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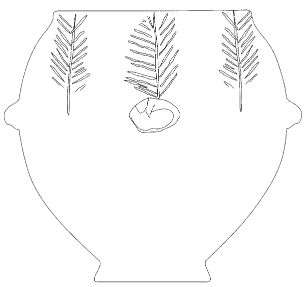
Almost fifty years ago (1964) a group of enthusiasts around the eminent Slovenian archaeologist Professor Josip Korošec at the University of Ljubljana established a new journal entitled *A Report on the Research of the Neolithic and Eneolithic in Slovenia* (*Poročilo o raziskovanju neolita in eneolita v Sloveniji*). Professor Korošec was the first editor and published the first two volumes, which were dedicated to the results of the excavations in the Ljubljansko barje region. After Professor Korošec passed away, the journal was edited by Professor Tatjana Bregant for the next twenty years (3rd to 21st Volumes). In this period, the journal became a respectable publication in Slovenia and the former Yugoslavia for topics relating to the Paleolithic, Neolithic and Eneolithic periods. A number of palaeoenvironmental and palaeoeconomic studies were also published alongside the archaeological topics.

Since the 22nd Volume, the editor has been Professor Mihael Budja, and the editorial policy has shifted from regional to global scale, and for its 25th anniversary the journal changed its title to *Documenta Praehistorica*. The journal started to publish selected papers that had been presented at the international conference established at that time entitled 'The Neolithic Seminar', which has been organised annually by the Department of Archaeology at the Faculty of Arts in Ljubljana for the past twenty years. The Seminars attracted leading researchers from the field and soon became a hub for discussing theoretical concepts, interpretative models and the results of interdisciplinary research studies and projects in Europe and Asia. A 'Ljubljana school' of Neolithic studies was formed within this intellectual milieu by a group of researchers who applied and developed ideas discussed at the seminars and in the journal. The papers in *Documenta Praehistorica* address studies that range from cultural and typological topics to archaeometry, from paleoclimate to paleoeconomy, from demography to archaeogenetics, and from symbolism to identity.

Since 1999, *Documenta Praehistorica* has had international members on the editorial board alongside Slovenian researchers, and since 2005 it has been enriched by a new web editor and a technical editor. With the formation of the journal's web page in 2001 the published papers can also be accessed on-line.

Documenta Praehistorica is the only international journal to focus on interdisciplinary research based on Neolithic studies. The main strength of the journal is that it provides an opportunity for the publication of diverse approaches, theories and specific case studies, while maintaining a coherent editorial policy in addressing significant topics and studies relating to the Neolithic and Eurasian prehistory in general. *Documenta Praehistorica* has thus emerged as a central hub where the richness of different approaches, theories and ideas in contemporary Neolithic studies is easily recognisable.

The editorial board
Ljubljana, November 2013



Contents

The beginnings of prehistoric agriculture in the Russian Far East: current evidence and concepts

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ABSTRACT – *The current situation with studies of prehistoric plant cultivation in the Russian Far East is presented. A critical analysis of existing concepts and models of the oldest agriculture in this region is also included. Reliable data allows us to conclude that humans in the southern Russian Far East (Primorye Province) began to cultivate millet at* c. *4700–4600 BP (*c. *3600–3400 calBC) in the context of the early Zaisanovka cultural complex of the Late Neolithic. The most probable source area for prehistoric agriculture in the Russian Far East was neighbouring Northeast China (Manchuria).*

IZVLEČEK – *V članku predstavljam trenutno stanje raziskav prazgodovinske kultivacije rastlin na ruskem Daljnem vzhodu. Vključena je tudi kritična analiza obstoječih konceptov in modelov o najstarejšem poljedelstvu na tem območju. Zanesljivi podatki kažejo, da so ljudje v južnem delu ruskega Daljnega vzhoda (provinca Primorye) pričeli gojiti proso ok. 4700–4600 BP (ok. 3600–3400 calBC) v kontekstu zgodnjega kulturnega kompleksa Zaisanovka v poznem neolitiku. Najverjetnejše izvorno območje prazgodovinskega ruskega poljedelstva na Daljnem vzhodu je sosednja severna Kitajska (Mančurija).*

KEY WORDS – *Russian Far East; Late Neolithic; Zaisanovka culture; prehistoric agriculture; millet*

Introduction

In original geographical sources, the Russian Far East refers primarily to Primorye (Maritime) Province, the Amur River basin, Sakhalin Island, and the Kurile Islands (*Suslov 1961; Ivanov 2002*). In this paper, a review of the current state of knowledge of the earliest (*i.e.* prehistoric) agriculture in this part of Northeast Asia is presented, with a discussion of existing concepts and models on the emergence of plant cultivation. Updated summaries of Stone Age (both Palaeolithic and Neolithic) archaeology and chronology in the Russian Far East can be found in volumes edited by Zhanna V. Andreeva (*2005*) and Sarah M. Nelson *et al.* (*2006*), and in an overview paper by Yaroslav V. Kuzmin (*2012a*). The current progress in archaeobotanical studies of agriculture in continental East Asia is given by Gary W. Crawford (*2006*), Harriet V. Hunt *et al.* (*2008*), Zhijun Zhao (*2011*), and Gyoung-Ah Lee (*2011*).

Materials and Methods

At present, traces of early agriculture (in the form of cultivated cereals) in the Russian Far East are known from about 10 sites (Fig. 1; Tab. 1). All except one (*i.e.* Valentin-Peresheek) are in the southern part of Primorye Province, mainly in the forest steppe biome (*Kuzmin 2006a.14–15*) and also on the coast of the Sea of Japan.

In Russian archaeological practice, so-called 'archaeological cultures' (to some extent similar to 'cultural complexes' in Western archaeology) are usually defined (*e.g., Trigger 2006.343*). Each culture or cultural stage, significant in terms of early agriculture, is briefly characterised here. It is also important to remember that in Russian archaeology, the Palaeolithic and Neolithic are separated on the basis of presence of pottery rather than agriculture (*e.g., Kuzmin 2006a; 2010a*).

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In the Neolithic of Primorye, the three main archaeological cultures are: Rudnaya [Rudnaia], Boisman, and Zaisanovka [Zaisanovsky] (*e.g., Zhushchikhovskaya 2005; 2006*). In the Rudnaya and Boisman complexes of the Early-Middle Neolithic, hunting, fishing, and gathering of terrestrial and marine organisms formed the basis of the economy (*e.g., Kuzmin 1995; 1997a; 2006b*). The Zaisanovka culture of the Late Neolithic has the earliest manifestations of agriculture, along with non-productive economic activities. Research indicates that the Zaisanovka complex dates to *c.* 5800–3100 BP (*c.* 4800–1500 calBC) (*Kuzmin 2002; 2006a; Kuzmin* et al. *1994; 1998a; 1998b*). Pottery analysis defines two chronological stages of the Zaisanovka complex: (1) an early stage, with located mainly on the coast of the Sea of Japan (including the Zaisanovka 7 site) and a few inland sites (the early component of the Krounovka 1 site; see below), dated to the 4th millennium BC; and (2) a late stage, with sites situated mainly on the Khanka Plain (including Novoselishche 4 and Rettikhovka-Geologicheskaya sites) and in the coastal zone (Zaisanovka 1 and Gvozdevo 4 sites), dated to the 3rd–2nd millennia BC (*Yanshina, Klyuev 2005.200*).

