reassessment, as most were excavated decades ago and never properly examined, or were lost after excavation. The best known is a Neanderthal 'flute' from Divje babe I (Fig. 1). The purpose of this bone has been disputed since its resurrection and the debate continues. Some believe that the holes are artificial (*Turk et al. 1997; 2003; 2005*), while others are not convinced (*d'Errico et al. 1998; Chase P. G. & Nowell A. 1998*).

The flute was found in the Mousterian horizon D, in the breccia layer near one of the hearths. It is made from the bone of a cave bear cub (*Turk et al. 1997*). It has aged in the last 10 years from about 45 000 (*Turk & Kavur 1997.149*) to about 60 000 years (*Turk et al. 2007.148*). It is impossible to determine with certainty if the holes in it are artificial, or were made by animals or other natural agents, but Turk and his co-workers conducted a series of experiments which show that it is more likely that the holes were made by a human than an animal. They demonstrated that drilling is not the only way to produce holes in bone, and that a bone or stone awl with a blunt tip could also be used. Such chiselled holes do not differ from those made with teeth and there are no traces of the production tool on their edges. On the other hand, it is very unlikely animals could damage bone in such a way that it would resemble a flute. Biting the bone with canines would not produce holes in a straight line and the bone would break before being punctured (*Turk et al. 2003*).

The holes of the 'flute' were examined by multi-slice computed tomography (MSCT). With this method it was possible to distinguish four holes. One was probably made by a carnivores, while other three were artificial. All the other damage made by the carnivores (mostly gnawing) was subsequent to the production of the holes (*Turk et al. 2005*). It is quite probable that the holes are anthropogenic, and given the age of the flute, could only have been made by Neanderthals. But, of course, even if the holes are artificial, the bone might appear to be a flute only from our Modern perspective, but not for Neanderthals, who might have used it in a totally different way.

Should we change our view of Neanderthals because of the flute from Divje babe I, and accept them as the first artists? But why is Neanderthal art so scarce and simple? Why did they create only simple lines or uncomplicated geometrical designs on stones and bones? Why are there so few coloured objects – like the polished mammoth tooth lamella with traces of ochre from Tata (*Marshack 1990*), if ochre or black pigments are quite frequent in Mousterian layers?

What we today call 'Palaeolithic art' is a form of communication. By painting pictures on the walls of caves or by making figures, Ice-age artists made the information durable, and accessible even to people with whom they were not in direct contact. Perhaps this form of communication could not spread, because Europe was too scarcely populated in the Middle Palaeolithic. Even if there were some simple artistic achievements, they could not develop further, because communication between Neanderthal groups was limited. So innovations were not widespread, but restricted to the group which invented them. If groups were small and far apart and the amount of information was rather limited, there was no need for the external and more permanent storage of knowledge, which developed later in the Upper Palaeolithic.

Sophisticated art as carrier of information was not possible until humans were able to form complex communication systems to transfer information to others. Only in such systems could the development of external storage systems and symbolic thought that we today perceive as Palaeolithic art have occurred. But such systems did not develop if the population was thin and uninterested in the extensive exchange of knowledge and ideas.

Groups of Neanderthals probably communicated their knowledge inside the group and much less to outsiders. Communication between people in close contact can be transmitted with gestures and voices. There is no need for images as visual mediators of ideas and knowledge, particularly if there is little information to be exchanged. If Neanderthals communicated with voices, then sounds, and consequentially, music were familiar to them. Words and sounds are suitable for transmitting knowledge, but with music it is possible to express feelings and also to comfort and entertain others. Experiencing comfort together might have consolidated bonds among the members of the group. Since the invention of the flute was not communicated to outsiders, it died out with the group.

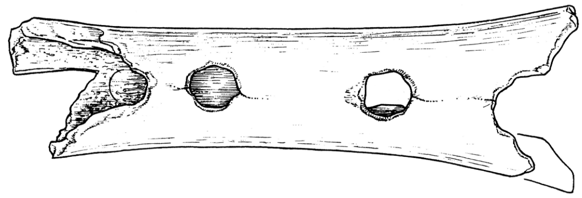

Fig. 1. Neanderthal 'flute' from Divje babe I (after* Turk & Kavur 1997a. sl. 12.1/1*).

There is a similar difficulty with so-called flutes from Slovenian Aurignacian sites – it is not certain if the holes are artificial. In Potočka zijalka, a cave bear lower jaw with a widened entrance to the nerve canal and three additional successive holes was found (Fig. 2), which the Brodars interpreted as a flute (*Brodar and Brodar 1983*). Similar jaws or 'flutes' are also known from Mokriška jama. Mitja Brodar believes that the holes are not pathological and that they might have been produced artificially. But he states that if there are no traces of stone tools, it is difficult to distinguish between holes made by animal gnawing and those made by humans (*Brodar 1985*).

Besides being potential musicians, Ice-age visitors to Potočka zijalka also engraved bone points. Approximately one third of the bone points from this site are engraved. There are two types of engraving: the first has parallel lines along the edges of the point; while the second has spirals winding around the point (Fig. 3). Most are very delicate (*Brodar 1935; Brodar & Brodar 1983*). They might be a form of counting or annotation of periodical events (a type of calendar). A recent interpretation of these engravings is that they were made for practical reasons – to facilitate the production of bone points (*Odar 2009*).

Fig. 2. Aurignacian 'flute' from Potočka zijalka (after* Brodar & Brodar 1983.sl. 57*).

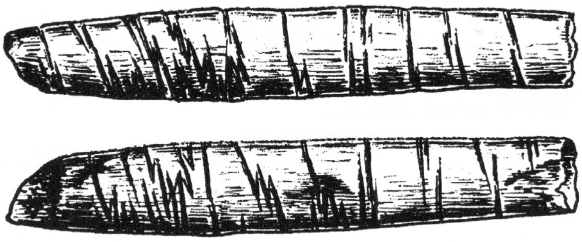

Fig. 3. Aurignacian engraved bone point from Potočka zijalka (after* Brodar and Brodar 1983.T8/97*).

An engraved bone was found in the Tardigravettian layers In Ciganska jama cave (Fig. 4). Brodar (*1991*) interpreted the lines as schematic female representations, but he states that the incisions were not made with stone tools, but with a carnivore canine. After renewed examination of the bone, it was found that the incisions are almost certainly natural, caused by plant roots.[1] Similar traces were described by D'Errico and Villa (*1997*).

It is interesting that engravings resembling those on the bone were recently found on a wall in this cave, but they are made in the fresh layer of calcite film on the wall, so they are recent and probably natural formations (Fig. 5).

Fig. 4. 'Engraved' bone from Ciganska jama (after* Brodar 1991.sl. 11*).

Fig. 5. Infrared photograph of the 'engravings' on the wall of Ciganska jama cave (photo Žiga Šmit).

This is an example of how easily we can be led by similar forms and wishful thinking to the conclusion that natural forms are some sort of prehistoric art, and how essential it is to find strong evidence for statements that objects are anthropogenic.

At beginning of the 19th century (*1819*), the lower jaw of a cave lion with an unusually shaped canine was found in Postojna Cave (Fig. 6). Freyer, who found the jaw, decided that it should be the part of the collection of the newly opened Land Museum in Ljubljana. Much later, S. Brodar suggested that the canine might have been artificially shaped to resemble an animal head, probably the head of a cave lion – that is the same animal species to which the jaw belonged. He excluded natural agents which could be responsible for the unusual shape of the canine. He also excluded the possibility that the canine was damaged by humans during the use of the jaw for different tasks like skinning and scraping hides, or as an axe, but he suggested that it might have been 'core' used for knapping some sort of 'tooth flakes'. Meanwhile, another researcher, Kos, described the jaw as an example of natural damage which occurred during the life and shortly after the death of the animal (*Brodar 1951*).

Brodar also suggested that three of the cave bear teeth from Potočka zijalka were artificially shaped, so that they resembled birds (*Brodar 1951*). But the teeth have been lost and so it is not possible to verify if they were really shaped by people, or if they were natural forms, and it was just wishful thinking that they represent Palaeolithic art. The interpretation of the teeth as 'birds' is probably merely example of the human need to place forms within known frameworks and associate them with something fa-

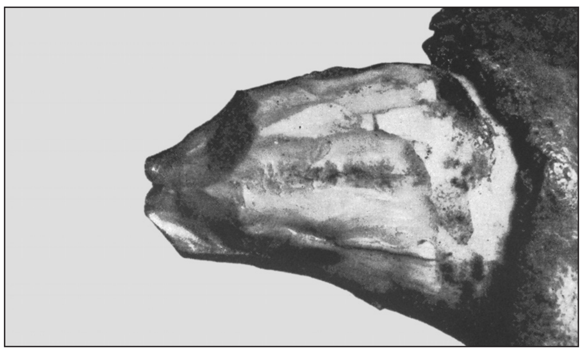

Fig. 6. Cave lion canine, which resembles the head of a cave lion. Postojnska jama, Upper Palaeolithic? (after* Brodar 1951.sl. 4*).

1 I'm thankful to Irena Debeljak, who showed me traces of the plant roots on the bone and enlightened me about natural phenomena on the bone surface.

miliar. People sometimes have difficulty accepting that nature can also be creative, and that it can form shapes which imitate objects made by human activities.

There is an interesting story connected with Slovenian Palaeolithic research, about a probable Palaeolithic cave painting somewhere near the spring of the Kolpa river. The story is based on a conversation between Srečko Brodar and a mining engineer called Šimečki. Šimečki told Brodar that a long time before (around 1890 – he was speaking in 1937) he had visited a cave near the Kolpa spring in which he saw something unusual on the wall. At first he thought

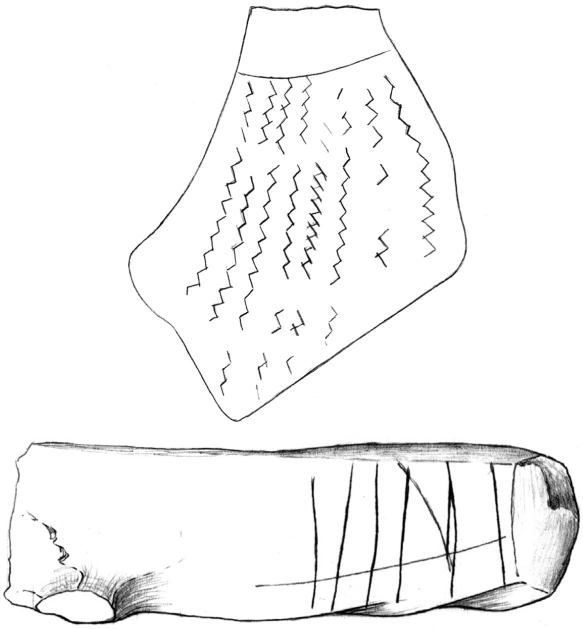

Fig. 7A and B: Engraved stones from Zemono (drawing by Ida Murgelj).

that it was algae, but on closer inspection, he realized that it was a painting of an elephant or mammoth. He also told Brodar that there was a lot of water in the cave. Today, this area is part of Croatia, but Slovenian researchers searched for the cave quite intensively in the time of the former Yugoslavia, but were never able to find it. The most probable candidate is Hajdučka pećina, but because of water it is inaccessible today and no matter how much speleologists and other researchers have tried, they have been unable to get through the narrow cave entrance to the deeper parts of the cave where the painting might be (*Brodar 1978; Josipović 1987*).

All the objects described thus far are more or less open to doubt regarding their artificial or intentional origins, but two stones from the Late Palaeolithic

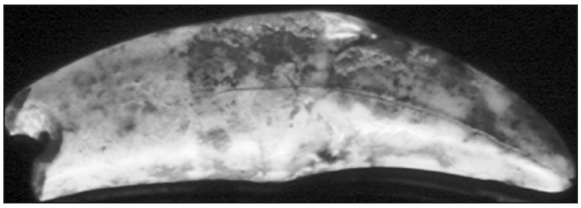

Fig. 8. Canine with hole drilled in the root from Velika Peč (after* Pohar and Josipovič 1992.sl. 1b*).

site at Zemono are undoubtedly engraved with geometric patterns. The incisions are very delicate and hard to detect. On one side of the first stone, there are eight zigzag lines, while on the other side there is a ladder motif and a longer line with smaller perpendicular ones (Fig. 7A). On the second stone (Fig. 7B), there is a much simpler pattern, composed of parallel and perpendicular lines (*Petru 2005*).

The meaning of the patterns can be interpreted in different ways. They could be symbols of water (*Marshack 1979*), or representations of entoptics (*Lewis-Williams & Dowson 1988*), or tallies.

Jewellery

There are three pieces of jewellery known from Slovenian Palaeolithic sites. A perforated Aurignacian or Gravettian canine was found in Velika peč cave, together with cave bear bones and a few stone tools (Fig. 8). The canine belonged to a type of canid, probably jackal. It has a hole drilled into the root of the tooth (*Pohar & Josipovič 1992*).

A similar artefact was discovered in the Tardigravettian layers of Ciganska jama (Fig. 9). It is a part of the upper jaw of a marten. A natural hole in the jaw is artificially widened for use as a pendant (*Pohar & Josipovič 1992*).

The most elaborate piece of jewellery is a ring found in the Epigravettian layers of Babja jama cave (Fig. 10). It is made from deer antler, is 5mm wide and has 22mm in diameter. There are traces of the stone tools used for the

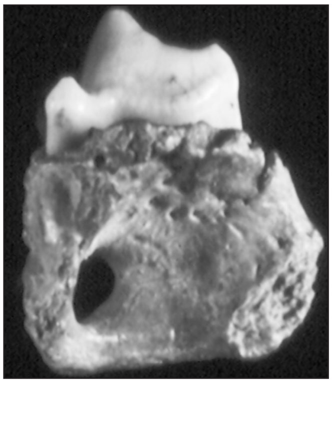

Fig. 9. Upper jaw of marten with artificially widened hole from Ciganska jama (after* Pohar and Josipovič 1992.sl. 2b*).

production of the ring and also traces of charcoal on the surface (*Pohar & Josipovič 1992*).

Pieces of ochre have been found in the cultural layers of many Palaeolithic sites. At Ciganska jama, particularly in the lower cultural layer, there were many small grains of this pigment. Grind-stones with traces of ochre were also found at three Late Palaeolithic sites (*Petru 2006*). All this indicates the use of the pigments in the Slovenian Palaeolithic. Of course, ochre can be used for practical reasons, but even if people at first used it in such a manner, they would probably have quickly recognised its dyeing potential, so the finds should not be overlooked.

Objects of an unquestionably artistic nature have rarely been found at Slovenian Paleolithic sites. But Slovenia probably was not a blank spot for Palaeolithic artistic aspirations. A possible explanation for the dearth of Palaeolithic art might be that most of the sites were excavated rather long ago without the deposits being sieved, so some artefacts might have been overlooked. The other reason might be climate, which has not allowed much cave art to survive. We can only hope that future excavations will bring surprises, like the engraved stones from Zemono, and that new surveys of caves for possible engravings will reveal the first Slovenian cave art.

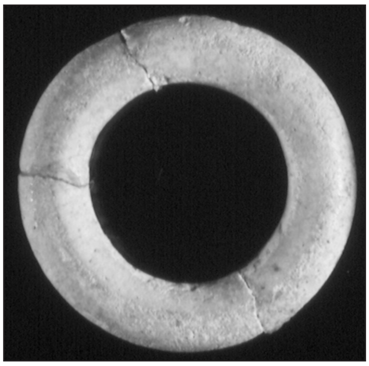

Fig. 10. Ring from Babja jama (after* Pohar and Josipovič 1992.sl. 3b*).

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Lithics in the Neolithic of Northern Greece: territorial perspectives from an off-obsidian area

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ABSTRACT – *C. Renfrew's research in the Aegean at the beginning of the 1970's and his hypothesis on the diffusion of obsidian from the island of Milos greatly influenced views of Greek Prehistory. Further lithic studies, especially in the Southern Aegean, have served to further confirmation the prevalence of obsidian in this area during the Neolithic. The aim of this paper is to draw attention to areas such as Northern Greece that are situated on the periphery of the Melian obsidian domain, where local materials occur in connection with imported ones from the North and South. With the aid of various examples from major Neolithic sites, we will discuss the question of procurement strategies in association with the reduction sequences of each material in use in this region, and outline trends of territorial organization among Neolithic farmers in the area.*

IZVLEČEK – *Na poglede o grški prazgodovini so močno vplivale raziskave C. Renfrewa na egejskem področju v začetku 1970- ih in njegova hipoteza o razširitvi obsidiana z otoka Milos. Nadaljnje proučevanje kamenih orodij, posebej v južnem Egeju, je služilo dodatni potrditvi o prevladi obsidijana v neolitiku na tem področju. Cilj članka je opozoriti na področja, kot je severna Grčija, ki leži na obrobju območja melijskega obsidijana in kjer se lokalni materiali pojavljajo v povezavi s tistimi, ki so uvoženi iz severa in juga. S pomočjo različnih primerov iz večjih neolitskih najdišč, bomo pretresli vprašanje strategij pridobivanja surovin v povezavi z redukcijskimi sekvencami vsakega materiala, ki so ga uporabljali na tem področju, in opisali smernice teritorialne organiziranosti med neolitskimi poljedelci na tem področju.*

KEY WORDS – *Neolithic; northern Greece; chipped stone industries; Dikili Tash-honey-Balkan flint*

Introduction

At the beginning of the 1970's, Renfrew's archaeological research in the Aegean and his hypothesis on the diffusion of Melian obsidian had an important impact on Greek Prehistory (*Renfrew, Cann & Dixon 1965; Renfrew 1973; Torrence 1986*). In the 1980's, the discovery of obsidian in the final Palaeolithic levels in the Franchthi Cave highlighted this lithic raw material as an extraordinary marker of early navigation in the Aegean (*Perlès 1979*).

More recent lithic studies undertaken by the author in the Southern Aegean have served to further confirm the prevalence of obsidian during the Recent Neolithic in this area. In two caves, Sarakinos, in Central Greece (*Kourtessi-Philippakis et al. 2008*) and Alepotrypa, in the Southern Peloponnese (*Kourtessi-Philippakis 2008*), obsidian occurs in remarkably high percentages, *i.e.* 94.15% and 91.50% respectively, alongside some tools from various categories of flint which are considered to have been brought ready-made to the settlements. In other words, the raw material distribution pattern in the Southern Aegean during the Recent Neolithic is characterized by a double 'importation'; a massive importation of obsidian from Milos and a minor importation of tools from flint of unknown origin. In territorial terms, we observe the existence of a 'koinê' characterized by the massive Melian obsidian distribution on a regional scale, while the local flint resources, notably those in continental areas, are neglected.

While the pattern of raw material distribution in Southern Greece during the Recent Neolithic has drawn increasingly more attention (*Perles 1990; Demoule & Perles 1993*), research on this topic in areas on the periphery of the Melian obsidian domain has just started.

The case of Northern Greece, from the river Evros in the East to the Pindos Mountains in the West, is particularly interesting in this respect. In this area, human settlement at open air sites – named 'toumba' – formed by the accumulation of sediments (*Kotsakis 1999*) was abundant especially during the Recent Neolithic (*Andreou, Fotiadis & Kotsakis 1996; 2001*). The present paper will focus on sites situated in the Drama basin, where extended surveys (*Grammenos & Fotiadis 1980; Grammenos 1991; 1997*) and important excavations have taken place since the 1970's at major sites such as Dikili Tash (*Treuil 1992; 2004; Koukouli-Chryssanthaki et al. 1997b*), Sitagroi (*Renfrew et al. 1986; Elster & Renfrew 2003*), and Dimitra (*Grammenos 1997*). We will focus on the archaeological level that coincides with the beginning of the Recent Neolithic (Recent Neolithic I phase), particularly from the end of 6th to the beginning of the 5th millennium BC, and also take into consideration settlements in Eastern or Western areas (Fig. 1).