The concept of 'economic-cultural type' (hereafter ECT) is used in Russian ethnographical and archaeological research to characterise major branches of palaeoeconomy: "*[that] groups together historically established cultural and economic characteristics of different people who are at the same level of socioeconomic development and live under similar natural conditions*" (*Cheboksarov 1981*). The main ECT of the Neolithic populations in the southern Russian Far East has been enumerated by Kuzmin (*2005. 186–187; 2012b*) (see Fig. 2). In the Early-Middle Neolithic, several ECTs existed in the Russian Far East: (1) forest hunters and fishers of the Sikhote-Alin Mountains and Zeya River basin; (2) fishers and hunters of the Amur River basin; and (3) coastal hunters, fishers, and marine mollusc gatherers of Primorye (*e.g,. Kuzmin, Rakov 2011*; Fig. 2.1–3). In Manchuria, the ECT of early horticulture based on millet cultivation emerged (Fig. 2.4). In the Late Neolithic, this ECT spread to Primorye and the Korean Peninsula (see Fig. 2); at the same time, the role of hunting, fishing, and gathering remained important, and the above-mentioned ECTs continued to co-exist in Primorye along with the new ECT of food producers.

For the purpose of this review, both direct and indirect data related to plant cultivation are used. The direct indicators are the finds of cultigens' seeds. As for indirect traces of agriculture, two kinds can be distinguished:

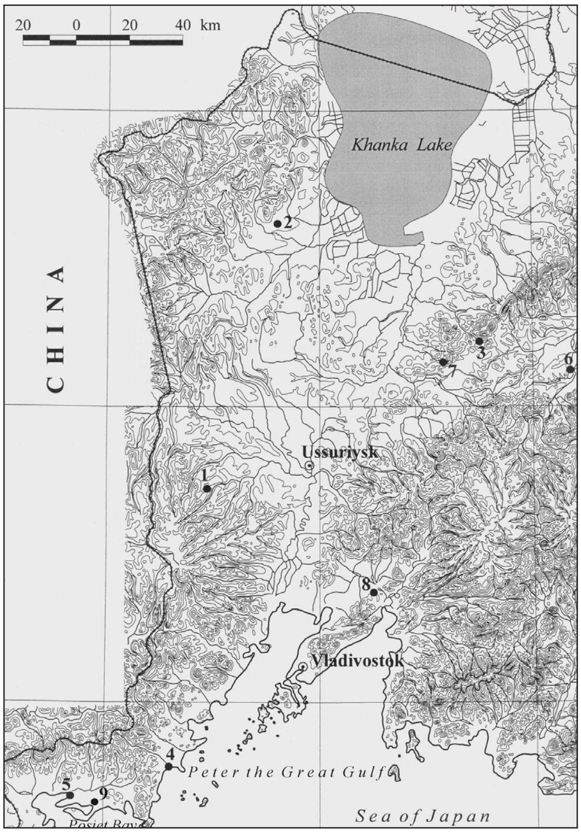

Fig. 1. The earliest sites with evidence of agriculture in Primorye Province: 1 Krounovka 1; 2 Novoselishche 4; 3 Rettikhovka-Geologicheskaya; 4 Boisman 2; 5 Zaisanovka 1, 2, and 7; 6 Sheklyaevo 7; 7 Mustang 1 and Bogolubovka 1; 8 Kirovsky; 9 Gvozdevo 4.

- ❶ archaeological evidence in the form of tools which might have been used in agricultural practices, such as hoes, ripping knives, and grind stones (querns);
- ❷ palynological indicators such as pollen of cultivated cereals.

The study of plant remains at prehistoric sites in Primorye, recovered from cultural layers by means of water flotation, was conducted according to international standards (*e.g., Harstorf, Archer 2008; Pearsall 2000*).

The radiocarbon dating of sites with evidence of early agriculture in Primorye was undertaken according to general practice in this field (*e.g., Taylor 1987; Jull 2007; Cook, van der Plicht 2007*). Critical analysis of the results obtained is a crucial part of age determination; the main principal is 'chronometric hygiene' (*sensu Spriggs 1989*; see also *Kuzmin 2006c*).

Site, layer	Material dated	^{14}C date, BP	Lab No.	Calendar age, calBC*	References
		Primary sites/components/dates			
Krounovka 1, levels 2–3	Charcoal	4670 ± 30	NUTA2-5643	3620–3370	*Komoto, Obata 2004*
	Charcoal	4640 ± 40	Beta-171662	3620–3350	*Komoto, Obata 2004*
Novoselishche 4, below Stratum 7**	Charcoal	3840 ± 70	AA-13400	2480–2050	*Kuzmin* et al. *1998b*
	Charcoal	3755 ± 35	AA-36748	2290–2040	*Kuzmin 2006a*
	Millet seeds	3840 ± 40	TKa-14081	2460–2150	*Sergusheva 2007b*
Rettikhovka-Geologicheskaya	Charcoal	3390 ± 55	SOAN-4239	1880–1530	*Kolomiets* et al. *2002*
	Charcoal	3310 ± 45	SOAN-4240	1730–1500	*Kolomiets* et al. *2002*
	Charcoal	3280 ± 45	SOAN-4238	1670–1450	*Kolomiets* et al. *2002*
		Secondary sites/components/dates			
Krounovka 1, levels 2–3***	Charcoal	4795 ± 45	NUTA2-5281	3660–3380	*Komoto, Obata 2004*
	Carbonized nut	4790 ± 40	Beta-180131	3650–3380	*Komoto, Obata 2004*
Novoselishche 4, Stratum 7 (?)	Millet seeds	3090 ± 50	SNU04-192	1490–1210	This paper
Novoselishche 4, Stratum 5	Seeds (unidentified)	3170 ± 60	SNU04-191	1610–1310	This paper
	Millet seeds	3015 ± 50	TKa-13487	1410–1120	*Sergusheva, Klyuev 2006*
Mustang	Charcoal	4660 ± 60	Ki-3151	3630–3200	*Kuzmin* et al. *1994*
	Charcoal	4050 ± 70	Ki-3152	2880–2460	*Kuzmin* et al. *1994*
Sheklyaevo 7	Food crust****	4435 ± 45	AA-60053	3330–2920	*Kuzmin 2012a*
	Food crust****	4430 ± 45	AA-60051	3330–2920	*Kuzmin 2012a*
	Charcoal	4390 ± 45	AA-60058	3320–2900	*Kuzmin 2012a*
Kirovsky	Charcoal	4150 ± 60	Le[RUL]-193	2980–2580	*Butomo 1965; Kuzmin* et al. *1998b*
Gvozdevo 4	Food crust****	4130 ± 40	AA-60612	2870–2580	*Kuzmin 2012a*
Zaisanovka 1	Carbonized nut	4010 ± 45	NUTA2-5282	2840–2360	*Komoto, Obata 2004*
	Carbonized nut	3970 ± 30	NUTA2-5483	2570–2350	*Komoto, Obata 2004*
Bogolubovka 1	Charcoal	3890 ± 60	SNU07-260	2560–2150	*Garkovik 2008*

*Calib 6.0.1 software was used, see *Reimer* et al. 2009 (± 2 sigma, all possible intervals combined and rounded to the next 10 years).
**Samples were collected from the floor of the dwelling.
***These ^{14}C values are less securely associated with the finds of millet seeds than the ^{14}C dates NUTA2-5643 and Beta-171662 (see text).
****These ages were obtained on food adhesions on the pottery surface, and could be older than the contemporaneous charcoal; see *Fischer, Heinemeier 2003*.

Tab. 1. Radiocarbon dates associated with the earliest millet agriculture in Primorye (from* Kuzmin *2012a, modified).

For readers who may be interested in the original Russian references, the citation of Russian sources is given as Romanisation for the titles of papers and monographs and their translations into English, and with only Romanised titles of edited volumes and journals. This method of quoting sources in non-Roman languages makes it possible to search for them in the catalogues of Western libraries. The current approach follows volumes edited by Nelson *et al.* (*2006*), Kuzmin *et al.* (*2007*), and Kuzmin and Glascock (*2010*).

The earliest agriculture in the Russian Far East: factual data

The oldest direct evidence for agriculture is found in the Late Neolithic component of the Krounovka 1 site (Fig. 1), located in the Krounovka River valley of southern Primorye. The site was discovered in the late 1950s (*Okladnikov 1965*), and the first excavations were conducted in the 1960s; it is a typical late Zaisanovka complex (*Brodiansky 1987.91*). The second campaign took place in the 2000s. The remains of two dwellings (Nos. 4 and 5) were found (*Komoto, Obata 2004*). Compared to the 1960s excavation, an earlier Zaisanovka component was discovered. Among the stone tools typical of Zaisanovka culture (arrowheads, scrapers, drills, and hammer-stones; see *Zhushchikhovskaya 2006.113–115*), several saddle querns and their fragments were found; these may have been used to process grain crops (*Komoto, Obata 2004*).

There are four ^{14}C dates associated with this cultural component (see Tab. 1). The value of *c.* 4795 BP was obtained on a sample collected from the site wall during the cleaning of the profile. The ^{14}C dates of *c.* 4640 BP and *c.* 4670 BP were generated on specimens from hearths in Dwelling 4. The ^{14}C value of *c.* 4790 BP was gained from carbonised acorn collected from a hearth near Dwelling 4. The ^{14}C values of *c.* 4640–4670 BP are the most securely associated with the millet seeds, and therefore provide the most reliable age estimate for the emergence of plant cultivation in the Russian Far East (see below).

Flotation of sediments from the Zaisanovka cultural layer resulted in the recovery of cultigen remains (*Sergusheva 2007a, 2007b; Sergusheva, Vostretsov 2009*). The cultigen seeds are all from dwellings 4 and 5, where 28 individual seeds (3.9% of total plant remains from both dwellings) of broomcorn millet (*Panicum miliaceum*), some 43 seeds (17.9% of total plants from Dwelling 5) of beefsteak plant (*Perilla frutescens*), and 2 seeds, provisionally identified as foxtail millet (*Setaria italica*), were recovered (*Komoto, Obata 2004. 48–50*). Seeds of unidentified wild grasses, barnyard grass (*Echinochloa crusgalli*), and several other unidentified species were also retrieved (1.3–2.7% of total plant remains) (*Sergusheva 2007a, 2007b*). Other wild plants include Amur cork tree (*Phellodendron amurense*), grape (*Vitis amurensis*), chenopod (*Chenopodium* sp.), amaranth (*Amarantus* sp.), and knotweed (*Polygonum* sp.). Nuts and acorns are also present: Manchurian walnut (*Juglans mandshurica*), hazel (*Corylus* sp.), and oak (*Quercus* sp.). Overall, wild plants constitute about 75–92% of the total seed assemblage.

The second site with reliable evidence of early agriculture is Novoselishche 4, situated on the Khanka Plain in the southwestern part of Primorye (Fig. 1). Excavations were conducted in the late 1980s and in the 1990s, and exposed a Late Neolithic pit house (*Sergusheva, Klyuev 2006*). Three cultural assemblages were identified: Late Neolithic (strata 6–7), Bronze Age (strata 3–5), and Early Iron Age (strata 1–2) (*Klyuev* et al. *2002*). The oldest cultural layer (Stratum 7) is of primary importance. The Late Neolithic pottery here resembles that of the Zaisanovka culture with 'vertical zigzag' and meander motifs (*Klyuev* et al. *2002*). Among the stone tools, typical of the Zaisanovka complex, semi-lunar knives, querns, and hoes are noteworthy. They may have been used to harvest and process cultivated cereals (*Sergusheva, Klyuev 2006*).

Two ^{14}C dates were generated from the dwelling floor of the Zaisanovka component: *c.* 3840 BP and *c.* 3755 BP (Tab. 1). The sample collected from the infill of the Zaisanovka dwelling belonging to strata 6–7 (*i.e.* above the dwelling's floor) returned an age of *c.* 3045 BP (*Kuzmin* et al. *1998b*). Thus, only material taken from the dwelling floor should be considered as corresponding to the Late Neolithic component of this site. The overlying Bronze Age component was dated to *c.* 2980 BP (*Kuzmin* et al. *1994*).

The Novoselishche 4 site is the first one in the Russian Far East where attempts to conduct direct ^{14}C dating of cultigens seeds were made (see Tab. 1). Two AMS ^{14}C dates were run in 2004: Stratum 5 – *c.* 3170 BP; and Stratum 7 (?) (broomcorn millet seeds) – *c.* 3090 BP (*Jong C. Kim, personal communication, 2004*). These values are younger than the dates on charcoal from the dwelling floor, *c.* 3840– 3755 BP (Tab. 1). Contamination from the overlying Bronze Age component, where millet seeds are abundant (*e.g., Sergusheva, Klyuev 2006*), may explain the discrepancy. Another AMS ^{14}C date was obtained on broomcorn millet from Stratum 5: *c.* 3015 BP (Tab. 1). The stratigraphic association of cultivated cereals at Novoselishche 4 remained in doubt until the AMS ^{14}C date of millet from the dwelling floor resulted in a date of *c.* 3840 BP (Tab. 1). Therefore, charcoal material from the floor of a dwelling at the Novoselishche 4 is most securely associated with cultigen seeds.

Plant remains, recovered from the Late Neolithic dwelling at the Novoselishche 4 site, include seeds of broomcorn millet from the bottom of the house fill (strata 6–7) and from the floor. There are 50 individual millet caryopses (about 30% of total plant remains) (*Sergusheva, Klyuev 2006*). Besides domesticated millet, vetch (*Vicia* sp.), barnyard grass, sheep sorrel (*Rumex acetosella*), hazel, Amur cork tree, oak, and grapevine, were found.