The Dikili Tash I assemblage

The lithic assemblages of the Recent Neolithic I phase, according to the Dikili Tash archaeological material (*Kourtessi-Philippakis 2006b; forthcoming*), are chipped in an important variety of raw materials identified macro and microscopically (*Garnaud & Frohlich in preparation*), including chalcedony, quartz, rock crystal, jasper, various categories of flint, among which are Balkan 'honey' flint, and obsidian. The chalcedony reduction sequence appears to be rather complete. Even if nodules of chalcedony are missing, we find cores and technical pieces in small quantities, flakes, blades, chips smaller than 1cm, abundant debris, as well as retouched or *a posteriori* tools. Prismatic cores do not exceed a length of 5cm and can be considered exhausted, since few of the blanks are situated below this limit (Fig. 2). Tablet cores and crested blades are scarce (0.80%). Debitage products are mostly flakes (50%), which dominate over blades (9%). Chalcedony blades feature unparallel arris and edges (Fig. 3). The debitage technique used was direct percussion for flake and indirect for blade production. The technological structure of the chalcedony assemblage and, particularly, the absence of tested nodules, the low occurrence of cortical flakes and technical pieces make us suggest that the first stages of the reduction sequence (testing nodules, decortication…) took place off settlements. In contrast, the high occurrence of flakes and debris, as well as chips smaller than 1cm, suggests that the stages of production of blanks and re-sharpening of tools took place inside the settlements. Chalcedony at Dikili Tash I occurs in very high percentages (47, 16%).

Among the various categories of flint, 'honey' flint is the most interesting (Figs. 3, 4). Its reduction sequence is not complete. No nodules, cores, first flakes, decortication flakes, or debris of 'honey' flint were found. It is obvious that the decortication and debitage stages took place elsewhere, outside the Drama basin, and debitage products arrived at the settlements ready for use. These blanks were regular blades with parallel arris and edges and a trapezoidal section. The width of these blades varies from 11 to 22.2cm, and their thickness from 3 to 5.5cm. These

Fig. 1. Northern Greece, with the Neolithic sites mentioned in the text: 1. Dikili Tash, 2. Sitagroi, 3. Dimitra, 4. Promachonas-Topolnitsa, 5. Stavroupolis, 6. Thermi B, 7. Paradeisos, 8. Paradimi, 9. Makri.

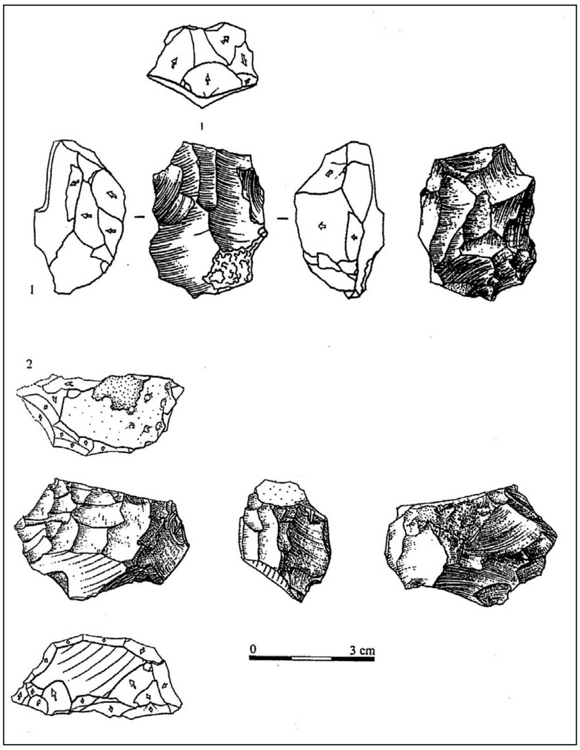

Fig. 2. Dikili Tash lithic assemblage. Cores. Chalcedony (drawings J. Espagne).

modules indicate that blades were produced during the phase of 'full' débitage. Generally, tools were used extensively with a shortened blank. In certain cases, tool re-sharpening was done *in situ* as the important number of chips of 'honey' flint smaller than 1cm indicates. These chips could also be the result of the use of splintered pieces. At Dikili Tash I, the various categories of flint reach 15.45%, and honey flint 8%.

Quartz was also chipped, as indicated by the number of tested blocs and debris. The aim was the production of flakes probably used without retouch. The example of a perforator from Dikili Tash is unique. Quartz occurrence is 3.60% at Dikili Tash I.

Rock crystal occurs in polyhedral blocks, a lot of debris, small flakes, and blades without retouch. Polyhedral blocks measure 24 by 26mm. The length of the complete flakes ranges between 20 and 22mm, and the width between 13 and 20mm. Bladelets do not exceed 20mm in length, and their width varies from 4 to 6mm. Butts are small, mostly linear. The technique of rock crystal debitage was implemented by pressure. Rock crystal occurs in low percentages, such as 2.38% at Dikili Tash I.

The jasper reduction sequence is complete. Besides scarce nucleus and technical pieces, debris is also present. The aim of the debitage was to produce flakes, as well as blades which were used as blanks for tools. If we compare the jasper reduction sequence to those of the other raw materials, we observe that it is more similar to the chalcedony one. So far, jasper has been considered as a local raw material. Its occurrence at Dikili Tash I is 1.25%.

The few pieces of obsidian which occur in this assemblage are essentially non-retouched bladelets, mostly mesial fragments of triangular or trapézoidal section. (width 8–9cm). This debitage module is very common in the Southern lithic Neolithic assemblages, as we have seen in Sarakinos and Alepotrypa. These bladelets were probably imported from Southern Greece into the Drama basin settlements. Obsidian occurrence at Dikili Tash is 0.37%.

Regional comparisons

A comparison of the raw material occurrence to those of neighbouring Neolithic settlements shows many common points.

In the Dimitra II phase (*Kourtessi-Philippakis 1997*) the same raw materials occur as in Dikili Tash I. Chalcedony is prevalent (40%), followed by 'honey' flint (26.49%), and quartz (21.95%), which are featured more in this settlement than in Dikili Tash. Jasper and rock crystal (2.24%) constitute, as at Dikili Tash, a category with low representation. Obsidian is absent in the Dimitra II phase. The reduction sequence of each of these raw materials is organized according to the pattern known from Dikili Tash.

In the Sitagroi II phase (*Tringham 2003*) the same raw materials occur. However, at Sitagroi, 'honey' flint is prevalent (73.3%) and, according to Tringham, was chipped *in situ*. This constitutes an exceptional trend in lithic assemblages in Northern Greece. Chalcedony follows with a rather low representation (9.2%), as well as quartz and rock crystal (7,7%), while obsidian is absent in the Sitagroi II phase. The reduction sequences at Sitagroi suggest the chipping *in situ* of chalcedony and quartz.

If we attempt a comparison with other distant settlements, for example Promachonas-Topolnitsa, near the Greek-Bulgarian border (*Koukouli-Chryssanthaki et al. 1979a*), we observe (*Kourtessi-Philippakis 2001*) that in this settlement various categories of flint are used, with a preference for a blue opaque flint which was chipped *in situ*. We also observe the occurrence of 'honey' flint (15%), chalcedony (20%), quartz (15%), while jasper, obsidian, and rock crystal occur in percentages lower than 1% for each one of these materials.

The picture in the Eastern regions beyond the River Nestos is rather incomplete, as lithic assemblages come either from old excavations, such as Paradimi, (*Bakalakis & Sakellariou 1981*), where no emphasis was placed on lithics, or sites such as Paradeisos, where the Recent Neolithic I phase is not represented (*Hellstrom 1987*), or even from new excavations, such as Makri, where only preliminary reports are available (*Skourtopoulou 1998*).

However, the situation changes in western regions and particularly Central Macedonia, between the Strymon and Axios rivers. We observe that the Neolithic settlements of Central Macedonia and especially Thermi B and Stavroupolis, where lithic assemblages have been the object of a specialized study, feature a very different pattern. In Thermi B (*Skourtopoulou 1992*) a local flint (61.90%) is preponderant, followed by quartz (35.3%), various categories of flint, chalcedony, and a few pieces of obsidian. In Stavroupolis (*Skourtopoulou 2004*) quartz occurrence is very high (54.6%). Second to quartz are other local materials, limonite (12.6%), and Melian obsidian, alongside small quantities of various categories of flint and a few samples of chalcedony. In this preliminary report it is stressed that local raw materials such as quartz and limonite were chipped *in situ*, while flakes or blades made from exotic materials arrived at the settlement ready to be used.

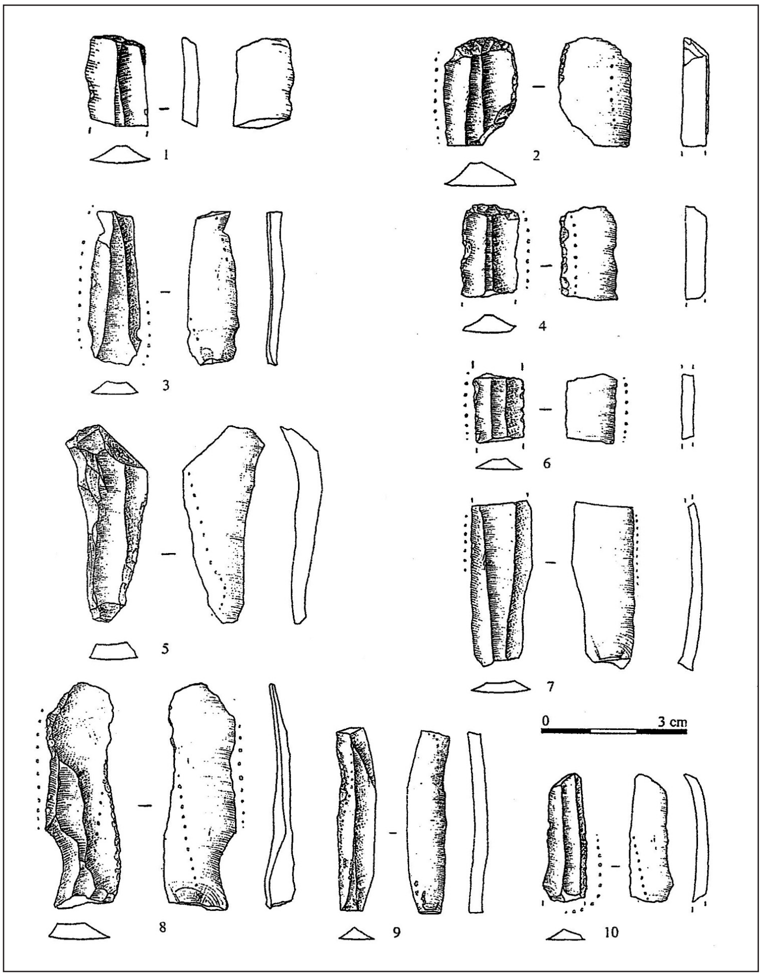

Fig. 3. Dikili Tash lithic assemblage. Sickles. 1: honey flint ; 2–4: flint; 5–6: burnt; 7–10: chalcedony (drawings J. Espagne).

Discussion

How can we explain the northern Greek pattern? A look at the lithostratigraphic map of Greece and its organization in vertical juxtaposed zones in the North/West-South/East direction could shed some light on this topic.

The Rhodopian zone, in which Dikili Tash, Dimitra, and Sitagroi are situated, is mostly comprised of chalcedony, followed by quartz and rock crystal. Chalcedony appears in outcrops near the mouth of the Strymon close to the Serbo-Macedonian zone in the west. Quartz exists in veins in granites, and rock crystal is found in rhyolites, which are abundant in the Rhodopes. Further west, we meet the Vardar zone, which coincides with the Axios basin. Its eastern part features predominantly schists, sandstones, and conglomerate with quartz, while the western part features jaspers. The Pelagonian zone, which follows, is composed of a metamorphic substratum on the top of which, under ophioliths, occur some siliceous levels and especially jaspers. Finally, the Pindus zone, which covers the Pindus Mountains, is rich in red jaspers, with radiolaires and flints outcrops in the Cretaceous lime-stones.

The low, but uninterrupted occurrence of jasper in northern Greek Neolithic assemblages calls for some comments. According to the geological data, jasper occurs in the primary position in the Pelagonian and Pindus zones, farther away from the Drama basin. It is important to stress that these 'geological localisa-

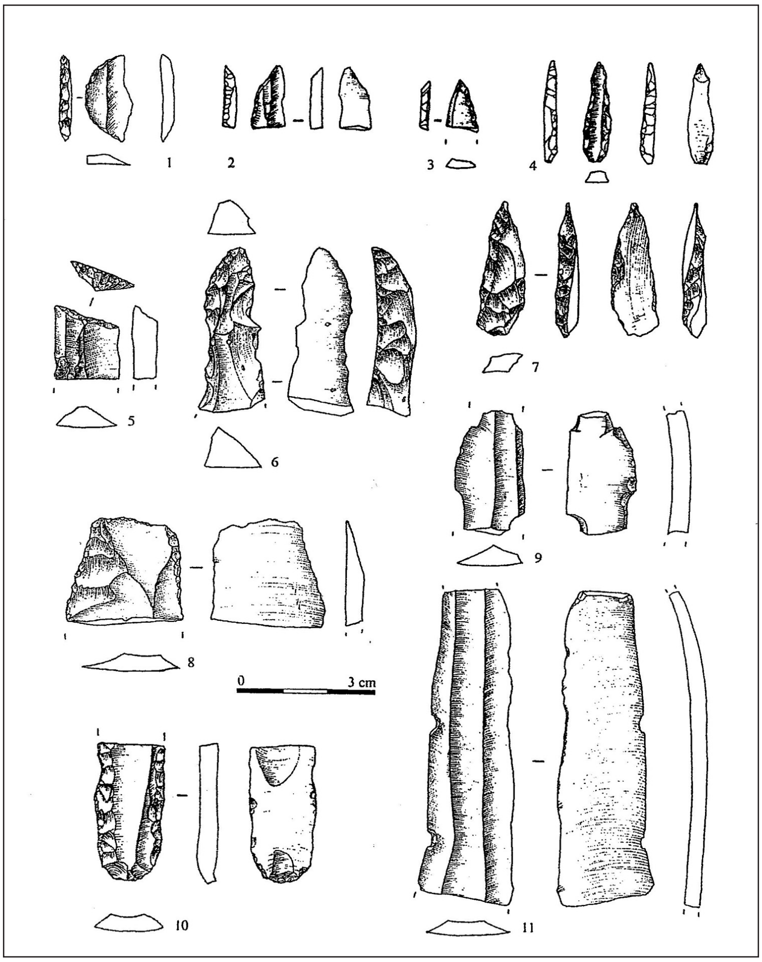

Fig. 4. Dikili Tash lithic assemblage. 1–3: backed pieces-chalcedony; 5: truncation-burnt; 4, 6, 7: perforators-flint; 8: retouched blade-flint; 9: burin-flint; 10: retouched blade – honey flint; 11: notched blade – honey flint (drawings J. Espagne).

tions' are derived from very general studies of the geological and lithological substratum in the area. It is very probable that jasper outcrops also occur in the Drama basin and have not been mapped so far (*pers. comm. from L. Dimadis*). On the other hand, jasper was introduced into Neolithic settlements in the form of small pebbles, with cortex collected in secondary sources of raw material. Indeed, if jasper does not occur in the primary position in the Rhodopian zone, it could be an excellent marker for the study of relations between East and West in Northern Greece. East-West relations could account for a new perspective of research in the area, which has been focussed on the diffusion of raw materials and cultures in the axe North/South along the natural routes of, among others, the Strymon and Axios.

'Honey' flint and obsidian do not occur in outcrops in the Rhodopian zone, or in Northern Greece. The use of 'honey' flint is extensive in the settlements and its occurrence reaches high percentages. This raw material has also been distributed in Greece, as attested by artefacts found in Neolithic sites of the Peloponnese (*pers. comm. from J. K. Kozłowski*). Nevertheless, its origin is still unspecified. Researchers (*Manolakakis 2005; Tringham 2003*) suggest a north-east Bulgarian origin, but so far no petrological characterization of this material has been conducted. It is important to stress that if 'honey' flint is present in Thrace, Eastern and Central Macedonia, it seems to be absent from the Neolithic settlements of Western Macedonia. Could the distance of these western areas from the main routes of distribution in the North/South direction be one of the reasons for this absence? Obsidian in Northern Greece is, with some exceptions, Melian in origin, as was demonstrated by the analysis carried out on a pan-Hellenic scale of the characterization of prehistoric obsidians organized by the 'Democritus' Archaeometric Centre in Athens. These two raw materials were imported, as indicated by the reduction sequence and the occurrence of blades only.

The composition of Neolithic lithic assemblages in relation to the lithostratigraphic structure of Northern Greece reflects the impact of an important parameter, the physical, which is essential to the relation between the following: lithological background/ settlement/raw materials in use. It is important to stress that chalcedony and quartz were the principal raw materials used by Palaeolithic people in the area. This observation also confirms the local/regional origin of these two materials.

But other parameters, such as the technological, essential to the relation between the following: available raw materials/technological skills/researched products, *i.e.* flakes or blades, and the economic: raw material availability/procurement modalities are also crucial for our understanding of Neolithic societies. Unlike in Palaeolithic hunter-gatherer societies, the availability of raw materials was not the principal criterion for Neolithic settlement. In Northern Greece, Neolithic inhabitants collected the local materials probably in secondary sources of raw material, except chalcedony, but this pattern has yet to be confirmed by further research.

Furthermore, a fourth parameter is territorial, which pertains to the relation between the following: sources of raw material/appropriation of the space/sources control and exploitation, and leads us to the following question: how was accessibility to lithic resources, whether primary or secondary, natural or cultural, organized in Northern Greece, and what happened to the distribution networks of raw materials and debitage products? In other words, what is the significance of the notion of territoriality in the Neolithic societies of Northern Greece? In the north, we observe the exploitation of local/regional lithic resources with limited imports. But the northern network is at the same time more complex, because it accounts for many different raw materials of different origins. This contrasts strongly with the pattern in Southern Greece, which is characterized by 'importation', as stressed in the introduction.

Another question raised is the following: can the low occurrence (decrease) of the obsidian in Northern Greece be explained only by the distance from Milos, according to the model proposed by Renfrew – if 'honey' flint comes from northeast Bulgaria the distance is equal and 'honey' flint is abundant – or by the position of the Melian sources to other procurement and distribution networks in Southern Greece? The aim of this proposition is not to rekindle the age-old debate about Northern Greece 'going' with the North or the South (*Heurtley 1939*), but to highlight the territorial parameter for a better understanding of what happened in Northern Greece. Therefore, it is important to take into consideration new approaches and to carry out increasingly more lithic studies in this direction.

Conclusions

In conclusion, in Northern Greece and in contrast to the south, a complex system of lithic raw material procurement was in use. A first group includes local raw materials, such as chalcedony, quartz, rock crystal, and different flints; they were derived from primary or secondary sources of raw material, where they had been tested beforehand in order to transport them to settlements, where the debitage took place, sometimes inside habitations. A second group is constituted by imported materials, such as Melian obsidian from Southern Greece, and 'honey' flint from northern areas, probably in northeast Bulgaria. Blades of 'honey' flint and bladelets of obsidian ready to be retouched were imported to sites. These two imported materials suggest contacts and communications with long-distanced areas, probably by indirect procurement. Jasper constitutes the third group. Outcrops of jasper are situated beyond the Axios River, in the Pindos Mountains in Western Macedonia. If this material indeed originated farther away from the Drama basin, jasper could help us to explore relations between East and West.

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Lithic raw material procurement in the Moravian Neolithic: the search for extra-regional networks

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ABSTRACT – *The study of lithic raw material procurement can contribute to the study of ancient networks. Petrographic analysis combined with systematic mapping of raw material outcrops has been conducted in Moravia and adjacent territories by A. Přichystal over a period of more than three decades. Combined with well excavated (including wet-screening) and ^{14}C (radiometric) dated sites, allows us to study changes in the distribution networks of raw materials during the Mesolithic and Neolithic periods.*

IZVLEČEK – *Študij oskrbe s surovinami lahko prispeva k razumevanju povezav v prazgodovini. A. Přichystal je petrografske analize v povezavi s sistematičnim kartiranjem najdišč na Moravskem vodil več kot trideset let. Dobro izkopana in ^{14}C datirana najdišča omogočajo študij sprememb v mezolitskih in neolitskih surovinskih distribucijskih mrežah.*

KEY WORDS – *Moravia; Neolithic; raw materials; networks; ^{14}C chronology*

Introduction

Since Neolithic cultures were first defined (*Palliardi 1914*) within the Middle Danube area, the main focus has been on pottery at the expense of other forms of material culture. The same trend may be documented during the entire 20th century; however in its last decades several researchers changed their focus to the study of stone tools, both from the viewpoint of raw material utilized for their production and their typology (*e.g.* Přichystal, Mateiciucová). Since the year 2000, stone industries have attracted greater attention within the Moravian archaeological community (I. Mateiciucová, M. Vokáč, M. Kuča). This paper continues this trend by looking at the Moravian Neolithic mainly in terms of the stone industry – combined with ^{14}C chronology and the palaeoclimatic record – while attempting to summarize contemporary research questions and preliminary results. In recent studies, the role of pottery has declined. Although the authors acknowledge the important role of pottery analyses, this study aims to take an innovative approach to Neolithic development in the region.