The third site with direct evidence of early agriculture in the Russian Far East is Rettikhovka-Geologicheskaya on the Khanka Plain (Fig. 1). It was discovered in 1992 (*Kolomiets* et al. *2002*), and excavated in 1999 and 2004. The cultural remains consist of two components, the Late Neolithic and Early Iron Age (*Kolomiets* et al. *2002; Sergusheva 2006*). Stone tools and pottery were recovered from the Late Neolithic layer. Arrowheads and querns are the most numerous stone artefacts. Pottery analysis indicates that the ceramics are typical of the late Zaisanovka complex (*Kolomiets* et al. *2002.98–99*). The capacity of some vessels is up to 30–40 litres, and for the largest container is more than 70 litres (*Kolomiets* et al. *2002; Sergusheva 2006*); these vessels may have

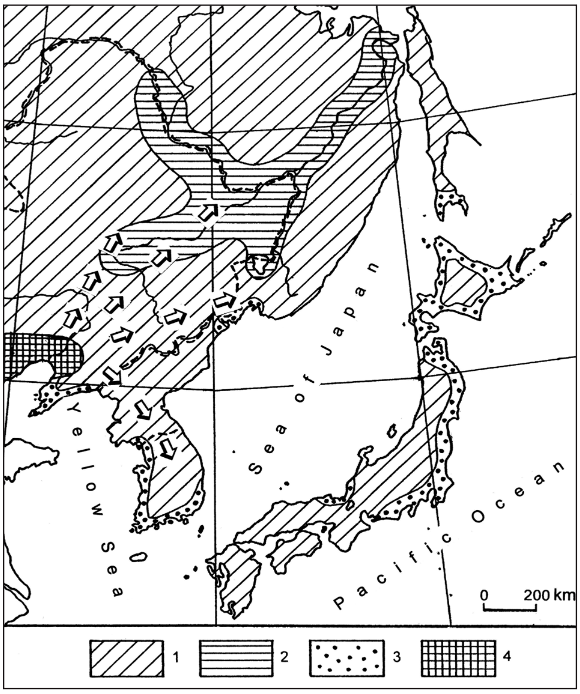

Fig. 2. Economic-cultural types (ECTs) of the Early-Middle Neolithic in Northeast Asia (before* c. *5000 BP) and the diffusion of millet agriculture from a core in Northeast China (shown by arrows). The ECTs: 1 forest hunters, gatherers, and fishers; 2 sedentary fishers and hunters in large river valleys; 3 coastal fishers, gatherers, and marine mammals' hunters; 4 millet hoed horticulturalists.

been used for grain storage. Three samples from the lower part of the Late Neolithic dwelling were ^{14}C dated to *c.* 3390-3280 BP (Tab. 1); all of these ^{14}C values overlap with ±2 sigma; the dates average 3330±50 BP (*c.* 1740–1500 calBC).

Sediments from a storage building adjacent to the dwelling with ^{14}C dated charcoal were flotated. Although the exact number of seeds is not reported, they are apparently numerous. Seeds of broomcorn millet and foxtail millet were recovered, constituting the majority of the plant remains (*Sergusheva 2006*). A few carbonised fragments of hazelnuts and walnuts were also identified.

In addition to these three sites with well-studied evidence of plant cultivation, some other Zaisanovka culture sites in Primorye yielded either single millet seeds or cereal pollen (Fig. 1) (see *Lysov 1966; Verkhovskaya, Kundyshev 1993; Sergusheva 2011.88*).

A small quantity of foxtail millet seeds was recovered from the Zaisanovka 1 site (*Sergusheva 2007a; 2007b*) on the coast of Posiet Bay (part of the Peter the Great Gulf) in southwestern Primorye (see Fig. 1). Another site in this area, Gvozdevo 4, also yielded a single seed of broomcorn millet (*Sergusheva 2011*). One broomcorn millet seed was found in the Zaisanovka component of the Sheklyaevo 7 site (*Sergusheva 2007b*) in continental southern Primorye (Fig. 1). At another site located nearby, Mustang 1, a possible foxtail millet seed was recovered; the uncertainty is related to its poor preservation (*Sergusheva 2007b*). Garkovik (*2008*) recently presented data on a find of broomcorn millet from the Bogolubovka 1 site in southern Primorye, from the Late Neolithic context of the Zaisanovka culture. The dates for these sites range from *c.* 4660 to 3890 BP (see Tab. 1).

At the multi-period site of Kirovsky in southern Primorye (*Okladnikov, Brodiansky 1969.3–4*), foxtail millet seeds are associated with a date of *c.* 4150 BP (Tab. 1). The millet was initially related to the Bronze Age complex (*Butomo 1965.228; Okladnikov, Brodiansky 1969.4*), but later appears to have been associated with the Late Neolithic component (*Kuzmin* et al. *1994.363; Kuzmin* et al. *1998b; Yanshina, Klyuev 2005.191*). The date of *c.* 4150 BP corresponds to the general chronology of the Zaisanovka culture (*e.g., Kuzmin 2002; 2006a; 2012a*).

The Late Neolithic component of the Boisman 2 site on the Peter the Great Gulf coast, associated with the Zaisanovka culture (*e.g., Zhushchikhovskaya 2006.113*), contains large grass pollen, which may be of cultivated species (*Verkhovskaya, Kundyshev 1993*). The ^{14}C date on charcoal from this component is *c.* 3710 BP (*Kuzmin* et al. *1998b*). Another site located north and east of the Peter the Great Gulf area, Valentin-Peresheek, also yielded pollen of possible cultivated cereals (*Kuzmin, Chernuk 1995*). It was identified in the main Neolithic cultural layer belonging to the Zaisanovka culture (*e.g., Zhushchikhovskaya 2006*). The ^{14}C dates from this layer are *c.* 4900–4320 BP (*e.g., Kuzmin 2006a*). Pollen of possible cultivated species was also detected at the Late Neolithic component of the Zaisanovka 2 site situated near the Zaisanovka 1 site (see Fig. 1) (*Kuzmin, Chernuk 1995*), but the age of the cultural layer is uncertain.

At the Novoselishche 4 site, the palynological analysis of the Zaisanovka component shows some of the grass (*Poaceae*) pollen (content about 0.4–3.3% of total non-arboreal palynomorphs) is thought to be from cultivated species due to its large size (*Verkhovskaya, Esipenko 1993*). This is supported by archaeobotanical materials from this site (see above).

Overall, the data on the pollen of cultivated cereals from some Late Neolithic settlements in Primorye provide additional evidence in favour of agriculture emergence in the Zaisanovka cultural context.

Concepts and models of the emergence of agriculture in the Russian Far East

Okladnikov-Brodiansky's paradigm of 'Far Eastern nidus of plant cultivation' in 1960s

The first concept of the emergence of agriculture in the Russian Far East was that of Aleksey P. Okladnikov and David L. Brodiansky (*1969*), who proposed the existence of an independent 'nidus' (*i.e.* centre) of plant domestication in the Neolithic and Palaeometal period (Bronze Age and Early Iron Age), particularly for millet and soybeans. Their Far Eastern 'nidus' covers territories of Primorye, Korea, and Northeast China (Manchuria) (*Okladnikov, Brodiansky 1969.13*). As a factual basis, Okladnikov and Brodiansky (*1969*) employed mostly indirect evidence, such as the presence of hoes, ripping knives, and querns, along with a few domesticated millet seed finds in the Bronze Age (Kirovsky site; later associated with the Neolithic) and Early Iron Age complexes. Pottery, associated with the earliest agriculture complexes in Primorye, according to Okladnikov and Brodiansky (*1969*), has 'vertical zigzag' and meander decorations. It was pointed out that their Far Eastern centre of domestication was in some kind of contact with other parts of greater East Asia, where agriculture was known in the Neolithic, primarily with the Yangshao culture of North China (*Okladnikov, Brodiansky 1969.13–14*).

On the basis of modern state of knowledge of prehistoric East Asian agriculture (*e.g., Crawford 2006*), Okladnikov and Brodiansky's (1969) ideas may general be said to fit the factual data, as well as some details. The earliest millet agriculture in Northeast Asia is now known from Early Neolithic complexes in southern Manchuria, dated to *c.* 7500–6500 BP (*e.g., Shelach 2006*; see also *Hunt* et al. *2008; Liu* et al. *2009*). In neighbouring Korea and Primorye, the earliest direct evidence of agriculture dates to the Late Neolithic, *c.* 4600 BP (*Crawford, Lee 2003; Kuzmin* et al. *1998b*).