Methodology

The analysis of raw material networks, particularly the distribution of specific varieties of raw material on the eastern Central European scale, has been the subject of several publications. While Lech (*2003*) studied the distribution of many types of siliceous rocks, Groneborn (*2003a*) focused on the distribution of several specific raw materials (Szentgál-type radiolarite, obsidian, Maas valley silicite, and Wittlingen chert). It is fruitful to study these raw material networks and compare them with hypothetical and radiocarbon record based models (*Bocquet-Appel et* *al. 2009*) of diffusion of the LBK and other Neolithic cultures across the European continent. Recently, Mateiciucová (*2002*) analyzed LBK raw materials from the Middle Danube area (Ph.D. thesis) and Kuča (*2008*) focused on the supply of Neolithic raw materials in a particular micro-region of the Brno Basin. One set of limitations regarding the methods used in Moravia is posed by the necessity of working with assemblages excavated and collected over a long period, by different people using different excavation methods, and often lacking in information concerning possible contamination by older or younger material (the majority of sites are poly-cultural). The lack of (or inconclusive) radiocarbon dating results is also a problem. Therefore, we have selected a set of reference-sites that we deem representative of each culture and cultural phase. The selected reference sites were excavated using modern field techniques (including wet-sieving and precisely fixing the provenance of all items) and dated using absolute dating methods. It will be necessary to excavate more such reference sites in Moravia in the near future.

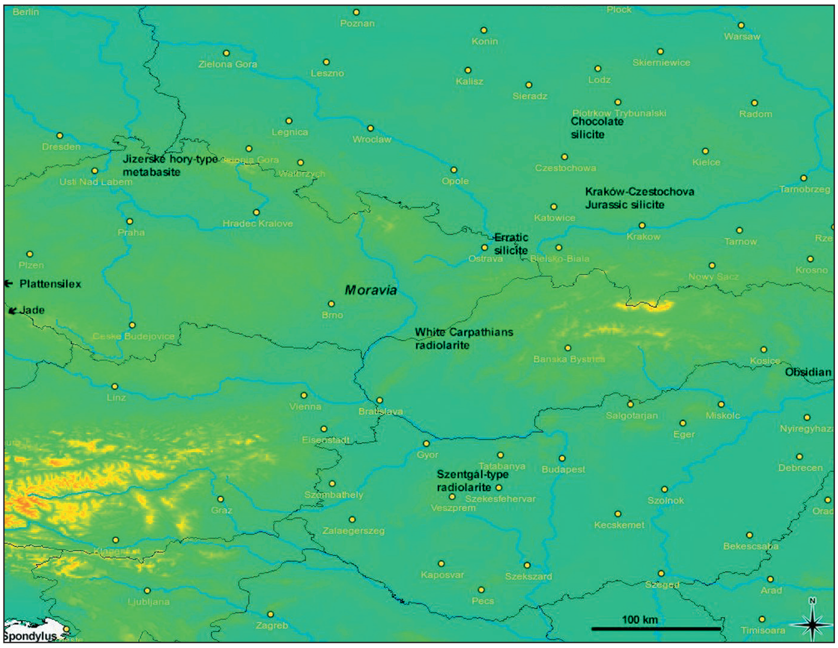

Fig. 1. Map showing raw materials imported into Moravia.

An important innovation in lithic raw material studies has been the development of a non-destructive method of sourcing raw materials. Using this method, it has been possible to determine the source of many (hundreds to thousands) chipped artefacts. The method involves matching chipped silicic artefacts with raw materials from geological sources using a stereomicroscope with water as an immersion liquid (*Přichystal 2002b*). This research has resulted in the sourcing of thousands of Neolithic chipped artefacts which, in turn, has made it possible to reconstruct raw material distribution networks.

The geographical and geological setting of Moravia

Moravia is a historical geographic unit (land) currently constituting the eastern half of the Czech Republic. From a geographical and geological point of view, Moravia lies on the boundary between the Western Carpathians in the east and the Bohemian Massif in the west, and also on the Black Sea (Danube, southern Moravia), and the Baltic Sea watershed (Oder River, northern Moravia). The relief of Moravia consists of river valleys surrounded by highlands. The river valleys are connected by gates which form a system of passages – communication routes which connect eastern and western, northern and southern Europe (*Svoboda et al. 1996*).

During the last glaciation Moravia was a periglacial zone between the Alpine and Fenoscandinavian ice sheets and allowed movements (migrating animal herds, hunter-gatherers, raw materials) in both of the above-mentioned directions. After the LGM, people penetrated Moravia from both western and eastern refuges (*cf. Semino et al. 2000*), and the Morava River served as an arbitrary boundary between the western Magdalenian and eastern Epigravettian culture complexes. The north-south became part of the (later period) so-called amber route. These main communication routes are now being utilized for a network of motorways.

The relief, slope erosion and intensive agricultural use of the lowland fields in the past (ploughing has caused erosion and the disturbance of archaeological material located near the surface) has had a negative impact on the preservation of ancient sites.

Local raw materials

The area has highly diverse geology, with many geological units in a relatively small area. This is reflected in the number of local and very often unusual raw materials (of different origin) suitable for both knapped and polished stone working.

The knapped stone industry
The most important locally available raw material is the Krumlovský Les-type chert. The main outcrops are in the Krumlovský Les Highland in southwestern Moravia (*Oliva 1990; Oliva, Neruda, Přichystal 1999*), where the nodules occur as pebbles with a characteristic black cortex (desert varnish) in Miocene gravel deposits. M. Oliva has documented the mining of this resource since the Mesolithic period (*Oliva 2008*). Isolated outcrops of this material, often of low-quality, are also known from another part of Moravia.

Other raw materials have been locally documented and include Olomučany-type chert, Stránská Skála-type chert, rock crystal, and Cretaceous spongolitic chert.

Isolated outcrops of Jurassic Olomučany-type chert are known only from the central part of the Moravian Karst (*Přichystal 1999a*).

The Jurassic Stránská Skála-type chert is present as nodules in organodetritic limestones at Stránská Skála hill on the eastern periphery of Brno (*Přichystal 1994*).

Primary sources of Cretaceous spongolitic chert occur in the general area of Boskovice Furrow (northwest of Brno) and secondary deposits can be found in the gravel terraces of south Moravian rivers (*Přichystal 2002*).

Rock crystal (respectively, smoky quartz, citrine and rose quartz) originates from pegmatites or quartz veins in the strongly metamorphosed crystalline rocks of the Bohemian-Moravian Highlands. This raw material is known to occur in colluvial deposits adjacent to the primary outcrops, as well as in (reworked) river gravels (*Vokáč 2004*); however, Alpine or Polish (Jeglowa) lithic sources may also have been used.

Various kinds of opal and chalcedony masses, which are the siliceous weathering products of various metamorphic rocks (especially of serpentinite), often called 'plasma, chalcedony, or opal', are known mainly from southwestern Moravia (*Vokáč 2004*); however there are less frequently utilized sources in other parts of Moravia and southern Bohemia (*Přichystal 2004*). Because of the nature of this group of raw materials, sources are very difficult to identify unambiguously.

Apart from obsidian originating in the Carpathian region, the use of a very unique and unusual local raw material, moldavite (tektite, natural glass), has also been documented (*e.g. Vokáč 2004*).

The polished stone industry
The sources of hornblende diorite of the Rokle-type, first described by A. Přichystal (*1988*), are in the Svratka River valley and its surroundings (northwestern outskirts of Brno). However, there is currently no direct evidence that it was mined (*cf. Vokáč, Kuča, Přichystal 2005; Kuča, Vokáč 2008; Kuča, Kirchner, Kallabová in print*).

The outcrops of diorite porphyry (porphyric microdiorite) are located to the west of Brno. Dykes of diorite porphyry intrude into both the granitoids and metabasites of the Brno Massif. They have a characteristically low magnetic susceptibility (*Vokáč, Kuča, Přichystal 2005; Kuča, Vokáč 2008*).

Outcrops of the chlorite-actinolite greenschist of the Želešice-type (see *Přichystal 1999b; 2000a; 2000b; Kuča, Vokáč 2008*) occur in the southeastern part of the Brno Massif. This raw material is characterized by a high magnetic susceptibility (1.5–55 x 10^{-3} SI units).

Both primary and secondary outcrops of amphibolites with banded structures are known in the Moldanubicum and Moravicum – geological units forming a strongly metamorphosed core of the Bohemian Massif in southeastern Moravia. Other possible sources are known to exist in the Hrubý Jeseník Mts. (northern Moravia) and the Malé Karpaty Mts. in western Slovakia.

Another important rock type for polished artefacts is eclogite, which is rock typically composed of garnet and pyroxene. There are local sources in the Moldanubicum; however, there are sources of eclogites in the Western Alps that were exploited in the Neolithic (*e.g. D'Amico, Starnini 2000*), and we cannot exclude the possibility that they were also imported from north-western Italy, as has been documented for jadeitites.

Culmian siltstones and silty shales are dark grey, fine-grained rocks from Lower Carboniferous formations in northern Moravia (Nízký Jeseník Mts.) and central Moravia (Drahany Highland, Maleník block). Greywackes used for polished hammer-axes occur in the same geological units (*Janák, Přichystal 2007*).

Cenozoic volcanics (basalts, phonolites, andesites) are known from several outcrops within the Middle Danube area, *e.g.* in northern Moravia, Silesia, northern and central Hungary, southern Slovakia (*Illášová 2001*), as well as northern and western Bohemia. The location of their sources is still being investigated.

Imported raw materials

Imported raw materials are defined as those coming from sources over 30–40km from the site (*i.e.* approximately a one-day walk). These distances are measured from the city of Brno, in southern Moravia.

The knapped stone industry

The radiolarites originating in the Balaton Lake area (*Biró, Regenye 2007*) were imported from the Bakony Mts. in Hungary. Local geologists distinguish several types of radiolarites (*e.g.* Szentgál, Sümeg, Harskút, Úrkút-Eplény). This raw material was imported in the form of whole nodules or blocks. It is approx. 220km as the crow flies from Brno to the sources of the Balaton radiolarites.

Obsidians were transported from Zemplínské Vrchy Upland, currently divided by the Slovak-Hungarian border. The only known obsidian source in Central Europe occurs in this area (*Biró 1981; Illášová, Spišiak, Toronyiová, Turnovec 2004; Přichystal 2004*). This is supported by all the currently available trace elements analyses of archeological finds.

The primary outcrops of the Kraków-Czestochova Jurassic silicite are located within the limestone area between Kraków and Czestochova in southern Poland. These outcrops are approx. 300km from Brno.

The outcrops of so-called chocolate silicite are located in the northern foothills of the Holy Cross Mts. in Central Poland (*Schild 1976*). These outcrops are approx. 420km from Brno.

The outcrops of a tabular banded Plattensilex (Arnhofen- and Baiersdorf type) are located in Bavaria, some 350km from Brno.

The most important Bohemian raw materials are Tertiary quartzites from north-western Bohemia – Skršín- type, Tušimice-type, Bečov-type (*Neustupný 1966; Malkovský, Vencl 1995; Přichystal 2004*). These outcrops are located approx. 260km from Brno.

We define erratic silicite as siliceous raw materials (silicites) collected from glacial and glacifluvial deposits in southern Poland and northern Moravia. The nearest such outcrops are approx. 110km from Brno. While in the northern Moravian sites, this raw material would be classified as local (*i.e.* it is not possible to separate the Polish from the Moravian sources), in central, western, eastern, and southern Moravia, it is an imported raw material.

Jurassic Carpathian or Alpine radiolarites were occasionally used in south-eastern Moravia. They were sourced in the White Carpathians on the Moravian-Slovakian border, or at Mauern, Vienna. These outcrops are approx. 110km from Brno.

The polished stone industry

A group of raw materials called metabasites of Jizerské hory-type comprise the most important raw material frequently utilized for polished artefact production in central Europe. It has low magnetic susceptibility values (0.30–0.80 x 10^{-3} of SI units). The primary outcrops were discovered in northern Bohemia: Jistebsko (*Šrein et al 2002*) and Velké Hamry (*Přichystal 2002a*). The latest characterization of the whole mining area was carried out by Šída (*2007*). The metabasite of Jizerské Hory-type has had a complicated geological history, and from a petrological point of view, it can be described as a thermally metamorphosed greenschist. Some authors prefer to identify this material as hornblende-plagioclase hornfels. These outcrops are some 200km from Brno.

The serpentinites originate from the Moldanubicum, and are characterized by high magnetic susceptibility values reaching dozens of SI units (*Přichystal, Gunia 2001*). Although this material is known from various sites in the Bohemian Massif, the most important source is probably in south-west Moravia (*Weiss 1966*). However, we cannot exclude the utilization of non-Moravian sources, such as those in southern Poland (*Wojciechowski 1983*). The distance of these outcrops from Brno is approx. 210km (in Poland).

Gabbro is a rock used for the production of perforated tools, known sources of which occur in several areas, including the Orlické and Železné Mts. and in Lower Silesia (*Ślęża Hill; Přichystal 1999a.222*). The distance of these outcrops from Brno is around 200km (in Poland).

The commercial term 'jade' often includes one of two very different materials – nephrite or jadeitite. While the only nephrite source in Central Europe has been found near the village of Jordanów in Lower Silesia (*Gunia 2000*), for jadeitite there are sources in the western Alps (*D'Amico, Starnini 2000*). The distance of these outcrops from Brno is around 200km (nephrite) and about 800km (jadeitite).

Neolithic mining of white marble was described at Bílý Kámen hill near Sázava (*Žebera 1939; Přichystal 2000a; 2000b*). The distance of the outcrops from Brno is approx. 140km.

The shells of the mollusc *Spondylus gaedoropus* L., in the central European LBK of anticipated Mediterranean origin (*Lenneis et al. 1995*), were utilized for the production of personal adornments (*Vencl 1959; Podborský 2002*). However, in Moravia the presence of this raw material has been documented not in the earliest LBK, but in later phases of LBK, most frequently as grave goods (*e.g.* in the Vedrovice burial ground, *Podborský et al. 2002*). In Moravia, the importation of this raw material ceased towards the end of LBK, probably as a sequel to changes in interregional distribution networks.

On the other hand, there is evidence that the raw material distribution networks operated in both directions, *i.e.* Moravian raw materials were being exported. Due to their inexperience, lithic analysts and geologists in neighbouring countries often do not identify these materials as Moravian; for example, we were recently able to identify Moravian raw materials (diorites from the Brno area were found in eastern Slovakia, Krumlovský Les breccia in southern Poland, metabasite of the Jizerské hory-type in Austria and Hungary, etc.).

The Late Paleolithic and Mesolithic background

The number of excavated Late Paleolithic sites is very limited because of the lack of sunken features from this period, the absence of loess sedimentation, and intensive erosion during later periods (up to the present). The Late Paleolithic is represented by a local variety – Tišnovian (a local variant of Federmesser-Gruppen), and there are no absolute dates. Only one excavated site (Tišnov-Dřínová site) and several surface collections have been reported. While the local raw materials, often poor in quality, were used in the Czech-Moravian Highland, the erratic silicite and Kraków-Czestochova silicite were used in the Morava River valley, which is located on the main communication route and closer to the sources.

Sandy dunes were the preferred locations during the Mesolithic period. Such sites often poorly preserve organic material, and were intensively disturbed by rodents (*cf. Škrdla, Poláček, Škojec 1999*). Several Mesolithic sites have been excavated and several more surface sites have been reported. The absolute chronology of the Mesolithic period (by 'absolute chronology' we mean calibrated radiometric dates – ^{14}C or AMS) indicates an age range of 9 to 6 millennia BC (*e.g. Valoch 1978; Svoboda 2003*). Mesolithic people used local raw materials, often collected from river gravels; however, Oliva (*2008*) recently documented extraction pits dating back to the Mesolithic in the Krumlovský Les mining area.

The Earliest Linear Band Pottery Culture (LBK) in Moravia

The earliest LBK in Moravia has links to the western branch of this culture and is represented in Moravia by phase Ia, based on the relative chronology developed by Tichý (*1962*), and expanded by Čižmář (*1998*), Pavúk (*2004*), and Pavlů (*2005*). The dating of the occupation discovered recently in Spytihněv has shown that the already well-documented earliest presence of this phase in Moravia dates back to 5420–5220 calBC (*cf. Schenk et al. 2008*). This does not necessarily mean that this was the earliest presence of LBK in Moravia. Another absolute date (5580–5220 calBC, p95%) is available from an earlier excavation at Žopy (*Quitta 1967; Mateiciucová 2002*). Another important site is at Brno-Ivanovice (*Čižmář* 1998), which yielded a date of 5570–5450 calBC (*Stadler et al. 2000*). Similar or identical absolute dates for the earliest LBK have been obtained for the broader region, including Lower Austria, Moravia, Bohemia, and southern Poland. Unfortunately, other examples of important Moravian LBK sites, often still lacking appropriate absolute dating, include Kladníky (*Mateiciucová 2000*), Vedrovice-Za Dvorem (*Mateiciucová 2001*), and Mohelnice (*Tichý 1998*, a Neolithic dendrochronology date exists for this site – 5450 BC).

The earliest Moravian LBK sites are generally located along the main rivers (*e.g.* Morava River) and follow the main natural geographic corridors connecting the Danube and Oder valleys. They are sometimes located on the margins of surrounding highlands, *i.e.* at strategic locations above the main river valleys (on hilltops).

A significant change in raw material procurement in the form of much more extensive raw material networks is observed when compared to the preceding period of the last hunter-gatherers. The raw materials were imported from all directions, often from hundreds of kilometers away. The raw materials that were not imported, or not utilized to a great extent during the previous periods, began to assume greater importance (in the polished stone industry). The raw materials identified at the sites indicate more extensive networks than during the Mesolithic period, and similar or more extensive networks compared to the Upper Paleolithic period. The extra-regional contacts are represented by marine shells imported from the Mediterranean, Krakow-Czestochova Jurassic silicite, northwest Bohemian metabasites, Szentgál-type radiolarite from the Balaton Lake area, and obsidians from eastern Slovakia.

Although we currently have a number of the earliest LBK assemblages in Moravia, we prefer to use the recently excavated site at Spytihněv as a reference site (*Schenk et al. 2008*). This site was excavated to modern archaeological field-work standards (recording the provenance of all artefacts, wet-sieving all excavated sediments), and yielded a collection of characteristic pottery and a representative collection of knapped stone artefacts and several polished stone artefacts. Absolute dates have also been obtained. Another reference site is Žopy, where Pavelčík excavated a sunken feature in the 1950s which yielded a date and a collection of 71 stone artefacts (*Groneborn 1997.169, Mateiciucová 2002*).

The site at Spytihněv (49°9'42.07"N, 17°29'25.83"E – WGS–84) is located on a southerly ridge extending from Maková Hill. The site reaches an altitude of 322.1m above sea level and rises to 135 meters above the Morava River. The site is in a strategic position that allows control of the lower Morava River valley. The collection of knapped stone from Spytihněv consists of 442 items, surprisingly dominated by erratic silicite (49%), followed by Kraków-Czestochova Jurassic silicite (32%). Contacts with the southeast Transdanubian region are indicated by the presence of Szentgál-type radiolarite (13%). The polished stone artefacts from Spytihněv were made from Jizerské Hory-type metabasite and Želešice-type greenschist (*Schenk et al. 2008*). The raw material spectrum is surprisingly rich and indicates intensive contacts with northern Bohemia (metabasites), the Brno area (Želešice-type greenschist), the Kraków-Czestochova area in Poland, the Balaton area (the Szentgál-type radiolarite) in Hungary, and eastern Slovakia (obsidian). The contacts with southern and eastern territories were expected to be similar to the LBK core area; however, the intensive contacts with northern regions from the earliest phase of LBK are important for creating and testing the hypothesis of the spread of LBK further to the north.