Kuzmin's concept of age and source of agriculture in the Russian Far East in 1990s–2000s

In the mid-late 1980s, a programme of extensive ^{14}C dating of prehistoric cultural complexes in the Russian Far East was initiated by the author (see summaries in *Kuzmin 2006a; 2012a*). The construction of reliable ^{14}C chronologies for major Palaeolithic and Neolithic complexes, along with new data on early agriculture in Primorye and adjacent Northeast Asia, allows the conclusion that the source of plant cultivation, known in the Russian Far East since *c.* 4200–3700 BP, lay in neighbouring North and Northeast China, where agricultural complexes based on millet had existed since at least at *c.* 7700–5500 BP (*Kuzmin* et al. *1998b.816*).

According to the data available in the late 1990s (see *Kuzmin 1997b; Kuzmin* et al. *1998b*), the most probable way in which agriculture spread within Northeast Asia in the later phases of the Neolithic (4th to 3rd millennia BC) was from the northern and northeastern parts of China toward Primorye and the Korean Peninsula (Fig. 2). The validity of Kuzmin's heuristic model of horticulture spreading from Northeast China to Primorye and Korea was attested by new direct data from these regions (*Crawford, Lee 2003; Lee* et al. *2007; Choe, Bale 2002; Sergusheva 2007a*). This new information is now incorporated into the updated author's concept of the appearance of the earliest agriculture in the Russian Far East (see *Kuzmin 2010a; 2012a; Kuzmin, Rakov 2011; Kuzmin* et al. *2009*).

Vostretsov's model of interaction between maritime and agricultural adaptations in 1990s–2000s

Yuri E. Vostretsov (*1999; 2006; 2010*; see also *Sergusheva, Vostretsov 2009*) created a concept of interaction between maritime-adapted cultural complexes of the Primorye's coast and migrating populations with knowledge of agriculture. He proposed four 'turning points' when changes in cultural traditions occurred in Primorye in the Middle-Late Holocene: 5400–5200 BP, 4700–4300 BP, 3600–3300 BP, and 2500–2200 BP; all these intervals are correlated with cooling of the atmosphere and falls in sea level (*e.g,. Vostretsov 2006*). He connects the beginning of agriculture in south-western Primorye with the first interval, 5400–5200 BP. It has been stated that during the second and fourth intervals (*i.e.* 4700–4300 BP and 2500–2200 BP) "*landscape changes destroyed the traditional subsistence base of hunters and fishermen*" (*Vostretsov 2006.27*). During the second interval, 4700–4300 BP, bearers of the Zaisanovka complex with evidence of millet farming began to spread in southern and central parts of Primorye (*Vostretsov 2006.28*). As a summary, it is postulated that "*agriculture spreads into new territories following certain ecological stresses that disrupt traditional resource bases and sub-*

sistence strategies and cause depopulation." (*Vostretsov 2006.31*).

However, these statements contradict the original data, as was highlighted in several recent publications (*e.g,. Kuzmin 2012a.733; Kuzmin, Rakov 2011.106–107*). Firstly, the earliest direct traces of agriculture in Primorye are known from the Zaisanovka component of the Krounovka 1 site dated to *c.* 4670–4640 BP (*Komoto, Obata 2004*; also see above). There is no evidence of agriculture practice at the Krounovka 1 or other sites in Primorye prior to this time, and Vostretsov's (*2006*) first 'turning point' of 5400–5200 BP is not supported by solid facts.

Secondly, the destruction of the maritime-oriented resource base and subsistence strategies during the second 'turning point' at *c.* 4700–4300 BP is unjustified. At that time, the maritime economy is known in southernmost Primorye at the Zaisanovka 7 site. This settlement existed at *c.* 4500–4400 BP (*Komoto, Obata 2004; 2005; Kuzmin 2012a.732*). It is represented by a series of shell middens with abundant remains of marine molluscs and fish, along with some terrestrial mammals (*Komoto, Obata 2005*). Thus, the maritime economy continued to exist in southern Primorye after its suggested decline at *c.* 5000 BP (*e.g., Vostretsov 2006.28*).

Unfortunately, several other discrepancies exist in Vostretsov's publications. For example, in the description of the interaction between maritime and agricultural adaptations, Vostretsov (*1999.323*) states that "*in the north-west sector of the Japan Sea and eastern Korea, the intensification of maritime adaptation strategies is connected with the cooling and regression of the sea*". However, in other papers (*e.g, Vostretsov 2006.28*) the cooling at *c.* 5000 BP is correlated with a decline in maritime-adapted complexes (such as the Boisman culture of southern Primorye, see above) and the appearance of agricultural populations, which migrated from neighbouring Manchuria. It is unclear to me which of these statements is correct.

The source of prehistoric agriculture in the Russian Far East

As for the possible source of agricultural tradition in Primorye, in my opinion, Northeast China seems to be the most reasonable choice (Fig. 2). The latest research allows us to establish firmly the presence of millet seeds in the Xinglongwa culture of Manchuria (see *Lee* et al. *2007.1087*), now dated to *c.* 7470–5660 BP, with the majority of ^{14}C dates clustering at *c.* 7470–6530 BP (*c.* 6200–5100 calBC) (*Shelach 2006*). Crawford (*2006.82*) assumed that the Xinglongwa complex with finds of broomcorn and foxtail millets could be as old as *c.* 8000–7000 BP. The pottery from the Xinglongwa site has mostly impressed zigzag design (*Guo 1995*). Yanshina and Klyuev (*2005.199*) found definite common patterns in pottery designs from the Zaisanovka complex in Primorye and the Neolithic cultures in Manchuria, such as Xinglongwa, Cishan, Yaojinzi, Fuhe, and Hongshan.

It seems that the whole region between the Liao River basin of Manchuria and southern Primorye of the Russian Far East had been in a state of active contact since the Neolithic and perhaps even earlier, the late Upper Palaeolithic (*c.* 10 000–15 000 BP). This is supported by other secure line of evidence such as the transportation and/or exchange of obsidian in Northeast Asia between prehistoric Korea, Manchuria, and Primorye (*Kuzmin 2010b; 2011; Kuzmin* et al. *2002*).

Therefore, it seems logical that the Early Neolithic agricultural populations of Manchuria with impressed pottery began to spread toward the adjacent Russian Far East (mainly Primorye) and the Korean Peninsula after *c.* 5000 BP (Fig. 2), bringing their knowledge of plant cultivation. This is in accord with archaeological and archaeobotanical data from these two regions, where the first reliable traces of millet cultivation are now dated to at least *c.* 4600 BP (*Crawford, Lee 2003*), and it broadly confirms our earlier suggestion about the dissemination routes of millet agriculture in Northeast Asia (*Kuzmin* et al. *1998b*). In North China, the beginning of millet agriculture is now dated to an even earlier time, *c.* 9210 BP (*c.* 8610–8290 calBC), in the Early Neolithic context of the Cishan site (*Lu* et al. *2009*; see also *Crawford 2009; Kuzmin* et al. *2009.896–897*).

Concerning the mechanism whereby millet agriculture spread from a Chinese centre to its periphery, diffusion seems to be the most suitable explanation, as suggested before (*Kuzmin* et al. *1998b.816*). The southern Russian Far East may now be added to regions where millet cultivation was introduced and expanded from a Chinese core (*e.g., Bellwood 2005.7*).