The site of Žopy (49°20'11.54"N; 17°35'44.25"E – WGS–84) is located in a brickyard, near the modern town of Holešov. The site is located in the Rusava River valley, a left-bank tributary of the Morava River, in the western foothills of the Hostýn Mountains, at an elevation of 250–255m (the relative altitude above the Rusava River is 12–17m).

According to Mateiciucová (*2002*), Kraków-Czestochova Jurassic silicite prevails (63.1%), supplemented by Szentgál-type radiolarite (10.5%) and erratic silicite (6.6%). Isolated artefacts were made from Úrkút/Eplény-type and Hárskút-type radiolarites, Krumlovský Les-type chert (variety I), and quartz. Details on polished stone raw materials are not available.

The third important site – Brno-Ivanovice – is located on the northern outskirts of the modern city of Brno (49°15'38.001"N, 16°34'47.256"E, WGS–84), in the valley of the Ponávka River. The site reaches an altitude of 255–260m and the relative altitude above the Ponávka is 10–20m. According to Mateiciucová (*2001*), the knapped stone industry was made on Olomučany-type chert (68%), Moravian Jurassic chert (10%), Krumlovský Les-type chert (variety II, 2%), and isolated artefacts were made from Krumlovský Les-type chert (variety I), Kraków-Czestochova Jurassic silicite, Bakony radiolarite and quartz (*Mateiciucová 2000.229*). Details on polished stone raw materials are not available.

The Vedrovice-Za Dvorem site (49°0'59.75"N, 16°22' 16.203"E, WGS–84) is located on the south-eastern slopes of the Krumlovský Les upland and reaches an altitude of 250m. Based on a relative chronology, the earliest phase of LBK is present (Ia, information by Z. Čižmář). Mateiciucová (*2001*) described a collection of 255 artefacts from two sunken features (176 and 179). The collection is characterized by a prevalence of Krumlovský Les-type chert (variety I, 63.5%), Olomučany-type chert (17.5%), Krumlovský Les-type chert (variety II, 9%). Only isolated artefacts were produced from Szentgál-type radiolarite, Kraków-Czestochova Jurassic silicite, and erratic silicite (*Mateiciucová 2001.10*). Relevant details on polished stone raw materials are not available.

This brief introduction to the major earliest LBK lithic collections demonstrates the importance of imported raw materials and contrasts with the limited use of locally obtained raw materials. The radiolarites of Hungarian origin and obsidian from eastern Slovakia (or northeastern Hungary) indicate contacts to the south and east, *i.e.* to the LBK core area, and are traditionally accepted as documenting the spread of the earliest LBK from Transdanubia to Moravia and further north (*cf. Groneborn 2003b; Mateiciucová 2002*). These raw materials constitute around 10–15% of the raw material spectra; the majority of raw materials were imported from northern territories, *i.e.* the opposite direction to the currently suggested Neolithisation. The Kraków-Czestochova Jurassic silicite dominates such early LBK sites in northern Poland, which are dated to the same period (*Boguszewo, Mateiciucová 2000; Malecka-Kukawka 1992*). The similarity in raw material supply patterns over a large area documents the significance of the Kraków-Czestochova Jurassic silicite for the earliest LBK in Moravia and Poland and documents a rapid diffusion of the earliest LBK in the region. The prevalence of the Kraków-Czestochova Jurassic silicite over the Hungarian radiolarites at the earliest Moravian LBK sites enables us to posit an alternative hypothetical route for the Neolithisation of Moravia – from the northern Kraków area (there are several mountain passes through the Carpathians from Slovakia to the Kraków area). Obsidian had been imported into Poland since the Mesolithic period (*Kozłowski 1989.202*). The presence of other imported raw materials such as erratic silicite and northern Bohemian metabasites support this 'provocative' hypothesis.

The end of phase I and middle phase of LBK

During the middle to late LBK (phases Ib to III are based on relative chronology), the occupation continues to penetrate deeply into the highlands and further from the main rivers; however, raw material procurement strategies are still similar to those of phase Ia.

The burial site at Vedrovice-Široká u Lesa, dated to phase Ib based on relative chronology, is one of the most important eastern Central European such sites (*Podborský et al. 2002*). The grave-goods were produced primarily from Kraków-Czestochova Jurassic silicite (37.3%), the local Krumlovský Les-type chert (25.4%), Szentgál-type radiolarite (7.5%), and included isolated artefacts made from Úrkút/Eplény-type radiolarite, reddish-brown radiolarite, erratic silicite and quartz (*Mateiciucová 2002*). Valuable grave goods are represented by a collection of artefacts made from Spondylus shells (*Podborský et al. 2002*).

In the middle phase of the LBK (phase II based on relative chronology, or the Musical Note Pottery phase of the LBK), density of occupation increased. The raw material networks were more extended and the quality of the raw material quality was a significant factor affecting choice. The Kraków-Czestochova Jurassic silicite dominate in the raw material spectra, supplemented in southern Moravia by locally available Krumlovský Les-type chert and Olomučany-type chert. Erratic silicite was almost ignored (*cf. Mateiciucová 2001*). While during this phase the importation of the Szentgál-type of radiolarite was limited (Vedrovice-Za dvorem, Přáslavice-Kocourovec; *Mateiciucová 1997*) to the end of middle phase, and in connection with increasing influences from the east (Želiezovce from south-eastern Slovakia), this raw material again increased in importance (*Mateiciucová 2001*).

The late phase of LBK

Occupation density decreased during the late phase of LBK, and distribution networks changed (*Mateiciucová 2001*). While eastern (Želiezovce) influences disappeared, western influences (Šárka) increased.

Stroke Ornamented Pottery Culture (SPC)

Moravia can be divided into a northern region, where the Stroked Pottery Culture is present, and a south-western, with Early MPWC and the episodic presence of Stroked Pottery Culture (SPC).

With the exception of several graves from Těšetice-Kyjovice – 5915 ± 30 BP, 5920 ± 30 BP, 5960 ± 30 BP, 5970 ± 30 BP, 5915 ± 30 BP, we currently have no radiocarbon dated SPC collections, and only preliminary results based on inadequately excavated collections are available. While northern and central Moravia are characterized by the predominance of erratic silicite (Olomouc-Slavonín, Určice), southern Moravia is characterized by local Krumlovský Les-type chert (Modřice, Křižanovice u Vyškova, Blučina) with imported erratic silicite present in small amounts. The local Olomučany-type chert, imported Bavarian plattensilex, north-west Bohemian quartzite, white marbles, Kraków-Czestochova Jurassic silicite, Szentgál-type radiolarite, and obsidian were documented only in small amounts (*Oliva 1996;*

Kazdová et al. 1997; 1999; Čižmář, Oliva 2001). Due to the lack of well excavated and absolutely dated SPC sites, a detailed raw material analysis (compared to LBK or Lengyel culture analysis) is not available.

Lengyel Culture (Moravian Painted Ware Culture, MPWC) in Moravia and Mährisch-Österreichische Gruppe (MOG) in Austria

The Lengyel Culture (in absolute chronology 4800–4000 calBC) is the most important upper Neolithic culture in the Middle Danube Region. In Moravia, two phases – I and II – were identified based on relative chronology (*Kazdová, Košťuřík, Rakovský 1994; Čižmář et al. 2004; Pavúk 2007*). MPWC sites have yielded the majority of the Neolithic radiocarbon dates from Moravia.

Currently, we have one of the earliest MPWC sites (phase Ia) reference sites in Moravia: Těšetice-Kyjovice – 'Sutny' (48°53'55.019"N, 16°7'57.925"E, WGS 84) in the south-west (*Kazdová 1984; Podborský 1988; Kuča, Kazdová in print*, etc.). A series of radiocarbon dates is available: 5450 ± 90 BP, 5625 ± 40 BP, 5870 ± 40 BP (*Podborský 1975/76; Kazdová, Dočkalová in print*). A collection of 1629 stone artefacts from selected sunken features was analyzed. The most commonly utilized material was the locally available Krumlovský Les-type chert (65%), supplemented by local siliceous weathering products of serpentinites (6%). Imported raw materials mainly include obsidian (14%), and isolated artefacts were made from occasional silicite, Kraków-Czestochova Jurassic silicite, and radiolarite (*Přichystal 1984*). Polished stone items were produced from metabasite of the Jizerské hory-type, and there were significantly fewer artefacts of greenschist of the Želešice-type.

There are two reference sites from phase Ib for MPWC culture. Březník-Zadní Hon is located in the Czech-Moravian Highlands (49°10'30.478"N, 16°12' 43.765"E, WGS 84). A single ^{14}C date is available for this site; 5780 ± 40 BP (Poz–22398; *Kuča, Nývltová Fišáková, Škrdla, Vokáč in print*). The dominant raw material is Krumlovský Les-type chert (95%). Only isolated artefacts were made from imported chocolate silicite (1.4%) and Kraków-Czestochova Jurassic silicite (1.0%). The majority of raw materials used for polished artefacts were imported from the Brno area (greenschist of the Želešice-type, amphibolitic diorite of the Rokle-type, and diorite porphyry/porphyric microdiorite). Amphibolite and metabasite of the Jizerské hory-type were also occasionally used.

Šebkovice is the second important site of the Ib phase of MPWC, also located in the Czech-Moravian Highlands (49°6'35.42"N a 15°49'57.16"E, WGS 84). It is dated by ^{14}C to 5845 ± 45 BP (GrA–34102, *Kuča, Vokáč, Nývltová Fišáková in print*). As in the previously described site, the Krumlovský Les-type chert prevails, supplemented by isolated artefacts made from local or regional origin (siliceous weathering products of serpentinites, opal, rock crystal, and chalcedony). More distant imports are comprised of isolated artefacts from chocolate silicite, obsidian, Kraków-Czestochova Jurassic silicite, erratic silicite, Bavarian plattensilex, and radiolarite. Polished tools were produced from greenschist of the Želešice-type, amphibolitic diorite of the Rokle-type, and diorite porphyry/porphyric microdiorite.

Three reference sites are available for phase Ic of MPWC. The first is Jezeřany-Maršovice-Na Kocourkách (49°2'37.05"N, 16°24'59.873"E, WGS 84), located directly on outcrops of Krumlovský Les-type cherts and dated to 5325 ± 50 BP (Bln–2067, *Rakovský 1985*). The assemblage numbers 2097 knapped artefacts, with Krumlovský Les-type cherts predominant. Other raw materials are represented only by isolated items and include radiolarite, Kraków-Czestochova Jurassic silicite, Bavarian plattensilex, erratic silicite, and chocolate silicite (*Rakovský 1985; Přichystal, Svoboda 1997; Oliva 2001*). Polished artefacts have not been published yet.

The second site from this period (phase Ic, MPWC) is Brno-Bystrc (49°13'12.516"N, 16°31'11.014"E, WGS 84), which yielded a date of 5570 ± 60 BP (Bln–2424, *Rakovský 1985*). The Krumlovský Les-type chert is again the most commonly used raw material, supplemented by Kraków-Czestochova Jurassic silicite, Olomučany-type chert, and Stránská Skála-type chert. Polished tools were produced from greenschist of the Želešice-type, amphibolitic diorite of the Rokle-type and diorite porphyry/porphyric microdiorite (*Přichystal 1988; Čižmářová, Rakovský 1988*).

The third reference site from this period was excavated in Mokrá near Brno (49°14'2.189"N, 16°44' 59.606"E, WGS 84) on the southern margin of the Moravian Karst. Two dates are available; 5645 ± 35 BP (VERA 760, *Šebela, Kuča 2004*) and 5640 ± 45 BP (GrA–34088, *Kuča 2008*). Imported raw materials are present in significant proportions – erratic silicite and Kraków-Czestochova Jurassic silicite are followed by Krumlovský Les-type chert, Olomučany-type chert, Crecateous spongolitic chert, obsidian and chocolate silicite. Polished tools were produced from raw materials obtained in the Brno area (greenschist of the Želešice-type, amphibolitic diorite of the Rokle-type and diorite porphyry/porphyric microdiorite).

The only reference site for phase IIa of MPWC is Dluhonice (49°27'47.311"N, 17°25'8.528"E, WGS 84) in the Moravian Gate, which yielded a ^{14}C date of 5675 ± 45 BP (GrA–34089). Knapped artefacts were produced only from erratic silicite and Kraków-Czestochova Jurassic silicite. Polished tools were produced from greenschists of the Želešice-type.

A radiometrically dated site from phase IIb of MPWC is not currently available. Two dates are available from phase IIc of the MPWC from Jezeřany-Maršovice (*Koštuřík et al. 1984; Oliva 2001*); 5040 ± 50 BP (Bln–2068) and 5120 ± 50 BP (Bln–2142). The only identified raw material present is the local Krumlovský Les-type chert and chert breccia. Imported raw materials have not been identified. Polished tools were produced from greenschist of the Želešice-type, amphibolitic diorite of the Rokle-type and diorite porphyry/porphyric microdiorite, amphibolite, and greenschist of undetermined origin.

Except for the earliest phase (Ia) of the MPWC, southern Moravia was characterized by the exploitation of several local raw materials (see below), while the area far to the east and to the north-east of Brno is characterized by significant amounts of erratic silicite and Kraków-Czestochova Jurassic silicite (*cf.* Mokrá; *Šebela, Kuča 2004; Kuča 2008a*). On the other hand, southwestern Moravia is a typical refuge area, with many local raw materials which were exploited at different rates (the Krumlovský Les-type cherts, siliceous geests, crystalline varieties of quartz, chalcedony, etc.; *cf.* Březník, Jezeřany-Maršovice, Šebkovice; *Kuča, Nývltová Fišáková, Škrdla, Vokáč in print; Přichystal, Svoboda 1997; Oliva 2001; Kuča, Vokáč, Nývltová Fišáková in print*). The situation in the Brno area relates to south-western Moravia and is characterized by a predominance of Krumlovský Les-type chert; however, the area is rich in local raw materials suitable for polished stone production (amphibolitic diorite of the Rokle-type, diorite porphyry/porphyric microdiorite, chlorite–actinolite greenschist of the Želešice-type; *cf.* Brno-Bystrc (*Rakovský 1986; Čižmářová, Rakovský 1988*). The lower Morava River valley and the Dyje-Svratka River valleys are regions influenced both by the nearby outcrops of the Krumlovský Les-type cherts and by the imported Kraków-Czestochova Jurassic silicite and erratic silicite from the north. The upper Morava River valley, North Moravia or Moravian Gate, through the Vyškov Gate, served as corridors used for transporting raw material to southern and south-western Moravia (*cf.* Dluhonice) during the MPWC.

Generally, the earliest (phase Ia) MPWC is characterized by a continuing tendency to use the local raw material, as is documented in the later phases of the LBK. During later phases (Ib–II) of the MPWC, the importation of rocks from the Brno area increases (greenschist of the Želešice-type, amphibolitic diorite of the Rokle-type, diorite porphyry/porphyric microdiorite). Polished stone items may have been valuable commodities traded for high-quality raw materials mainly from the north (the Kraków-Czestochova Jurassic silicite, chocolate silicite, erratic silicite?). During the later phases (Ib–II) of MPWC, imports are usually less numerous. Based on preliminary analyses, we can conclude that the Krumlovský Les-type silicite, erratic silicite and Kraków-Czestochova Jurassic silicite played a major role in the later phase (II) of the MPWC.

Conclusion

During the earliest LBK, raw materials were imported from all directions, often over distances of hundreds of kilometers. The extra-regional contacts are attested by the Krakow-Czestochova Jurassic silicite, north-west Bohemian metabasite, Szentgál-type radiolarite from the Balaton Lake area, and obsidian from eastern Slovakia (the obsidian demonstrates contacts with the region occupied by the eastern branch of the LBK). This raw material spectrum documents the extended raw materials networks which were connected to Moravia from all points of the compass, which is a contrast to the preceding Late Paleolithic and Mesolithic occupation, where the economy was based on the utilization of local raw materials. The extent to which the hunter-gatherer way of life survived until the Early Neolithic penetrated the main river valleys remains an open question. Taking into account the significant differences in the raw materials of the economy (and other aspects of social life) between the Mesolithic (Mikulčice, Smolín) and the earliest LBK (reference sites), contact between the two cultural complexes appears to have been very limited. However, in order to test interaction hypotheses, more radiometric dates are needed.

During the later phases of the LBK, the imported raw material (Krakow-Czestochova Jurassic silicite, northwest Bohemian metabasite, and Szentgál-type radiolarite) continued to be significant; however, the amount of local raw materials increase, and this is clearly visible, especially in southern and south-western Moravia (an area rich in quality local raw material sources). The valuable grave goods and the most distant contacts are represented by a collection of artefacts made from Spondylus shells.

The western influences (from Germany) led to a significant difference in raw material spectra during the SPC. This is demonstrated by the presence of western raw materials not previously imported to Moravia (Bavarian plattensilex, north-west Bohemian quartzite, and white marble). The Kraków-Czestochova Jurassic silicite, Szentgál-type radiolarite, and obsidian imports continue to be significant, but they are present in smaller quantities. The use of local raw materials is similar to the later phases of the LBK and continues in similar proportions until the end of the Neolithic. The main extra-regional contacts are indicated by the presence of Bavarian plattensilex, Kraków-Czestochova Jurassic silicite, Szentgál-type radiolarite, and obsidian. The area of the obsidian outcrops was occupied by the Bükk culture people, and the Lake Balaton area was occupied by bearers of the earliest Lengyel Culture.

The earliest phase of MPWC (Ia) is characterized by similarities with the later phases of the LBK, both in artefact typology and raw materials (*e.g.* north-west Bohemian metabasites). A significant change begins with phase Ib, which is characterized by increasing regionalization and utilization of local raw materials (especially for polished stone). While the Kraków-Czestochova Jurassic silicite maintains its importance, obsidian began to play a more important role than before. Chocolate silicite from central Poland occurs for the first time. The extensive raw material networks present highly exotic and high-quality raw materials such as nephrite and jadeitite, documented in the early phase of MPWC (*Vokáč 2008*). Beginning from phase Ic, and during phase II of MPWC, raw material supply is characterized by the prevailing

Lab. Number	Site	Culture/ Phase	^{14}C–Age [BP±STD]	CalAge p(95%) calBC	CalAge p(68%) calBC	Reference
Bln–57	Žopy	LBK Ia	6430±100	5580–5220	5400±90	*Felber, Ruttkay 1983*
Poz–21786	Spytihněv	LBK Ia	6340±40	5420–5220	5320±50	*Schenk, Kuča, Škrdla, Roszková 2008*
1272	Těšetice	LBK II	6150±35	5260–4980	5120±70	*Kazdová, Dočkalová in print*
1275	Těšetice	LBK II	6210±35	5300–5020	5160±70	*Kazdová, Dočkalová in print*
1276	Těšetice	LBK II	6210±35	5300–5020	5160±70	*Kazdová, Dočkalová in print*
VERA–4591	Těšetice	LBK II	6225±35	5350–5030	5190±80	*Kazdová, Dočkalová in print*
VERA–4590	Těšetice	LBK II	6210±35	5300–5020	5160±70	*Kazdová, Dočkalová in print*
Poz–22715	Těšetice	LBK II	6200±30	5270–5030	5150±60	*Kazdová, Dočkalová in print*
Těšetice	Těšetice	MPWC Ia	5450±90	4490–4050	4270±110	*Podborský 1975/76*
Těšetice	Těšetice	MPWC Ia	5800±60	4790–4510	4650±70	*Podborský 1975/76*
GrA–34102	Šebkovice	MPWC Ib	5845±45	4850–4570	4710±70	*Kuča, Vokáč, Nývltová Fišáková 2009*
Poz–22398	Březník	MPWC Ib	5780±40	4750–4510	4630±60	*Kuča, Nývltová Fišáková, Škrdla, Vokáč in print*
Poz–22525	Pavlov	MPWC Ic	5780±35	4730–4530	4630±50	*Kuča in preparation*
GrA–34088	Mokrá	MPWC Ic	5640±45	4590–4350	4470±60	*Kuča 2008a*
VERA–760	Mokrá-lom	MPWC Ic	5645±35	4560–4400	4480±40	*Šebela, Kuča 2004*
Bln–2067	Jezeřany-Maršovice	MPWC Ic	5325±50	4320–4000	4160±80	*Rakovský 1985*
GrA–34089	Dluhonice	MPWC IIa	5675±45	4620–4420	4520±50	*Kuča in preparation*
Bln–2068	Jezeřany-Maršovice	MPWC IIc	5040±50	4010–3690	3850±80	*Košturík, Rakovský, Peške, Přichystal, Salaš, Svoboda 1984*
Bln–2142	Jezeřany-Maršovice	MPWC IIc	5120±50	4040–3760	3900±70	*Košturík, Rakovský, Peške, Přichystal, Salaš, Svoboda 1984*
Bln–2424	Brno-Bystrc	MPWC Ic	5570±60	4520–4320	4420±50	*Rakovský 1985*
Vera–2596	Brno-Ivanovice (Globus)	LBK I	6545±40	5570–5450	5510±30	*Stadler et al. 2000*

Tab. 1. List of available radiometric dates from Moravia, calibrated using CaPal, ver. 07.

use of local raw materials. Extra-regional contacts are limited and can be demonstrated only along the main communication corridors which played a more important role (imports of obsidian or Kraków-Czestochova Jurassic silicite). However, 'prestigious' imports of high quality raw materials from more distant areas (chocolate silicite, jadeitite, nephrite) are also occasionally present, but the tools made from these materials may have had a symbolic or prestigious function and consequently may not reflect regular raw material networks.