Conclusions

Based on the most recent direct and reliable data on the earliest agriculture in the southern Russian Far

East, the appearance of millet cultivation in Primorye can be placed at *c.* 4700–4600 BP (*c.* 3600– 3400 calBC) in the context of the early Zaisanovka cultural complex of the Late Neolithic. The further development of millet agriculture is known in the late Zaisanovka culture, *c.* 3800–3300 BP (*c.* 2200–1600 cal BC). The primary Late Neolithic sites, where plant cultivation was practiced, were situated in the forest steppe area of southern Primorye, where natural conditions such as open spaces and a drier climate were favourable for millet cultivation compared to the surrounding forested areas.

Prehistoric cultural developments in the Russian Far East were a combination of local processes and influences from neighbouring regions of Northeast Asia. It is obvious today that the Russian Far East was a secondary area in terms of the origin of millet cultivation. The source region responsible for the appearance of agriculture in the Russian Far East is probably neighbouring Manchuria, where millet had been cultivated since the Early Neolithic, *c.* 7500–6500 BP (*c.* 6200–5100 calBC).

Okladnikov-Brodiansky's (*1969*) concept of "*Far Eastern nidus of ancient agriculture*" is generally correct, although it was significantly enhanced and transformed in recent decades. Vostretsov's (*1999; 2006; 2010*) model of maritime and agricultural adaptations and their relationship in the Neolithic of Primorye turned out to be in conflict with the primary information. Attempts to find a direct correlation between the climatic fluctuations and changes in human subsistence (*e.g., Vostretsov 2006; 2010; Sergusheva, Vostretsov 2009*) seem to be unproductive. Perhaps, the relationship between these two processes in the Russian Far East was quite 'non-linear', and more work needs to be done in order to identify the major driving force(s) which caused changes in human adaptive strategies in the Neolithic, including the beginning of agriculture.

As for the spatial-temporal relationship between pottery and agriculture, it is now clear that in the Russian Far East the emergence of pottery was not related to the origin of plant cultivation (see *Kuzmin 2013*). This feature is generally quite common in Northeast Asia, where the earliest pottery complexes dated to *c.* 13 700–13 300 BP (*e.g,. Kuzmin 2010c*), while rice and millet agriculture appeared at least several millennia later (*e.g., Bellwood 2005; Crawford 2006*).

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The problem of the neolithisation process chronology in Povolzhye

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ABSTRACT – *The Lower and Middle Volga basin regions border the Caucasus and Central Asia in the South. These regions are important in the study of the neolithisation process in Europe and the chronology of Neolithic cultures is of great significance in this respect. New ^{14}C dates of different organic materials from archaeological sites in these regions have been obtained in the last five years. According to these data, the beginning of neolithisation in North Caspian region can be dated to the beginning of the 5th millennium BC; but in the Povolzhye it happened at least a millennium earlier.*

IZVLEČEK – *Področje spodnjega in srednjega dela reke Volge meji na jugu na Kavkaz in Centralno Azijo. To področje je pomemben del študij neolitizacije v Evropi in kronologije neolitskih kultur. V zadnjih petih letih smo pridobili celo serijo novih radiokarbonskih datumov, pridobljenih iz različnih organskih snovi, za arheološka najdišča v tej regiji. Glede na te najnovejše podatke lahko začetek neolitizacije na področju severnega Kaspijskega morja postavimo na začetek 5. tisočletja BC; na območju ob Volgi pa se je začela vsaj tisočletje prej.*

KEY WORDS – *Povolzhye; Northern Caspian Sea; neolithisation; pottery; radiocarbon dating*

Introduction

Most archaeologists accept the considerable role of Povolzhye Neolithic cultures in the neolithisation of bordering areas, although numerous questions still remain open to discussion (*Vasiliev, Vybornov 1988; Mamonov 1999; Timofeev 2002; Dolukhanov 2003; Vybornov 2008a; Dolukhanov* et al. *2009; Vybornov* et al. *2009a; 2009b; 2012a; 2012b; Gronenborn 2009*). Thus, there are certain discrepancies between data on the chronology of younger Povolzhye sites. At present, investigations of typological and technological characteristics of pottery as well as radiocarbon dates of organic matter found in pottery allow us to consider some problems relating to the abovementioned questions. The method of direct dating of pottery has been published elsewhere (*Skripkin, Kovalyukh 1998; Kovalyukh, Skripkin 2007; Zaitseva* et al. *2008; 2009; 2011*) and it already gave positive results (*Vybornov 2008b*).

Dating the Early Neolithic in the Northern Caspian Sea area

The first radiocarbon dates for Early Neolithic sites in the Povolzhye region were obtained in the mid-1990s. For the Kairshak III site, the charcoal soil from the bottom of the lowest layer was dated to 6950±190 BP (Gin 5905), and to 6720±80 BP (Gin 5927) from the top of this layer; the upper layer is dated to 6100 BP. The date of 5500±150 BP (Gin 6777) (*Lavrushin* et al. *1998*) was obtained from soil at the Tenteksor site, which contained artefacts typologically dated to a younger period. These results allowed researchers to hypothesize that the Early Neolithic period in the southern Caspian Sea area can be dated from the beginning of the 5th millennium BC and up to the middle of the 4th millennium BC.

In 2007, the radiocarbon laboratory of the Institute of the Geochemistry of Environment, National Aca-

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demy of Sciences of Ukraine in Kiev obtained the following dates for the Early Neolithic: 7780±90 BP (Ki-14471), 7740±70 BP (Ki-14095), and 7680±90 BP (Ki-14096) from organic matter found in pottery at the Kairshak III site. From the Tenteksor site the 6640±80 BP (Ki-14101) date was obtained (*Vybornov 2008a*). The date of 6695±40 BP (Ua-35227) from the same site, obtained at Uppsala radiocarbon laboratory from carbon preserved in pottery, confirms the date of the Kiev laboratory. Thus, these dates turned out to be 1000 years older than the dates obtained in the mid-1990s. These dates offered the possibility of placing the Early Neolithic period in the northern Caspian Sea area from the beginning of the 6th millennium BC to the second quarter of the 5th millennium BC.

At the same time, the dates of 7190±80 BP (Ki-14633) and 7010±80 BP (Ki-14634) were obtained at the Kiev laboratory, and 7030±100 BP (SPb-316) at the laboratory of the Herzen State Pedagogical University of Russia in 2011 from bone samples from Kairshak III. These dates are similar to the dates from charcoal, although the dates of bones are younger than those for the pottery. Thus, there is some disagreement between the dates obtained in the mid-1990s and those in the past ten years. The older age of the pottery could be explained by its composition since Neolithic pottery in the Northern Caspian Sea area was made of lake silt with shell inclusions (*Vasilieva 1999*), which could give older dates due to the freshwater reservoir effect (*Fisher, Heinemeier 2003*).

The radiocarbon dating of shells inside the pottery fabric, found at the Tenteksor site, confirms this suggestion. In 2007, shell fragments extracted from the pottery were dated to 7235±45 BP (Ua-35226). The organic matter inside this pottery was dated to 6695±40 BP (Ua 35227). The reservoir effect in this case thus consists of more than 500 years (*Zaitseva* et al. *2008*). However, it should be noted that the shell-tempered pottery was treated with hydrofluoric acid to remove the mineral inclusions. For this reason, the reservoir effect is less likely. Confirmation of the validity of these dates comes from the laboratory of the Herzen State Pedagogical University of Russia with the date 6650±100 BP (Spb-423), that was obtained from organic matter inside pottery from the Tenteksor site in 2012. Moreover, there is another date available from this laboratory, 6540±100 BP (Spb-315a) obtained from bone collagen from Tenteksor that corresponds with the date from pottery. Furthermore, a similar date 6070±290

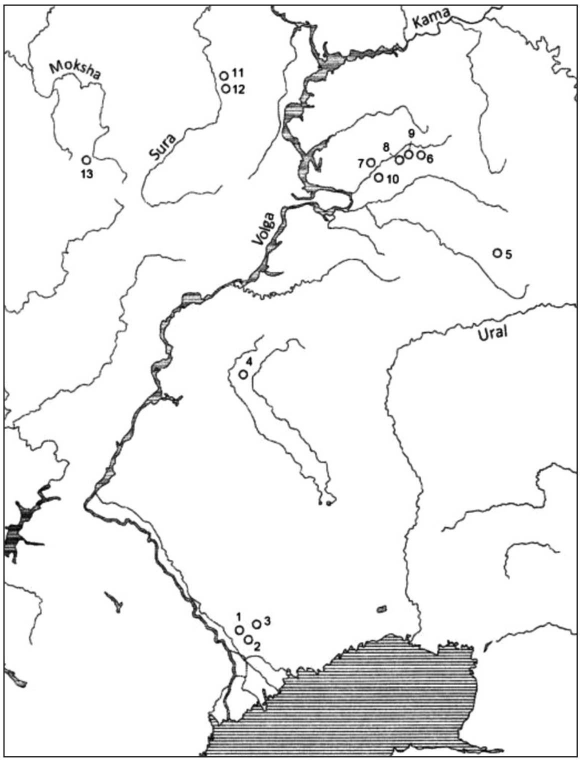

Fig. 1. Map of Neolithic sites in the northern Caspian Sea area and Povolzhye: 1 Kairshak III; 2 Kairshak I; 3 Tenteksor I; 4 Varfolomeevskaya; 5 Ivanovskaya; 6 Chekalino IV: 7 Lebyazhinka IV; 8 Iliinskaya; 9 Bolshaya Rakovka II; 10 Krasnyi Yar; 11 Lake Vjunovo I; 12 Utyuzh I; 13 Imerka VII.

BP (Le-9476) was obtained from bones from the same site in the laboratory of the Institute for History of Material Culture, Russian Academy of Sciences. If we correct this date to 6400 BP, it conforms to the previous results.

A date of 5560±100 BP (SPb-315), obtained from charred bones from Tenteksor, was measured in 2011 and corresponds with the date from the charcoal inside soil samples. This younger date can be explained by collagen loss during burning of the bones. It is possible that the dates of the charred bones and charcoal from soils are connected with a younger burning event at the site. These dates place the Tenteksor site to the 5th millennium BC. Archaeologists studying the Neolithic of the southern regions have concluded that there are close similarities between the artefacts from Tenteksor and layer 2A at the Varfolomeyevskaya site. Varfolomeyevskaya dates to 6693±39 BP (Ua-41362) and 6544 ±38 BP (Ua-41361) were obtained from food crust preserved on pottery (*Zaitseva* et al. *2011*). These dates correspond with the dates obtained by the Kiev laboratory and the dates of the pottery and bones from Tenteksor.

Some researchers (*Kuzmin 2012*) have noticed a discrepancy between the dates of the bones and pottery of several hundred years for the European Neolithic. This could also be a problem in the dating of the Neolithic in the Povolzhye steppe: dates of 6693±39 BP (Ua-41362) and 6540±80 BP (Ki-14613) for layer 2A at Varfolomeyevskaya were obtained from pottery, and dates on bones range from 5430±60 BP (Ki-3589) to 5220±50 BP (Ki-3596).

The ^{14}C dates of bones from the Kairshak III site are 500 years younger than those obtained from pottery. The bones probably came from the upper layer of the cultural deposits (*Vybornov 2008b*). This horizon is 500–600 years younger than the lower horizon, according to Spiridonova's data (*Lavrushin* et al. *1998*). The koulan bones that have been radiocarbon dated were excavated in 32–33 grid squares of the Kairshak III site and they were well preserved. The bones from other grid squares were in a much worse state of preservation and quite porous. Three pottery sherds of the same vessel were found in grid square 28 (located next to grid square 33) in the upper layer of the site. They are different from the Kairshak pottery and more similar to those from Tenteksor. We suggest that the pottery and bones belong not to the main (Kairshak) collection, but to the later, early Tenteksor type. The pottery samples are similar to earlier types than the Tenteksor III ceramics, which were dated to 7005±90 BP (Ki-14445) (*Vybornov 2008a*). We can suppose that these pottery samples are the same age as the bones, and the dates of 7190±80 BP (Ki-14633), 7010±80 BP (Ki-14634) and 7030±100 BP (Spb-316) are valid, but do not refer to artefacts of the Kairshak type, but to the earlier Tenteksor type. To resolve this contradiction, new dates of the Neolithic material in the north Caspian Sea area were obtained.

The date of 7775±42 BP (Ua-41359) (*Zaitseva* et al. *2011*) on food crust on the pottery surface from Kairshak III site was obtained on AMS in the Uppsala laboratory in 2011 and confirmed the previous dates from the Kiev laboratory. The confirmation of these dates comes from another sample of food crust on pottery from the same site, which is dated dates to 7700±120 BP (Spb-377); the analysis was performed at the laboratory of the Herzen State Pedagogical University of Russia. According to Jan Heinemeier (oral presentation in 2012), charred food crust could also give older dates due to the reservoir effect if aquatic food was cooked in ceramic vessels. The deviation in this case could be approx. 500 years (B. Philippson's report in 2012 at the radiocarbon seminar in Helsinki). It should be noted that the Kairshak III site is located some 600m from the nearest water source and no fishing tools made from stone or bone were discovered at the site. According to paleogeographic data, no suitable trees for boat construction were available near the site in the Neolithic (*Lavrushin* et al. *1998*). Additionally, the analysis of faunal remains showed that no fish bones had been found at the Neolithic sites in the northern Caspian Sea area (report by P. A. Kosintsev, 2011, Samara). Therefore we presume, that fish was rarely used for cooking at the Kairshak III site and the dates obtained from the charred food crust should be assumed to be valid.

According to typological analysis, artefacts from the Kairshak I site are younger than those from Kairshak III (*Vybornov 2008b*). This is supported by radiocarbon dates 7230±90 BP (Ki-14094) and 7180±80 BP (Ki-14132), obtained from organic matter inside pottery. Moreover, these dates are also supported by dates obtained from the laboratory of the Herzen State Pedagogical University of Russia (*e.g.*, 7100±200 BP; SPb-425). This contradicts the typological analysis that interprets Kairshak I artefacts as earlier than those from Kairhak III, where profiled and biconical vessels were found (*Viskalin 2010*). It should be mentioned that early pottery from the Elshanka sites has similar characteristics. Another argument for the younger dates of the Kairshak I assemblage are trapezes stone tools, which are typical of the younger Neolithic period. The dates and artefact analyses confirm that Kairshak I is indeed younger than Kairshak III.

Therefore, we conclude that the Neolithic at sites such as Kairshak and Tenteksor in the North Caspian Sea area developed from the second quarter of the 6th to the middle of the 5th millennium BC.