We can conclude that Moravia, rich in local raw materials derived from its complicated geological structure, was an important communication corridor (and also a node at the junction of several corridors) not only during the Neolithic, and this is reflected in the diverse and extensive raw material networks.

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Neolithic/Eneolithic settlement patterns and Holocene environmental changes in Bela Krajina (south-eastern Slovenia)

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ABSTRACT – *This paper examines the archaeological settlement pattern and vegetation history of Bela krajina region of Slovenia in order to better understand the interaction of human activities and environmental processes in the landscape. Pollen record of two small palaeoecological sites (Mlaka and Griblje) indicates that human impact on the vegetation at circa 4150 calBC was intensive (forest cutting/burning, beech decline and formation of fields, pastures, meadows) and can be associated with numerous Neolithic/Eneolithic sites, located in the Lahinja river basin and the Kolpa lowlands. Human pressure on the (lowland/riverine) environment slightly decreased between* c. *3750–2850 calBC. This coincides with the appearance of a more dispersed settlement pattern, including the formation of short-term settlement/activity areas on the karst plateau. This change to a more extensive Eneolithic settlement pattern can be presumably associated with change in economy (more intensive pastoralism and transhumance, possibly also soil erosion) and is partially borne out by evidence from excavated sites in the area.*

IZVLEČEK – *Članek primerja arheološki poselitveni vzorec in zgodovino razvoja vegetacije na področju Bele krajine, z namenom, da bi bolje razumeli povezavo med človekovo dejavnostjo in okoljskimi procesi v pokrajini. Pelodni zapis dveh majhnih paleoekoloških najdišč (Mlake in močvirja pri Gribljah) kaže, da je bil človekov vpliv na vegetacijo pred c. 4150 pr. n. št. intenziven (sekanje/ požiganje gozda in upad bukve, pojav polj, pašnikov in travnikov), kar lahko povežemo s številnimi neolitskimi in eneolitskimi arheološkimi najdišči ob Lahinji in Kolpi. Človekov pritisk na nižinsko okolje ob rekah je bil nekoliko manj intenziven v obdobju pred c. 3750–2850 pr. n. št. To sovpada s pojavom bolj razpršenega arheološkega poselitvenega vzorca in nastankom kratkotrajnih naselbin/ uporabo prostora na kraškem višavju. Ta prehod v bolj ekstenziven eneolitski poselitveni vzorec domnevno lahko povežemo s spremembo ekonomije (intenzivnejše pašništvo, verjetno tudi erozija tal), kar deloma potrjujejo tudi rezultati arheoloških izkopavanj.*

KEY WORDS – *Palynology; beech decline; anthropogenic indicator; karst; core settlement; dispersed settlement pattern; off-site activity; Lengyel; Lasinja*

Introduction

Bela krajina is a lowland karst region in south-eastern Slovenia. It is bounded on the east and south by the river Kolpa and on the west by the high dinaric uplands of Kočevski rog. It is separated from central Slovenia by the Gorjanci hills. The lowland karst plateau has limited surface water, particularly rivers and streams in deeply incised valleys or gorges. The karst itself is characterised by a range of karst features, such as uvalas and swallow holes, but there are extensive areas of Pleistocene deposits in the Kolpa valley and to a lesser extent in the catchments of the river Lahinja (*Plut 1985.13–15; Radovčić, Galović 2002.10–31*).

The region has a relatively long tradition as an area of research into the Neolithic and Eneolithic, due to the relatively rich data from these periods (*Dular 1985.18–19, 42–43*). It was arguably the first area in the country, for which targeted research led to the formulation of a coherent model of Neolithic and Eneolthic settlement dynamics (*Budja 1988.50–55; 1989.83–102; 1990.113–134; 1992.95–109*) The expansion of archaeological fieldwork (field survey, trial trenching and excavation) has much increased the available archaeological data (*Mason 2008.18–22*). This data and that from earlier research can now be examined and compared against an increasing corpus of new data that of recent palynological research in the region (*Andrič 2007*), to assess the nature and dynamics of Neolithic and Eneolithic settlement patterns in the light of Holocene environmental changes.

Vegetation history and human impact on environment

To date palaeoecological research in the area focused on studies of vegetation development in lowland Bela krajina. The vegetation history of the karst plateau was not investigated, therefore only lowland vegetation can be presented and compared with the archaeological settlement pattern (Pl. 1).

Palynological research at Mlaka and Griblje wetlands (Figs. 1, 2) showed that, on the local scale, the Holocene vegetation development was very dynamic, with significant human impact on the environment (*Andrič 2007*). This became apparent due to natural characteristics of selected study sites, which are small (with small relevant source area of pollen, *Sugita 1994*) and therefore sensitive to local vegetation changes and human impact on the environment. Both study sites are located in the vicinity of Neolithic/Eneolithic settlements (Figs. 3, 4; Ržišča, Pusti Gradac, Griblje).

The results of pollen analysis at Mlaka (Fig. 1, Tab. 2) suggest that at *c.* 6900 calBC the early Holocene open woodland of oak (*Quercus*), hazel (*Corylus*), lime (*Tilia*), birch (*Betula*) and pine (*Pinus*) was suddenly replaced by beech (*Fagus*) forest. This is presumably associated with an increase in precipitation; a similar spread of beech also occurred at Griblje (Fig. 2, Tab. 3), probably simultaneously with Mlaka (*Andrič 2007*). Between *c.* 6900 and 5500 calBC beech canopy was occasionally opened by small-scale landscape burning at both study sites. However it is not clear from the present state of research, whether this fire disturbance regime was natural or anthropogenic (*e.g.* Mesolithic people were using fire to open the landscape).

The initial spread of beech forest was followed by beech decline and a change in forest composition, with an increase of monolete fern spores and initially lime at Mlaka and pine and trilete fern spores at Griblje. Landscape also became more open. This unusual beech decline is specific for Bela krajina region and it seems unlikely to be triggered by a global cold climatic fluctuation, although it is possible that vegetation composition was affected by local climate (*e.g.* drier and hotter summers in Bela krajina region of Slovenia). It is also possible that this vegetation change was caused by human impact, but the main problem of this explanation is that no archaeological sites, dated to 5500–5000 calBC were discovered in the area, so further archaeological and palaeoclimatological research is needed to better understand this unusual vegetation change.

After 5000 calBC open areas were regrown by hazel and oak and, between 4700 and 4100 calBC, hornbeam forest at Mlaka. An increase of 'anthropogenic indicator' herb taxa, *e.g.* ribwort plantain (*Plantago lanceolata*), plants of the *Centaurea* family (*e.g.*

Pl. 1. A view of the Palynological site of Mlake in a typical Bela krajina landscape (photo by Maja Andrič).

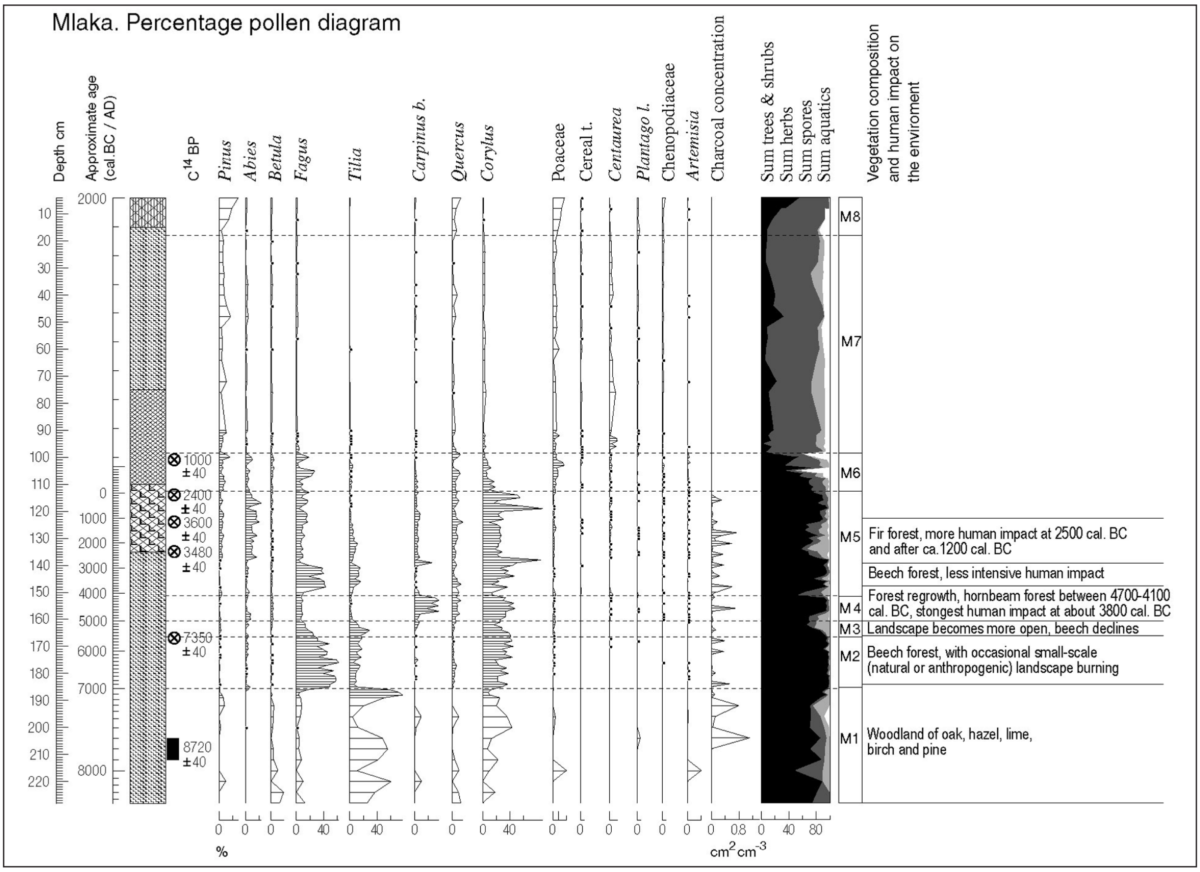

Fig. 1. Mlaka: Percentage pollen diagram (prepared by Tamara Korošec).

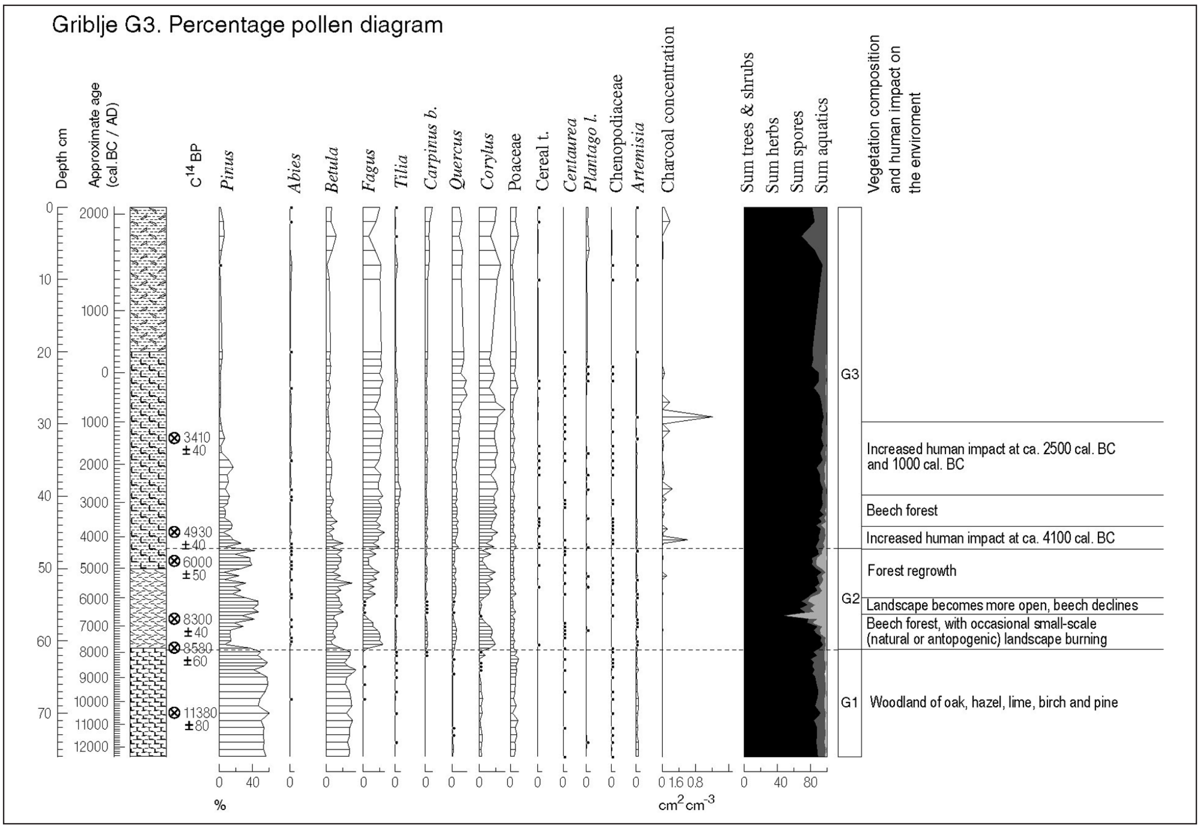

Fig. 2. Griblje G3: Percentage pollen diagram (prepared by Tamara Korošec).

cornflower), Cereal type pollen grains and other herb taxa, characteristic for agricultural fields and pastures, can be associated with Neolitihic settlements, located in the vicinity of both study sites. It is possible that people living near the Mlaka site were using local hornbeam forest (coppicing and wood pasture, which prevented beech regeneration). At about 3800 calBC human pressure on the environment increased, hornbeam forest was probably burnt and the landscape became open again, with meadows and fields located in vicinity of the Mlaka site. Similar vegetation development, but without a hornbeam phase and with less intensive forest clearance, was detected also at Griblje.

Later, with decreased human impact on the environment, beech forest returned between 3700 and 2800 calBC. Forest composition changed again at 2800 calBC, when fir (*Abies*) replaced beech at the Mlaka site, whereas fir increase is not that pronounced at Griblje. This vegetation change could be associated with wetter climate and/or beech cutting (if beech wood was needed for metallurgy). Human impact on the environment slightly increased by 2500 calBC and after *c.* 1200–1000 calBC. The landscape was gradually becoming more open at both study sites, which could be associated with numerous Bronze Age and Iron Age sites in the area (*Andrič 2007.763–776*).

The early Holocene archaeological evidence

An examination of the archaeological evidence for the Neolithic/Eneolithic settlement pattern in Bela krajina provides a more episodic view of human activity in the early Holocene within the broad trends, shown by the palaeoecological research. There is only minimal archaeological evidence for human activity in the region prior to the 5th millennium BC. This is confined to a single site of Epigravettian occupation in a cave site, Judovska hiša, in the Krupa gorge (*Pohar 1985.7–15*). Thus the palaeoecological evidence gives us the strongest for potential Mesolithic activity outside the area of the single known site (Tabs. 2, 3).

Models of Neolithic/Eneolithic settlement

The existing model of spatial exploitation in the Neolithic and Eneolithic in Bela krajina was developed in the 1980's. It was based on the results of the Moverna vas field survey project in the Krupsko polje, which was supplemented by small scale excavation on the central site of Moverna vas in 1988 (*Budja op. cit.; Tomaž 1997.113–142*). The model formulated from this work also includes field survey work around Pusti Gradac and Zorenci on the upper reaches of the river Lahinja (*Budja op. cit.*). The small-scale excavation on the Gradac settlement from 1993–1995 showed a broadly similar chronological situation to that at Moverna vas (*Mason 1995.183–199*). The field survey data and the data from the two limited stratigraphic excavations were employed in conjunction with data from previously known sites that had not been subject to either modern excavation or extensive field survey to extend the model to whole of the river Lahinja river system and by inference to the whole of Bela krajina.

The model can now be supplemented by the results of developer-funded field survey and excavation, as well as research oriented field survey over the last

Sample no. (material dated)	Site sample no.	Conventional radiocarbon age	C^{13}/C^{12} ratio	2 sigma calibration (Intcal 04)
Čardak				
Beta–229147 (charcoal)	CARDAKIII038	2760±40 BP	–24.7 o/oo	1000–820 calBC
Beta–229148 (charcoal)	CARDAKIII039	2940±40 BP	–27.7 o/oo	1280–1010 calBC
Beta–229149 (charcoal)	CARDAKII492	2130±40 BP	–25.6 o/oo	350–290 and 220–50 calBC
Beta–229150 (charcoal)	CARDAKII566	2840±40 BP	–24.5 o/oo	1120–910 calBC
Beta–229151 (charcoal)	CARDAKIISE405	4590±50 BP	–24.8 o/oo	3510–3420, 3380–3320, 3230–3110 calBC
Ržišča				
Beta–229154 (charcoal)	RZISCE753	5040±50 BP	–25.2 o/oo	3960–3700 calBC
Beta–229155 (charcoal)	RZISCE1022	2970±40 BP	–24.3 o/oo	1360–1350, 1310–1050 calBC
Beta–229156 (charcoal)	RZISCE1349	5840±70 BP	–26.0 o/oo	4840–4530 calBC
Vinji vrh				
Beta–229157 (charcoal)	VINJIVRH262	3600±50 BP	–25.9 o/oo	2130–2090, 2050–1870, 1840–1820, 1790–1780 calBC
Beta–229158 (charcoal)	VINJIVRH275	3650±60 BP	–25.5 o/oo	2200–1880 calBC

Tab. 1. The Radiocarbon dates of Neolithic/Eneolithic archaeological sites in Bela krajina.

Approximate age (Mlaka)	Vegetation composition and human impact on the environment	Archaeological settlement pattern
2800 – 1000 calBC	Fir forest, more human impact at 2500 calBC and after *c.* 1200 calBC	Ržišča
3700–2800 calBC	Beech forest, less intensive human impact	Ržišča, Moverna vas, Pusti gradec Gradac
5000–3700 calBC	Forest regrowth, predominantly hornbeam forest between 4700–4100 calBC, strongest human impact and forest clearance at about 3800 calBC	Ržišča, Moverna vas, Pusti Gadec Gradac
5500–5000 calBC	Landscape becomes more open, beech declines	
6900–5500 calBC	Beech forest, with occasional small-scale (natural or anthropogenic) landscape burning	
9500–6900 calBC	Woodland of oak, hazel, lime, birch and pine	

Tab. 2. Radiocarbon dating of vegetational phases at Mlaka and the associated archaeological settlement pattern.

ten years. This has led to the discovery of a range of new settlement sites and off-site data, as well as a range of associated radiocarbon dates and pedological data. It also means that there are now other excavated sites in the upper reaches of the Lahinja system (Ržišča, Gradinje) and two large sites (Griblje, Podklanec) in the Kolpa valley (*Mason 2001.10; 2008.20–21; Mason, Bricelj 2006.41–42; Mason, Pintér 2001.141–142; Mason, Tomažič, Novšak 2006.95–96; Pintér 1998*). These were defined by field survey that was supplemented by small-scale excavation and monitoring of infrastructure projects. This has permitted the extension of the model with a greater degree of veracity to the rest of Bela krajina.

Neolithic settlement (Fig. 3)

The model posits the first appearance of agricultural settlement in the Middle Neolithic in the 5th millennium BC. The initial colonisation of the interior of Bela krajina was centred on the drainage system of the river Lahinja and its tributaries. The primary settlements complexes were located on fertile soils, close to the rivers. Two typical locations can be identified – river meanders, *e.g.* Pusti Gradac and Gradac, and canyon or terrace edge sites, *e.g.* Griblje, Moverna vas, Podklanec, Ržišča and Zorenci (*Mason 1995.192; 2008.20*). The cave site of Judovska hiša also continued in use (*Pohar op.cit*).

The earliest dates for this initial Neolithic phase are 4900 calBC at Moverna vas and 4840 calBC at Ržišča, which would coincide with the hornbeam phase of strongest human impact (*Budja 1994.20, Fig. 5; Mason 2008.20*) (Tabs. 1, 2, 3). The other sites lack radiocarbon dates, but it can be asserted with some degree of certainty that those that are only known from small-scale excavation (Gradac) and field survey (Pusti Gradac, Gradac, Zorenci and Griblje) have produced material from secure contexts, which indicates that they probably have a similar early origin.

Approximate age (Griblje)	Vegetation composition and human impact on the environment	Archaeological settlement pattern
2800–1000 calBC	Increased human impact at *c.* 2500 calBC and 1000 calBC	Griblje
3700–2800 calBC	Beech forest	Griblje
4400–3700 calBC	Increased human impact (‘anthropogenic indicator’ taxa) at *c.* 4100 calBC	Griblje
6000–4400 calBC	Forest regrowth	
6600 – 6000 calBC	Landscape becomes more open beech declines	
7900–6600 calBC	Beech forest, with occasional small-scale (natural or anthropogenic) landscape burning	?
before7900 calBC	Woodland of oak, hazel, lime, birch and pine	?

Tab. 3. Radiocarbon dating of vegetational phases at Griblje and the associated archaeological settlement pattern.

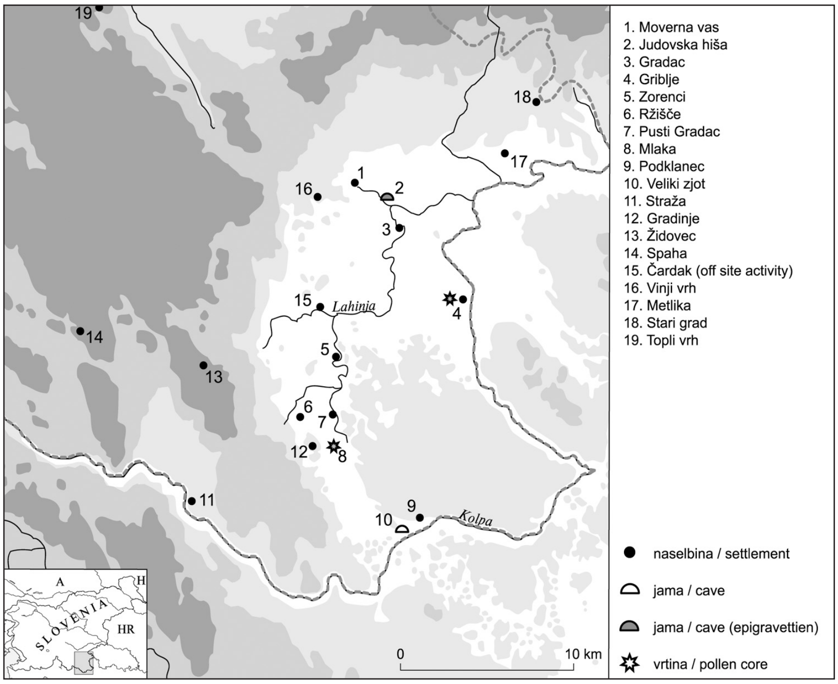

Fig. 3. Neolithic settlement sites in Bela krajina (prepared by Tamara Korošec).

It has been suggested that arable farming was an important part of the economy, but the site locations suggest that they were optimally placed to exploit riverine environments for summer grazing, fodder, fishing and wildfowling, as well as the arable potential of the first terrace and the grazing potential of the drier karst hinterland (*Mason 1995.185–187*).

It is possible that the Middle/Late Neolithic core settlements may have seen a seasonal element in their occupation throughout their use. The presence of midden deposits might be indicative of seasonal gatherings on the sites, which were otherwise occupied by smaller populations during the rest of the year. The presence of fine wares with burnt food deposits in the midden deposits are perhaps related to seasonal symbolic feasting, reintegrating an otherwise scattered population at a centre at certain times of the year.

Eneolithic settlement expansion (Fig. 4)

The settlement pattern changed in the 4th millennium BC. There is a visible expansion out from the Late Neolithic settlement centres into the drier karst hinterland through a process of secondary colonisation (*Budja 1989.93–98; Mason 1995.193–195*). This can best be seen in the original Moverna vas/Krupsko polje field survey and in more recent work. Similar expansion can be seen around the Pusti Gradac site (meander and first terrace) and Eneolithic activity is clearly present on core settlements at Gradac, Zorenci and Ržišča (*Budja 1992.102–109; Dular 1985.65; Mason 1995.191; 2008.21*). The most complete new evidence for a Neolithic/Eneolithic settlement pattern comes from the Griblje area and mirrors that of the Krupsko polje that is a Neolithic core settlement with later Eneolithic expansion into the drier hinterland (*Mason 2001.10*). However, it should be noted that seasonal ponds are present within the hinterland and probably formed foci for Eneolithic and possibly earlier Neolithic activity. Expansion was more likely to take place into the karst hinterlands and not laterally along the terrace – activity here was present in the form of satellite activity areas throughout the Neolithic and Eneolithic.

It has been hypothesised that this expansion was linked to increased population and was made possible by the increasing importance of the stock-raising element in the economy, which led to a more mobile lifestyle (*Budja 1989.93–98; Mason 1995.193–194*). This may be seen in the expansion of occupation of cave sites, such as Veliki zjot in the Kolpa valley (*Leben 1991.169–191; Turk 1991.189*). Enclosed upland sites, such as those at Spaha, Straža, Židovec, Topli vrh and potentially Metlika, also appear in the Lengyel and Lasinja phases (*Breščak 1992.255–256; Dular 2001.89–106*) and may be connected to increased competition in the area. They have also been tentatively connected to the appearance of transhumance (*Mason op. cit. 194*). However, it must be admitted that this hypothesis can only be tested against a large stratified faunal assemblage, which are unfortunately completely absent due to poor conditions for the preservation of animal bone in the area. The decline and disappearance of this settlement pattern in the second half of the 3rd millennium BC has been seen as a result of overexploitation, leading to environmental degradation (*Mason op. cit. 195*).

Recent excavations in some swallow holes have provided vital insights into the nature of Eneolithic occupation and/or environmental degradation in

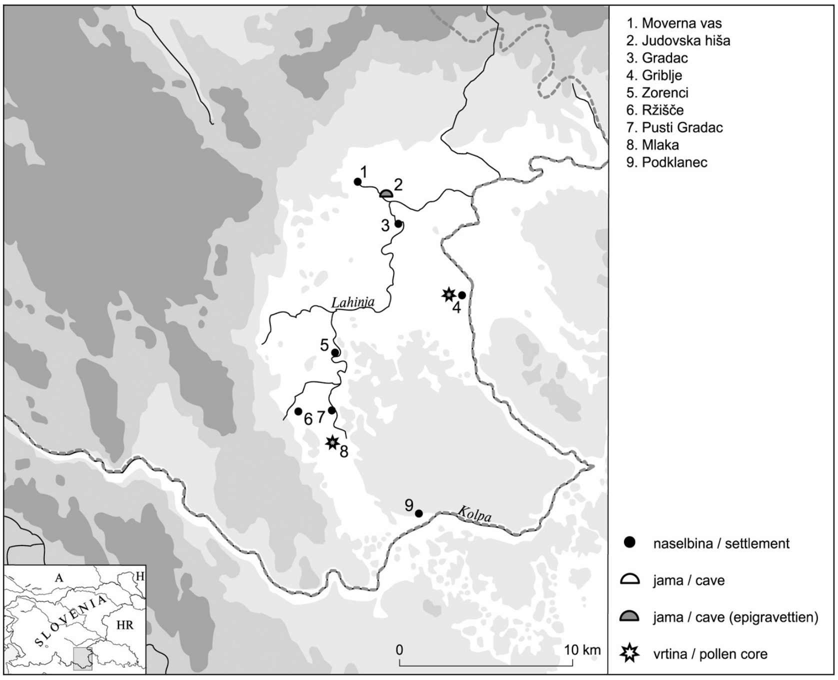

Fig. 4. Eneolithic settlement sites in Bela krajina (prepared by Tamara Korošec).

locally related to the Gradinje settlement site, which is without radiocarbon dates (*Mason, Tomažič, Novšak 2006. 95–96*). It should be also noted the final phase of occupation at Gradac terminated in a major erosion event, which is contemporary with Moverna vas phase 8 (*Mason 1995. 195*). It is now becoming increasingly clear that the main feature of the transition from the Eneolithic to the Early Bronze Age was the abandonment of the Neolithic/Eneolithic core settlements, but the continuation of the small-scale ephemeral settlements in their hinterland – indicative of an increasingly mobile way of life.

the karst hinterland. The site of Čardak II in the lowland karst on the edge of the valley of the river Dobličica has no direct evidence of Eneolithic settlement, but the charcoal in primary erosion deposit in the is dated to the mid to late 4th millennium BC (Beta-229151: calBC 3640–3420 (calBP 5460–5380), calBC 3380–3320 (calBP 5330–5270) calBC 3230–3110 (calBP 5180–5060) (*Mason 2008.21; Mason, Predan, Murko, Pintér 2006a.23–24; 2006b.24–26*) (Tab. 1). Eneolithic activity here would then fall within the Eneolithic expansion into the karst hinterland, but also within the phase of beech regeneration, noted at Mlaka.

The other karst hinterland site is that of Vinji vrh near Semič was subject to limited excavation in 2004 (*Mason, Britovšek, Pintér 2006.182–183*). It proved to be an late Eneolithic or Early Bronze Age settlement site, which at least partially lay within a swallow hole. The settlement was of low intensity without deep occupation layers and was later subject to intensive erosion. It has produced a range of ^{14}C dates, but the final date lies within in the second half of the 3rd millennium or at the beginning of the 2nd millennium BC (Beta-229158: calBC 2200–1880 (calBP 4150–3830) (*Mason 2008.22*) (Tab. 1). This is just outside the phase of more intensive human impact detected at Mlaka around 2500 calBC. It is clear that the intensity of human impact in the Eneolithic phase varied in space and time and was not a unitary phenomenon. The impact at Mlaka may be

In conclusion, the evidence suggests that the existing model for Neolithic and Eneolithic settlement patterns in Bela krajina still offers the best means of interpreting the growing body of data for these periods. The model can now be extended with some confidence to the Kolpa valley and to other parts of the Lahinja catchment. What is now needed is the expansion of field survey work in these areas, particularly on sites that are incompletely defined, *e.g.* Podklanec. It is only then that the veracity of this model can be tested. The true nature of the Neolithic core settlements remains equally enigmatic, but as this can only be tested by large-scale excavation, it must remain so for the moment. On-going work in the spheres of palaeobotanical studies and off-site landscape studies may also be expected to provide vital results on the development of the Neolithic and Eneolithic landscape, particularly with regard to possible environmental degradation during and at the end of the Eneolithic, something which at the moment remains on the level of an intrasite phenomenon on the few excavated sites. It is also to be hoped that the tantalising palaeobotanical evidence for Mesolithic activity will be matched by archaeological evidence.

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Geo-pedological and climatic impact on the distribution and organization of Neolithic settlements in Eastern Croatia (Western Syrmia)

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ABSTRACT – *This paper analyzes a sampling of settlement patterns in the extreme eastern periphery of Croatia during the prehistoric period. The layout of present-day settlements from Vukovar to Ilok and the local, very specific relief, indicate a degree of mutual interaction. The combination of a series of components such as deep ravines (known locally as* surduk*) and high loess terraces indicates a unique structure which has been apparent from prehistory to the most recent history.*

IZVLEČEK – *V članku analiziramo poselitvene vzorce na skrajnem vzhodnem obrobju Hrvaške v času prazgodovine. Tloris današnjih naselij med Vukovarom in Ilokom ter lokalen, zelo specifičen relief, nakazujeta medsebojni vpliv. Kombinacija elementov, kot sta globoka soteska (lokalno znana kot surduk) in visoka puhlična terasa, nakazuje edinstveno poselitveno strukturo, ki ji sledimo od prazgodovine do najbolj nedavne zgodovine.*

KEY WORDS – *Eastern Croatia; Neolithic; loess; ravines; settlements*

The geographical territory of Eastern Croatia has witnessed very intense activity. Trade routes intersected here, with the associated intermingling of influences, and prehistoric cultures significantly influenced one another. This is a place where the old and new met, and evidence of these long-past contacts can be found underground.

Geology and hydrology

In Eastern Slavonia and Syrmia (Srijem), people say that the soil is so fertile that "seeds land upside down and still sprout". When agriculture was at its peak in this region (in the 1980s), few other zones could generate better crop yields than the zone bordered by the cities of Đakovo to the west and Zemun to the east. The reason for this is the specific, very fertile soil which exerted an influence on prehistoric human communities that far surpassed its fertility: loess. It characterized the entire surface of Eastern Croatia.

This loess was created by the settlement of dust raised and conveyed by winds in the wake of the erosion of the Alpine massif and the mountains of Slavonia, rich in muscovite (*Galović 2005.221*). The Pannonian plain is an area with the highest concentration of loess and similar sediments in Europe, and its thickness varies depending on the region (Fig. 1). The sedimentation of loess in the form of flattened slabs (tablelands) is a 'trademark' of what is known as 'flat Slavonia', *i.e.* the fertile plain of the eastern section of Croatia as an integral component of the South Pannonian zone. Loess and its derivatives cover approximately 35.7% of Croatia's total surface area, reaching thicknesses of up to 30 meters. It was generally formed during the younger Pleistocene (*Galović 2005.7; Galović et al. 2009.85*) (Fig. 2). The extreme south-eastern Slavonian plain has been shaped by two major rivers: the Drava and Danube. The Danube, flowing in from the north, runs through raised loess terrain, which considerably impedes its progress, creating spill-over, while the Drava flows

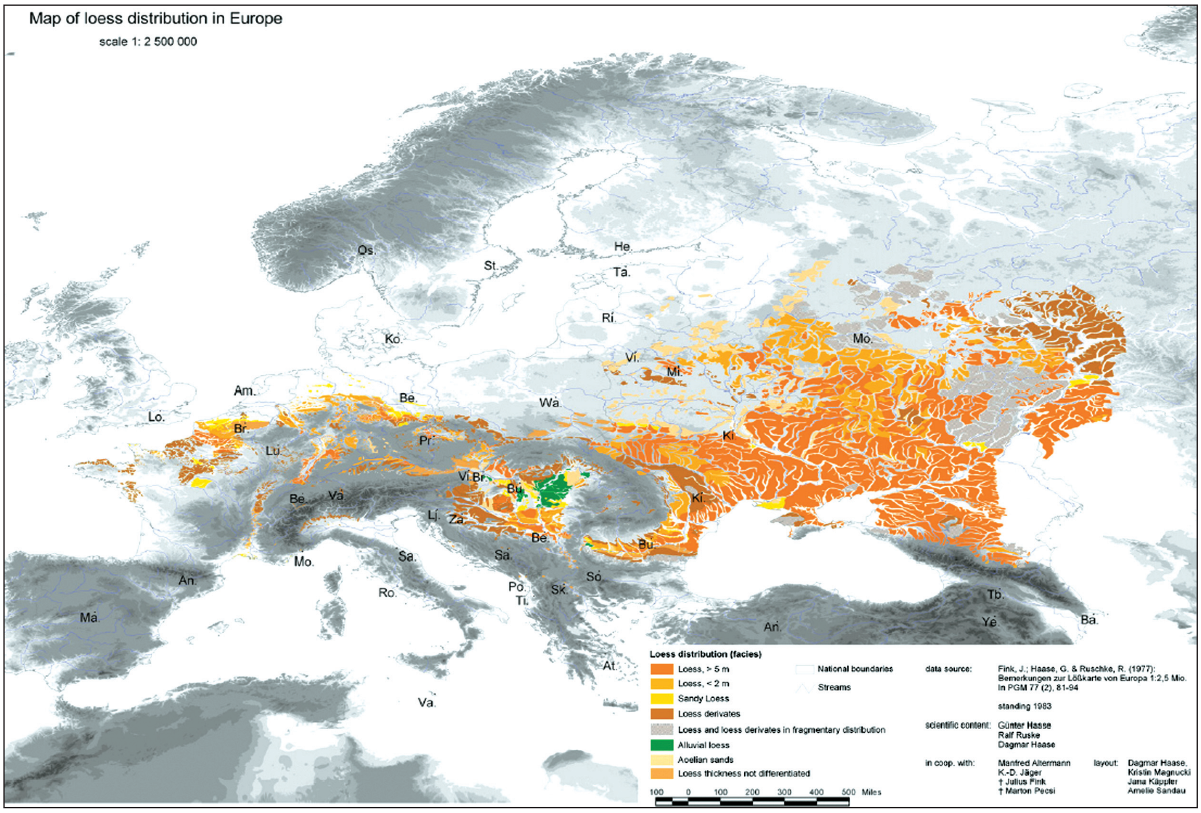


Fig. 1. Map of loess sediments of Eurasia (based on* Hasse et al 2007*).

into it on its right bank. The interacting hydro-dynamics of these two rivers, wherein the low waters of the Drava are halted by the high waters of the Danube, create a unique wetland known as Kopački rit (*Galović 2005.2*), one of the most important habitats for wading birds in Europe. This interchange between a lower, inundated zone with a raised, drier zone created the current relief picture of Eastern Slavonia and Syrmia, with the Drava and Danube flowing on their northern and eastern peripheries. In geological terms, two categories of sediment are present in this area's relief: Pleistocene loess and Holocene alluvial sediments (*Galović 2005.1*). The alluvial sediments pertain to the lowest terrain, which are inundated and damp, and thus quite suitable for the growth of forests of, among others, the famed local oak trees. Eastern Slavonia is bordered by a third river in the south: the Sava. The entire territory bordered by the Drava, Sava and Danube is divided into three geotectonic units: the eastern section of the Drava depression in the north, the Slavonia-Syrmia depression in the south, and the plain of Đakovo, Vinkovci and Vukovar between them (*Bačani et al. 1999.141*). The tablelands are slightly higher than the local relief, and thus ideal for cultivation, because they do not flood as easily, something of which prehistoric populations were well aware. In morphological and structural-tectonic terms, these are complex structures which are separated from the depressions by sharply divided systems of deep fissures which reach down to the tertiary bedrock (*Bačani et al 1999.141*). The Vukovar tableland, which will be covered most extensively here, is the easternmost tableland in Croatia. This is an asymmetric tectonic block, covered by an average of 22 meters of loess sediment. The north-eastern section leans slightly toward the Danube, which begins to undercut it here, so that it terminates in a steep and entirely vertical break which extends parallel to the Danube from Vukovar to Ilok (*Mutić 1990.53*). It extends from the so-called Vinkovci tectonic hub of the fissure (from the north-west, the north-south fissure from Našice to Vinkovci, and the other fissure from the western side along the Vrpolje-Mikanovci-Vinkovci line) (*Mutić 1990.35*), up to the Mohovo-Bapska-Šid fissure, where it crosses into the western foothills of Fruška Gora (*Galović 2005.36*). The principal and best-known branch of the Vukovar tableland, 22 meters high, on which much research has been conducted, is the so-called Gorjanović (Gorjanović-Kramberger) profile, slightly downstream from central Vukovar (*Gorjanović-Kramberger 1912. 29; Galović I. & Mutić 1984.299*). The Gorjanović profile is particularly significant because it has seen the longest period of continuous development of loess sediments on dry land, in contrast to that of

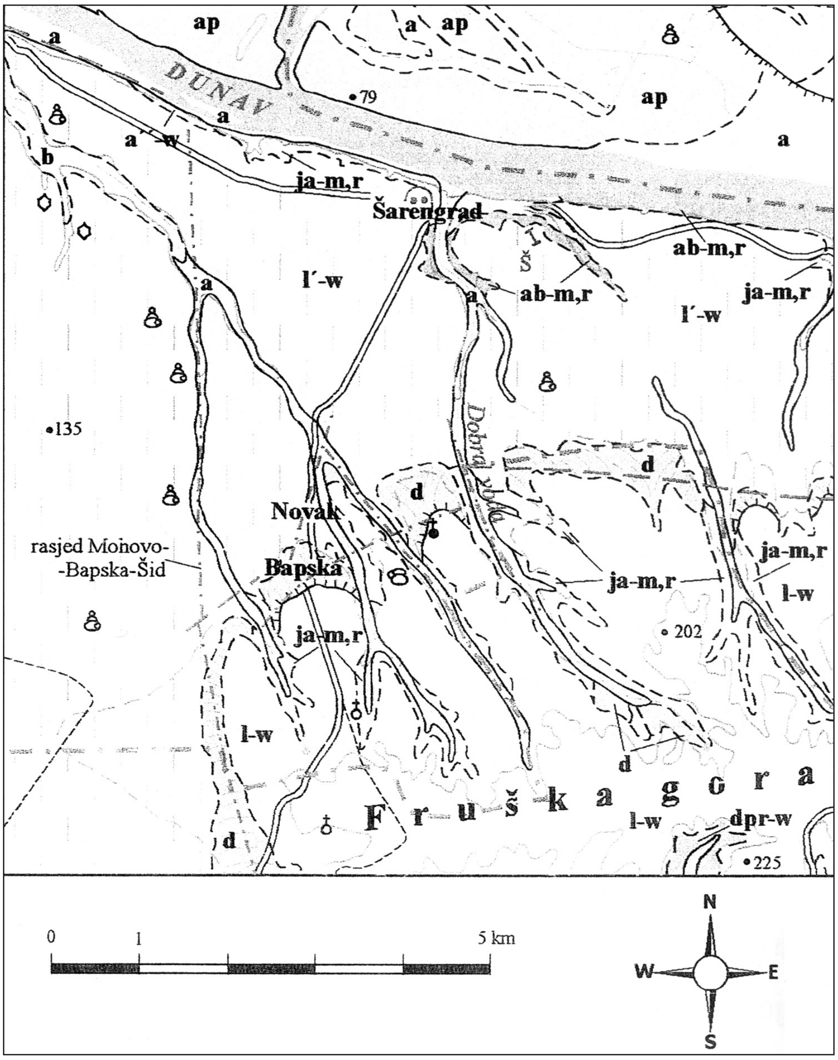


Fig. 2. Loess sediments of the eastern section of the Vukovar plain (based on **Galović 2005***).*

Almost immediately after it passes the Gorjanović profile, the Danube veers sharply leftward, after which one reaches Vučedol, one of the best-known sites of Croatian archaeology.

The western foothills of Fruška Gora, which form the eastern boundary of the Vukovar tableland, largely consist of metamorphic rock and serpentinite (*Osnovna Geološka Karta L 34-99, 1983.13*), meaning rocks which are potentially sound materials for making Neolithic implements. Serpentinites are generally associated with the streams in the villages around Neštin (Serbia), while the metamorphic rock appears on the surface in the form of sericitic-chloritic shales and calcschist. The territory along the Mohovo-Bapska-Šid line lies on riverine-lacustrine (JA-RW), and riverine-palustrine (AB-RW) sediments, which were discovered in the steep ravines from Opatovac to Neštin (*Osnovna Geološka Karta L 34-99, 1983.17*) (Figs. 2 and 3). This accounts for the entire series of sources of potable water in the immediate vicinity of the Late Neolithic tell of Gradac in Bapska, which were vitally important to the village (as confirmed in testimony from older residents of Bapska), and certainly to the residents of the Neolithic settlement at Bapska.[2]

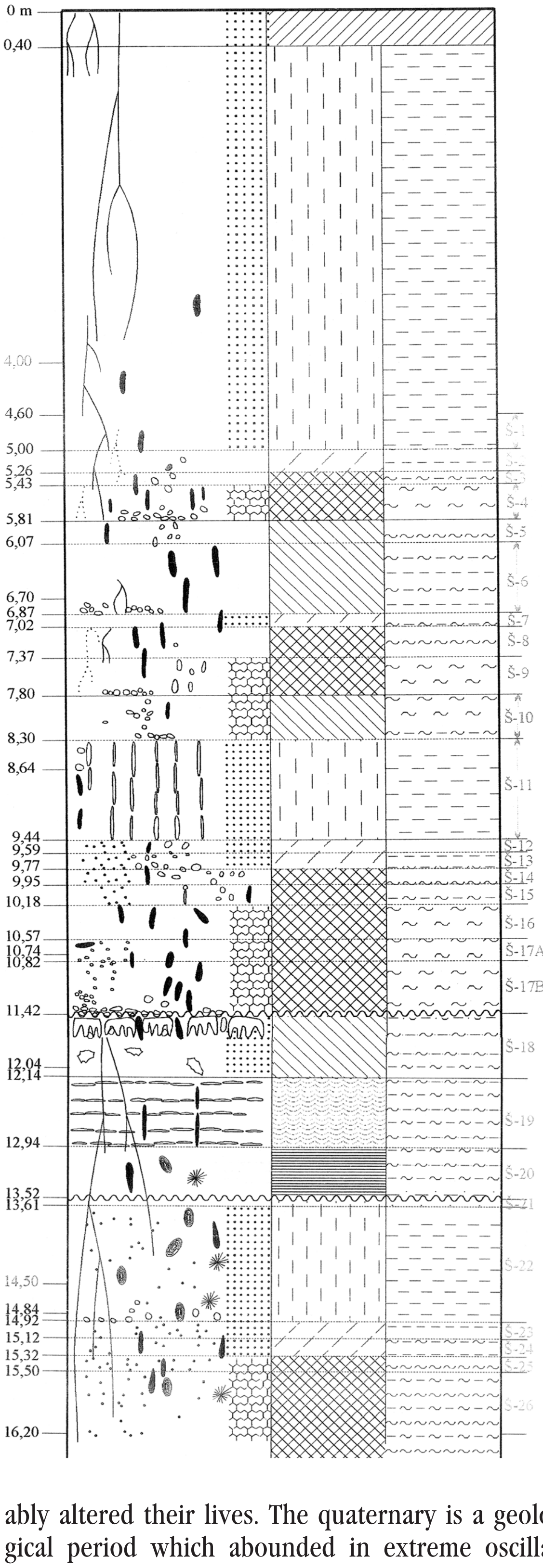
Vinkovci and Đakovo, where sedimentation proceeded partially or entirely under water (*Mutić 1990.52*), and which is why the latter contain a higher share of clay (*Mutić 1990.71*). Radiocarbon dating of the Gorjanović profile has ascertained an age of 33 000 to 16 600 years.[1] The sequence of loess on it constitutes a deposit of fine, dusty, terrigenous material formed under stable, dry and hot climatic phases (*Mutić 1990.52–53*). Its most important features are the high content of dusty fractions (64–83%) and the high content of calcium carbonate ($CaCO_3$) (*Osnovna Geološka Karta L 34-99, 1983.19*). Viewed vertically, these are light-yellow layers, interspersed with dark and thinner offshoots which represent warming or interglacial periods, best seen when one goes downstream along the Danube from Vukovar.

Climatic and ecological changes on the Vukovar tableland

Climatic variations prompted numerous processes which influenced the geomorphology, sedimentation, pedogenesis and similar processes which exert the greatest impact on plant and animal development (*Poje 1986.19*). Since prehistoric people were quite dependent on these changes, the climate consider-

1 There are no data on calibration.

2 During excavations in 2009, attempts will be made to ascertain the age of these two sources to establish whether the spring and stream were at this site during the existence of the prehistoric settlement.



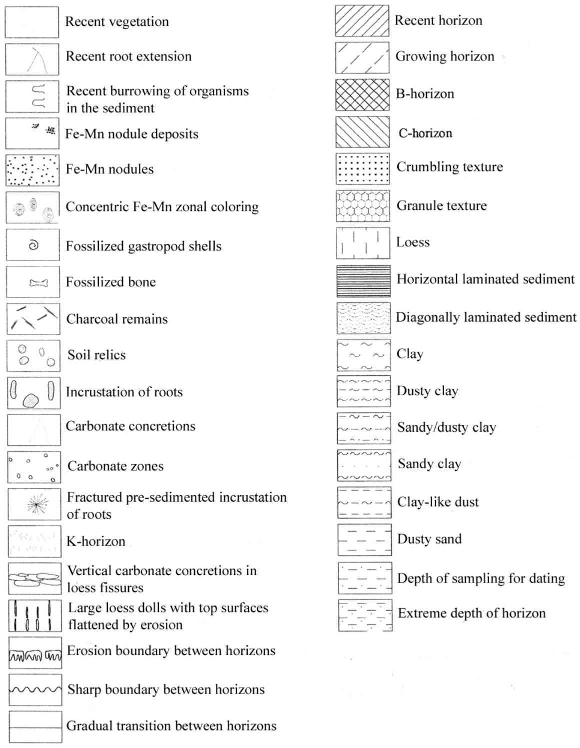


Fig. 3. Loess profile in Šarengrad (based on Galović 2005).

ably altered their lives. The quaternary is a geological period which abounded in extreme oscillations in temperature and climate. From the Brunhes/ Matuyama palaeomagnetic boundary (0.73 mil. years), there were eight glacial-interglacial transitions, and a total of seventeen during the Holocene (*Poje 1986.19*), so the old division of the quaternary into four Alpine glacial phases (1909) no longer stands in the geological literature (*Rukavina 1983.199*), even though it can still be found in archaeological discourse. During the Holocene, and even during the Neolithic, some relatively significant climate changes occurred in this region. During the Boreal (*c.* 8000–6000 calBC), the climate remained within the framework of the continental: warm and dry summers, and cool and dry winters, while during the Atlantic period, winters were warmer and wetter, and summers similarly cooler and wetter. During the transition from the Atlantic to the Sub-Boreal, the continental formula of the Boreal was restored (*Link 2006.6*).

Loess is a soil in which quaternary climatic changes can be best observed (*Poje 1986.20*). The aforementioned lighter and darker yellowish layers are actually the first visual markers indicating the intensity of climate change over the past thirty-five thousand years.[3] As stated, the dark layers indicate a warming

3 Using state-of-the-art methods, it is possible to ascertain when an individual grain of quartz was last exposed to daylight. During conveyance by wind, the electrons in the grain's crystal lattice are excited by photons in sunlight. When a grain falls into a sediment (covering other grains), the electrons begin to lose energy and 'drop' to lower energy levels, and this marks the point of departure for measuring sedimentation (*Galović 2005.56*).

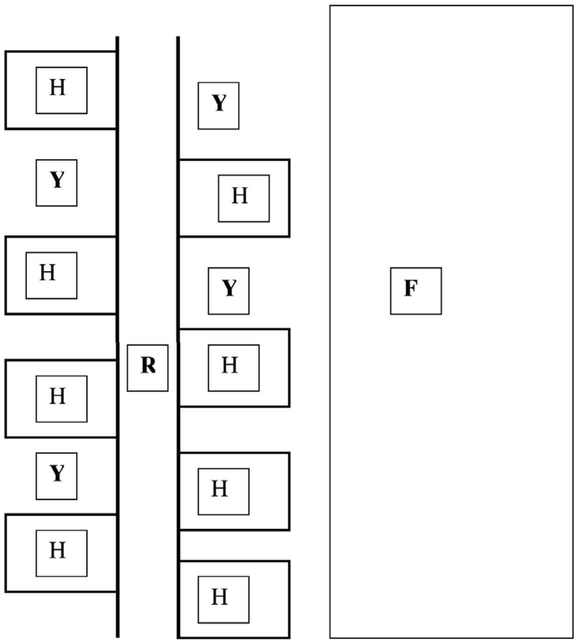


Fig. 4. Very simplified schematic for the organization of villages in Slavonia and Baranja (H = house; Y = yard; R = road; F = field).

period and higher moisture, and even stagnation in the conveyance of dusty substances. Under these damp conditions, calcium carbonate dissolved much more quickly, contributing to the formation of various loess concretions in the lower loess horizons (*Mutić 1990.53*), while so-called loess 'dolls' are one of these manifestations which can also be found in archaeological research. It is worth noting that among the igneous materials (apatite, zircon, amphibole, biotite, etc.), the Gorjanović profile also contains traces of volcanic glass (obsidian), thus indicating vestiges of volcanic activity in the Eastern Carpathians (Harghita-Calimani mountains in Romania) (*Mutić 1990.54*).[4]

The Danube bank from Vukovar to Ilok

The situation described above indicates that this zone was ideal for settlements of Neolithic and other prehistoric and historical communities. Western Syrmia is thus a slightly elevated 'island' of exceptionally fertile soil bordered by the Danube to the north. This raised character affords protection from floods during seasons when the Danube is swollen with melt-water from Alpine zones. The Fruška Gora highlands play a crucial role in this eco-system: their configuration and genesis ensure a constant inflow of potable water, entirely independent of the dry months and the associated variations in the levels of the Danube and nearby Bosut and Sava Rivers, while their geological base is a source of outstanding stone materials for tool-making.

Besides its fertile plain, Eastern Croatia is also known for its specific type of settlement (village) development, which is common to almost the entire lowland area of the southern part of the Pannonian plains. These so-called *šorovi* (*šor* – a village lane) denote the building of settlements along a single main thoroughfare, along which the houses are arranged regularly in a line on each side (Figs. 4, 5).

An exception in this regard is the area between Vukovar and Ilok. The specific relationship between the relief, geology and large rivers altered the general pattern here, which is apparent in both the present and prehistoric organization of settlements. When this model is examined more closely, one can conclude that it is the only one possible, and that the tradition is probably rooted in prehistoric times. It has already been noted that this right bank of the Danube is furrowed with intense riverine erosion, so it is steep along its whole length. On a clear

Fig. 5. Satellite image of a village in Slavonia-Baranja (Sotin).

4 Traces of obsidian are also visible in samples from the Vinkovci tableland (*Mutić 1990.73*). Those obsidian traces are of course, in the shape of dust.

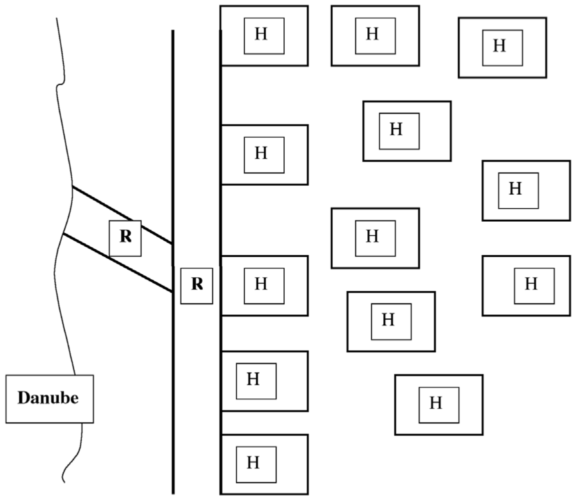


Fig. 6. Very simplified schematic of a village in a ravine (H = house; R = road).

day, the foothills of Fruška Gora can easily be seen from Vučedol, the well-known Eneolithic site, as the intervening area is entirely flat (a distance of roughly 40km as the crow flies). The view is not even impeded by any modern settlements, because with the exception of Sotin, there are none – only endless fields and vineyards. The terrain is entirely flat, interrupted only occasionally by ravines, which gently descend to the Danube from high terraces. If one sets off by road from Vukovar toward Ilok, the first such ravine can be seen immediately after leaving Vukovar, and it leads along the Danube to Vučedol (Figs. 7, 8). There are no modern settlements here, except about a dozen weekend cottages. The Vučedol plateau is slightly elevated above the surrounding terrain of the Vukovar tableland, which extends farther eastward. There was a prehistoric here, followed by cultivated surfaces toward the east. The Vučedol ravine is partially visible as a sandy approach to the banks of the Danube on the left of Figure 7. After Vukovar and Vučedol, one arrives in Sotin, a settlement 3km farther on which is rich in prehistoric remains, and which was also the site of an exceptionally important Roman-era settlement. The emergence of the contemporary village links the medieval tradition with Antiquity, when a very important Roman crossing of the Danube *limes* was located here. Today's Sotin is the successor settlement to this Roman-era predecessor.[5] This fact alone indicates that Sotin did not emerge in the aforementioned 'traditional' manner, but was influenced by the presence of the Roman army, which regularly applied its own methods for building settlements. After Sotin, the terrain is flat until the next major ravine, considerably larger than its Vučedol counterpart. The road which runs parallel to the Danube (approx. 100m above sea level) intersects this ravine at a right angle and enters Opatovac, descending into the settlement located therein (approx. 75m above sea level). The centre of Opatovac is located at the lowest point of the ravine's floor, *i.e.* almost at the level of the Danube. As soon as the ravine begins to ascend on its other side (farther eastward), houses become rarer, completely disappearing after one leaves the settlement. This is followed by fields until Mohovo, and then Šarengrad, which, based on the aforementioned model, are identical to the situation described in Opatovac. Excluding Sotin and its different origin, Opatovac, Mohovo and Šarengrad are the only settlements from Vukovar to Ilok associated with the right bank of the Danube, and all three are in ravines (Figs. 6, 6a).

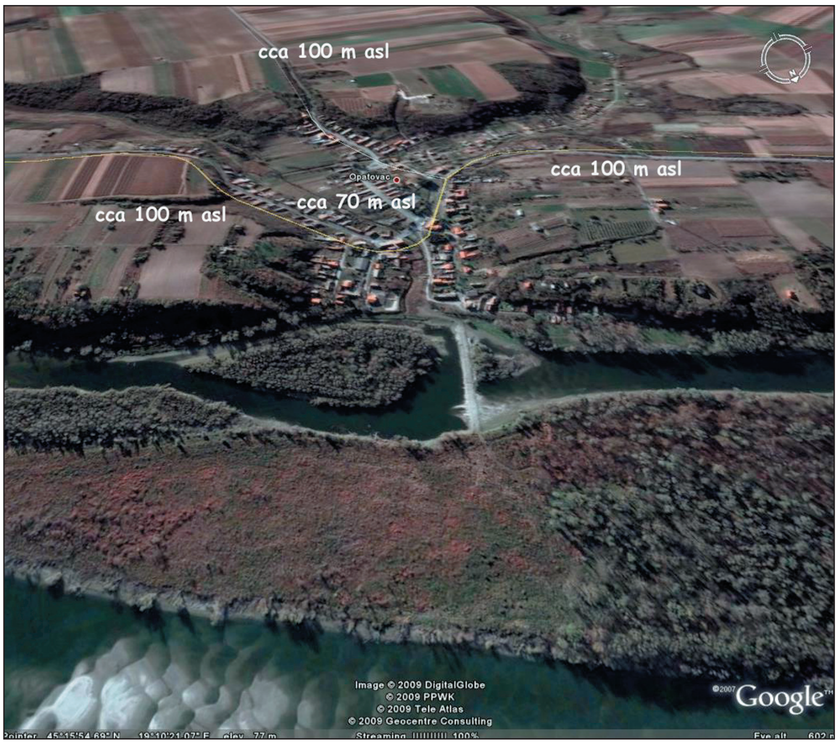


Fig. 6a. Satellite image of a village in a ravine (Opatovac).

5 Sotin also has two small ravines which descend to the Danube.

Why is so?

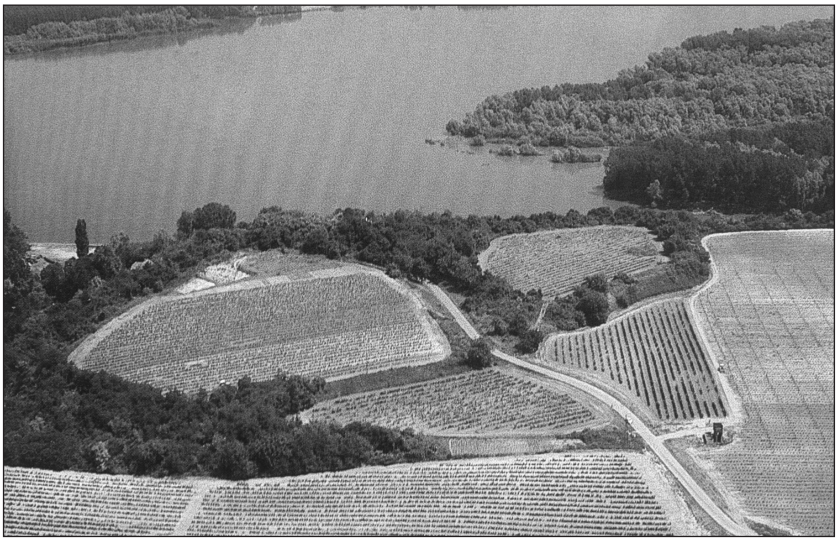


Fig. 7. Aerial view of Vučedol.

The reasons, which immediately become apparent, are very practical. Loess, as a very friable and sandy soil, drains well and does not retain water. Since the banks are steep, approximately 25 to 35 meters above the Danube, a settlement built anywhere else would require wells at least that deep to obtain water. Beside a river abundant in water (and fish), this would have been absurd, as it was crucial simply to control and settle access to the river. Communication with the Danube was simplest from ravines which gently descended to its banks. Settlements thus emerged precisely at such sites. The cold northeast winter winds certainly played a role in this selection of ravines as ideal habitation sites. There are many more reasons: the streams which flow through these ravines, and the possibility of building hoards/basements in the vertical loess faces, which are today mainly used as wine cellars, *etc.* These key factors for establishing settlements were also shared by the prehistoric communities, which is apparent in the lack of prehistoric settlements on the upper terraces more distant from the ravines. During tours of the terrain in these upper sections, the appearance of prehistoric ceramics has been recorded only along the river itself, directly above the ravines, while the wider area is only known by cases of numerous hoards (Šarengrad, Lovas) (*Brunšmid 1900; Vinski 1958*). Besides these sporadic finds with the character of hoards, which by their very nature are normally found outside the perimeter of settlements, the remaining area of the terraces above the ravines in this region are, as far as we know, almost entirely archeologically sterile. However, the advantages offered by ravines have one very negative aspect as a counterweight. The ideal availability of water and shelter from turbulent weather carry a price: the settlements have exceptionally unfavourable strategic locations. They are located in a narrow area, with flat terraces above them on both sides. In cases of threat, they are almost impossible to defend. Lying below any invaders, they are entirely helpless in any type of military manoeuvre. This situation has been confirmed even in the most recent history. During the Cold War tensions in neighbouring Hungary (October 1956), the army of the former Yugoslavia dug in at Vučedol itself (Fig. 9)[6]. Traces of a military trench are visible in the profiles of the Vučedol archaeological test dig. Had the

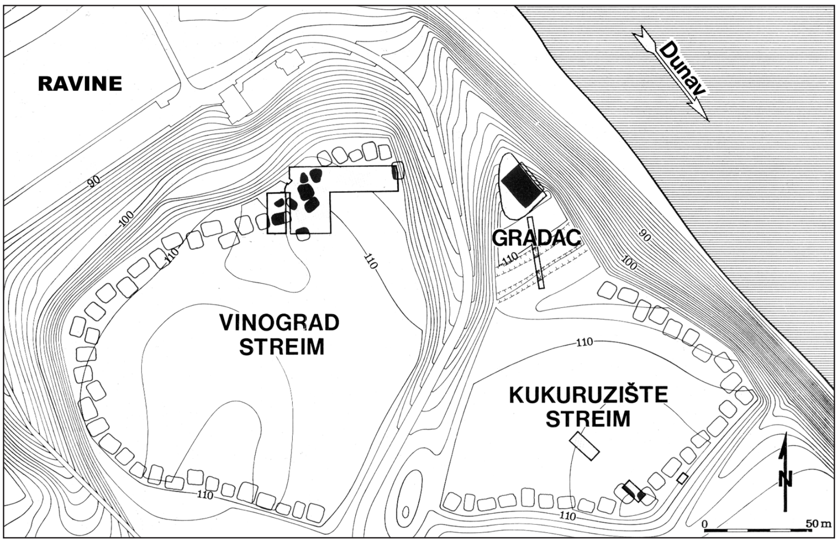


Fig. 8. Vučedol site. The two squares on the image next to the field are test trenches from the last 1980s (based on **Durman 1988***).*

6 We would like to thank A. Durman (Archaeology Department, University of Zagreb) for turning our attention to the modern military trench in test dig V–87, thereby prompting a line of thought which, in its own way, resulted in this text.

USSR, heading the Warsaw Pact, moved armoured formations towards Bačka and Syrmia, the territory from Ilok to Vukovar would have been evacuated due to the impossibility of defending these settlements, *i.e.* the entire area. The situation with armoured vehicles was the same in Croatia's Homeland War in 1991. As in the hypothetical case in 1956, Croatia's territory in 1991 was defended from Vukovar, which was the first line of combat. To be sure, the strategic positions which were relevant 5000 years ago are still relevant to this day.

Fig. 9. Traces of a military trench from the late 1950s in research test pit V-87, northern profile. Marked with arrows (photograph: M. Burić).

What is the current situation of prehistoric settlements in this part of Croatia? Vučedol, Ilok and Bapska (Fig. 10) are large prehistoric settlements erected at the very edges of ravines, which is a key common feature. Access to water from the ravine and fish from the river were thus controlled, and the surroundings were also overseen, with their seemingly endless expanse of fields containing excellent soil and space for pasturing. The construction of prehistoric settlements at the edge of ravines eliminated the negative components of digging wells, *i.e.* the problem of the water supply, the importance of which to the functioning of a settlement needs no further discussion. The settlement of the ravines in this manner demonstrates a set of rules which are rooted in prehistoric times, as seen in the examples of Vučedol, Bapska and Ilok as prehistoric settlements in one direction, and in the other direction in Opatovac, Mohovo and Šarengrad as modern settlements. All of them have in common a ravine as the axis of their organization (Figs. 7, 11). Besides these larger archaeological settlements which have been, some more, some less, researched over the past seventy years, Neolithic ceramics were also registered along the actual shoreline of the Danube, again along the edges of ravines and near the river. A preliminary field inspection conducted by a team from the Archaeology Institute in Zagreb resulted in the discovery of a group of Starčevo finds between Opatovac and Ilok (oral communication from Darija Ložnjak-Dizdar and Marko Dizdar). The prehistoric settlement in Bapska (Gradac) is particularly interesting among these settlements because, as opposed to the two mentioned above, it is not on the Danube itself. Located four kilometres south of Šarengrad, but also on the edge of a ravine in which there are roughly twenty sources of potable water over a one kilometre stretch (Fig. 10). Erected on a loess ridge 188m above sea level, it integrates all of the aforementioned ad-

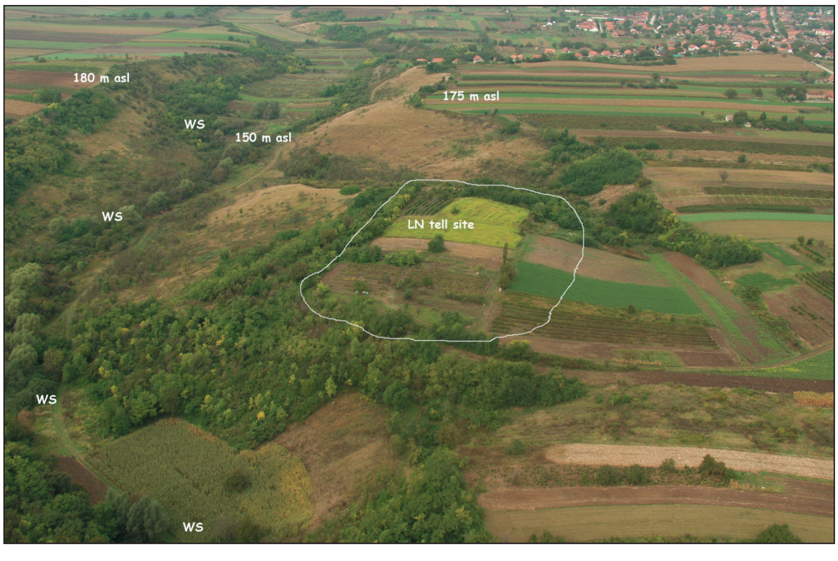


Fig. 10. Gradac in Bapska. The elevations of both sides of the ravine and several local sources of water are (WS) marked (photograph: M. Burić).

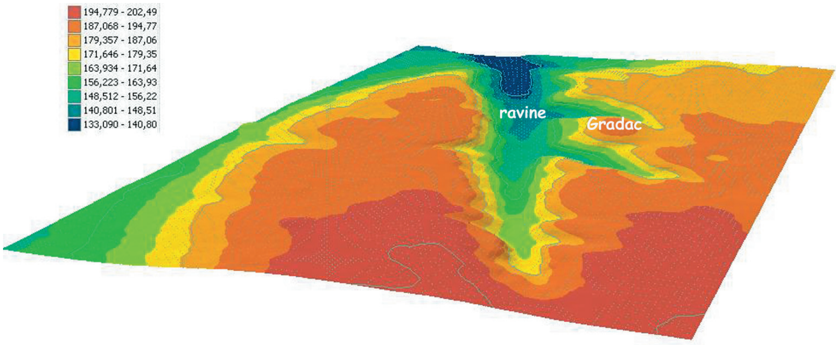


Fig. 11. Hypsometric image of Gradac in Bapska (made by A. Kuveždić 2006).

vantages except for the immediate vicinity of the Danube (Figs. 11, 12). Its strategic position is indicated by the fact that its upper archaeological layers belong to the last branch of the Vinča Culture, characterized by the turbulent time of its abandonment. The identical nature of the late Vinča ceramics from an eponymous site 114km distant leads to the conclusion that this cultural layer is that of a Vinča Culture population which withdrew westward, where it then disappeared in the period immediately after the mid-fifth millennium BC. Perhaps it is worth observing that the last culture at Gradac (Baden) was also the first culture at Vučedol, which is situated in the zone of emergence of the deep Syrmia ravines, where the space for withdrawal and defence is considerable larger and more secure. Current knowledge on the prehistoric settlements in this area regularly show a direct dependence of the organization of life on the immediate vicinity of the ravines, as their combination of shelter and access to water and fish and the strategic position of their edges raised into terraces made them ideal for settlement in the rich (pre)history of Western Syrmia. Western Syrmia, the area between Vukovar and Ilok, despite having the highest concentration of well-stratified and stratigraphically legible units in Croatia, is actually still quite under-researched. However, this can also be said of the rest of Slavonia, which, thanks to increasingly intensive rescue research in recent years, is revealing many settlements from all prehistoric periods (Kruševica-Njivice at Slavonski Šamac, Aljmaš-Podunavlje; numerous sites along the V-c motorway, such as the Đakovo-Sredanci and Belišće-Staro Valpovo sections, etc.) (*Miklik-Lozuk 2004.37, 38; Šimić 2005.7; Wiewegh & Kezunović 2005.8, 9; Šimić 2006.9, 10*).

By the same token, the narrow belt along the Danube itself, in the Croatian part of Syrmia, as noted, is revealing new sites with prehistoric finds. The intensive reconnaissance of this area, conducted by the Archaeology Institute in Zagreb and ongoing for some time, marks only the beginning in this area of data-gathering without resorting to destructive archaeological methods. All the results so far, as well as much older knowledge, indicate the same cause-and-effect sampling for the selection of sites for settlement, *i.e.* the location of settlements: exclusively on the steep-sided tops of ravines in prehistoric contexts, or in lower positions as settlement cores in more recent settlements.

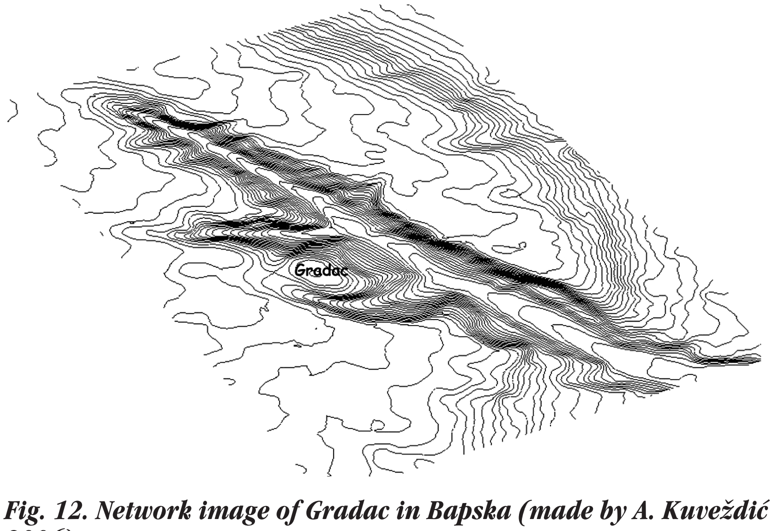


Fig. 12. Network image of Gradac in Bapska (made by A. Kuveždić 2006).

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Book reviews

Geoff Bailey, Penny Spikins (eds.)

Mesolithic Europe. Xviii+467 pages, figures 96, pages 27. 2008. New York: Cambridge University Press. ISBN 978–0–521–85503–7 (hardback)

The book is a collection of interpretative essays, local and regional, on the Mesolithic in Europe. The chapters are organised in broadly geographical order and focus on the definition of the Mesolithic, chronology, technology and subsistence, arts and rituals, settlements and social organisations.

The opening chapter is an introduction to a different perception of the Mesolithic, and suggests we shift from narratives of passive Mesolithic societies to a new generation of interpretations. The final chapter, follows a discussion of Mesolithic-Neolithic transition, dominates many contributions. This chapter actualises the 'Neolithic' interpretative model of 'demic diffusion', suggesting that there is no evidence of interaction between the Mesolithic and Neolithic populations of the Balkans and the Mediterranean.

However, the book suggests that elsewhere different elements of the 'Neolithic package' were introduced and adopted selectively and separately. Unfortunately, the book overlooks relevant information such the recent discussions of the origins and diffusions of 'Mesolithic' and 'Neolithic' Y-chromosomes and mitochondrial DNA haplogroups, and human population trajectories in the context of processes in the Mesolithic-Neolithic transformation. It does not reflect the discussion on the 8600–8000 and 6000–5200 calBP climate anomalies, which undoubted correlate chronologically with the Mesolithic and the Neolithic and drastically affected global environmental conditions.

'Mesolithic Europe' offers an interesting regional synthesis of the Mesolithic in different parts of Europe and is a perfect complement to Barker's volume 'The Agricultural Revolution in Prehistory. Why did Foragers become Farmers?'

Dusan Borić and John Robb (eds.)

Past Bodies. Body-Centered Research in Archaeology. viii+151 pages, figures 57, map 1, table 1. 2008. Oxford: Oxbow Books. The Cromwell Press, Trowbridge. ISBN–13: 978–1–84217–341–1; ISBN–10: 1–84217–341–3

"*The body in archaeology is both omnipresent and invisible.*" (Borić and Robb, p.1)

The book is a collection of essays resulting from two symposia, 'Past Bodies' in Cambridge in 2006, and 'Acting and Believing: An Archaeology of Bodily Practices', held at the Society for American Archaeology meetings at San Juan, Puerto Rico in 2006. The book is in four sections, with papers grouped by general theme or approach in order to draw attention to cross-disciplinary linkages. The first section presents a general introduction to social theories of the body and an overview of relevant archaeological methodologies. The second presents studies of the represented body, and the third, studies of the body in death. The fourth section contains studies which cut across traditional domains of study such as representation and burial, and focus upon the socially contextualised body at particular historical moments.

The articles range from the hunter-gatherers of the Upper Palaeolithic through modern British populations. The majority refers to the European sequence, but there are discussions of Near Eastern, North American and Mesoamerican cases. The book offers three theoretical implications: (i) it underscores the productive richness of the concept of the body in archaeology; (ii) it shows that the archaeology of the body is not the monopoly of a single province of archaeology, particularly data-rich regions; (iii) it goes beyond such stereotypes and prejudices as 'symbols, gender, agency, social relations and ritual experience, *etc*., are all very well, but you can only do them where you have texts'.

DOI: 10.4312/dp.36.23

The field of 'body studies' has become increasingly influential in a growing range of academic subjects since the 1980's, when Norbert Elias introduced the 'homo clausus' or 'closed personality' image of human beings running through much of modern Western philosophy and social and political thought, with its emphasis on autonomy, freedom and independent agency. He suggested that this picture be replaced by one of human beings as 'open personalities', bound together in social 'figurations', and characterized more by interdependence than autonomy.

The book's most significant contribution is its evidence and argumentation highlighting the partiality of the, traditionally Western, homo clasus conception of the embodied being. It accomplishes this through various demonstrations of the 'relationality of embodied subjects' and 'fractal thinking'. It also addresses issues relating to questions of epistemology (knowledge and representation of the body), phenomenology (lived representations of the body), and ontology (the material bodily properties and capacities of our antecedents). The case studies provide explorations of corporeal knowing, sensing and being, and archaeology's concern with the 'open' and varied relationships that exist between embodied subjects and the social bodies of tribe and society.

Robert Bégouën, Carole Fritz, Gilles Tosello, Jean Clottes, Andreas Pastoors and François Faist (with the collaboration of François Bourges, Philippe Fosse, Sébastien Lacombe and Mathieu Langlais)
La Sanctuaire secret des Bisons. Il y a 14 000 ans, dans la caverne du Tuc d'Audoubert. 415 pages, 484 illustrations. 2009. Paris: Somogy éditions d'art. ISBN 978–27572–0203–6.

Tuc d'Audoubert – with Les Trois Frères and Enlène – is part of the cave system of the River Volp, and best known for its bison sculpted in clay. The monograph 'La Sanctuaire secret des Bisons' is the result of intense scientific research between 1992 and 2004 on the cave and its Pleistocene art. The important part of the research was the re-examination of the archaeological material from earlier excavations. The book begins with the exciting story of the discovery of Tuc d'Audoubert in 1912 and the subsequent research of the cave's chambers and galleries, which are decorated with numerous paintings and engravings. The geographical position of the cave, the genesis of the cave system and landscape are then described, and environmental facts, and the cultural characteristics of the Magdalenians in the Pyrenees region are presented. The reasons for the excellent preservation of the cave art are also emphasised. The methods of research and various techniques for documenting parietal art are presented and some terminological problems explained. The main part of the book is dedicated to the cave art of Tuc d'Audoubert. The reader encounters various motifs and representations in a voyage through the cave chambers and galleries from the entrance to its deepest recesses, where the journey ends with the most spectacular find – sculptures of bison. The Magdalenians did not visit the cave only to create images – they also lived in it for short periods, and left artefacts and animal bones in some parts. Among the more enigmatic finds are objects pushed into fissures in the cave walls. Similar objects have been found in other caves and might be interpreted as offerings of some kind, which connected people with the cave and underground world. There are numerous impressions of human feet in the cave. It is interesting that there are adult and children's impressions deep inside the cave, so at least one child accompanied adults to the Gallery of the Clay Bison. In the final chapters, the authors explain the chronology of the art in Tuc d'Audoubert. They discuss the figurative and non-figurative themes of the art, the art techniques, the distribution of the images and the relation between the mundane and symbolic or "sacred" spaces of the cave. The cave and its art are set in the context of the Magdalenian cultural region of the Pyrenees and the wider south-western European region. The book ends with an attractive epilogue, in which imagination takes wings in a story about the life and creativity of the Magdalenian people who visited Tuc d'Audoubert. "La Sanctuaire secret des Bisons" is an extensive work, which systematically presents a Palaeolithic cave art site. The numerous illustrations contribute to the general attractiveness of the book.

Mihael Budja and Simona Petru

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