Dating the Early Neolithic in the forest-steppe of Povolzhye

One of the oldest Neolithic cultures in Eastern Europe is the Elshankaya culture from the Middle Povolzhye region. This culture influenced the neolithisation process of other regions (*Dolukhanov* et al. *2003; Vybornov 2008b; Vybornov* et al. *2009a; Gronenborn 2011; Vybornov, Vasilieva 2012*). There are approx. 70 radiocarbon dates obtained for the Elshanskaya culture and measured at different laboratories from various materials such as organic matter in pottery, clam shells, charcoal, bones and adjoining soils. The earliest dates were obtained from shells from sites such as Chekalino IV, Lebyazhinka IV and Ilyinka, and the formation of the Elshankaya culture is placed in the second half of the 7th millennium BC (*Mamonov 2006*).

Some researchers insist that these early dates are valid and that the dated shells are of anthropogenic origin; additionally, this is supported by palynological analyses at these sites. Nevertheless, other archaeologists are critical of this view and argue that radiocarbon dating of shells is problematic since shells usually show dates that are too old due to the reservoir effect (*Kotova 2002; Vybornov 2005; Stavitsky 2005; Viskalin 2006*). We argue that the ambiguity of radiocarbon dates from Chekalino IV can be explained by the fact that deposits with shells were formed earlier than layers with the main cultural assemblage; the same situation can be also noted at Ilyinka and Lebyazhinka IV. The dates of the shells contradict the dates of the main cultural assemblage and the chronology of Early Neolithic cultures in bordering areas. There is an effect of isolation of Elshanka materials, which, according to the technological analysis of pottery, appeared in the region already developed (*Vasilieva 2006a*). Therefore, these dates could not be taken into consideration.

The next group of ^{14}C dates for Elshanskaya culture date this culture to the first half of the 6th millennium BC. These dates were obtained at several laboratories from various types of organic material (*Vybornov 2011*). The oldest dates from this package are from shells from the Chekalino IV site and bones from the Ivanovskaya site; these dates could also be connected to the reservoir effect, re-deposition or a Mesolithic context.

The date 7660±200 BP (Spb-424), recently obtained for pottery from Chekalino IV in the laboratory of the Herzen State Pedagogical University of Russia, correlates well with the dates of shells from the same site, and the pottery is typologically similar to vessels from Ivanovskaya. Considering the large dispersal of this date, it almost coincides with the other dates mentioned above. This is an argument for their reliability and their dating to the Neolithic.

No.	Site	Index	Material	Culture	Age (BP)	Age, calBC (2 σ)
1	Kairshak III	GIN 5905	Humic acids	Kairshakskaya	6950±190	6250–5450
2	Kairshak III	GIN 5927	Humic acids	Kairshakskaya	6720±80	5740–5480
3	Kairshak III	Ki–14 097	Pottery carbon	Kairshakskaya	7890±90	7100–6500
4	Kairshak III	Ki 14 471	Pottery carbon	Kairshakskaya	7780±90	7050–6400
5	Kairshak III	Ki 14 095	Pottery carbon	Kairshakskaya	7740±70	6700–6430
6	Kairshak III	Ki 14 096	Pottery carbon	Kairshakskaya	7680±90	6700–6260
7	Kairshak III	Ua 41 359	Ceramic food crust	Kairshakskaya	7775±42	6690–6490
8	Kairshak III	SPb–377	Ceramic food crust	Kairshakskaya	7700±120	7050–6250
9	Kairshak III, upper layer	Ki 14 633	Animal bone	Kairshakskaya	7190±80	6230–5890
10	Kairshak III, upper layer	Ki 14 634	Animal bone	Kairshakskaya	7010±80	6020–5720
11	Kairshak III	SPb–316	Animal bone	Kairshakskaya	7030±100	6073–5718
12	Kairshak I	Ki 14 094	Pottery carbon	Kairshakskaya	7230±90	6390–6010
13	Kairshak I	Ki 14 132	Pottery carbon	Kairshakskaya	7180±90	6230–5840
14	Kairshak I	SPb–425	Pottery carbon	Kairshakskaya	7100±200	6375–5637
15	Tenteksor I	GIN 6177	Humic acids	Tenteksorskaya	5500±150	4700–3950
16	Tenteksor I	SPb–315	Burning bone	Tenteksorskaya	5560±100	4620–4230
17	Tenteksor I	Ua 35 266	Shells from pottery	Tenteksorskaya	7235±45	6220–6000
18	Tenteksor I	Ua 35 267	Pottery carbon	Tenteksorskaya	6695±40	5670–5520
19	Tenteksor I	Ki 14 101	Pottery carbon	Tenteksorskaya	6640±80	5720–5470
20	Tenteksor I	SPb–423	Pottery carbon	Tenteksorskaya	6650±100	5735–5464
21	Tenteksor I	SPb–315a	Animal bone	Tenteksorskaya	6540±100	5640–5315
22	Tenteksor I	Le–9476	Animal bone	Tenteksorskaya	6070±290	5600–4300
23	Varfolomeevskaya 2A	Ua–41 362	Ceramic food crust	Varfolomeevskaya	6693±39	5680–5530
24	Varfolomeevskaya 2A	Ua–41 361	Ceramic food crust	Varfolomeevskaya	6544±38	5620–5580
25	Varfolomeevskaya 2A	Ki 14 613	Pottery carbon	Varfolomeevskaya	6540±80	5622–5340
26	Varfolomeevskaya 2A	Ki 3589	Animal bone	Varfolomeevskaya	5430±60	4350–4040
27	Varfolomeevskaya 2A	Ki 3595	Animal bone	Varfolomeevskaya	5390±60	4350–4040
28	Varfolomeevskaya 2A	Ki 3590	Animal bone	Varfolomeevskaya	5270±50	4230–3970
29	Varfolomeevskaya 2A	Ki 3596	Animal bone	Varfolomeevskaya	5220±50	4230–3940

Tab. 1. ^{14}C dates of Neolithic sites in the Northern Caspian sea.

Furthermore, the radiocarbon date 7790±200 BP (Spb–426), obtained from organic matter in pottery from Bolshaya Rakovka II, also correlates well with the dates of pottery and bones from Ivanovskaya and shells and pottery from Chekalino IV.

We accept the validity of this early dates since there are several known Mesolithic-Neolithic sites in the Ust'-Tashelka region (*Vybornov 2008b*) and their dates coincide with Chekalino IV and Ivanovka sites. Therefore, this series of dates places the Elshanskaya culture of the Povolzhye forest-steppe into the first half of the 7th millennium BC. However, this hypothesis needs more evidence. There is a date of 7250±60 BP (Poz–42051), obtained from a small piece of charcoal in the pointed base of an Elshanka vessel from Chekalino IV and dated at the Poznan laboratory with the AMS method. The calibration date relates to the end of the third quarter of the 7th millennium BC. According to this date, the age of this site could be younger than previously assumed, but this date could also be the result of discrepancies between the dates from different organic materials. In this pottery sample, we suppose that Elshanskaya pottery was made from silty clay without shells and not from silt with natural lake or river shells inclusions (*Vasilieva 2006b*), and the reservoir effect is unlikely for this date. Some pottery was made with the application of organic solutions (*Zaitseva* et al. *2011*). Similar AMS radiocarbon dates from two laboratories, from Arizona and Poznan, were obtained on organic material from Lake Vjunovo I pottery, *i.e.* 7222±58 BP (AA–96017) and 7160±40 BP (Poz–47870) respectively (*Vybornov* et al. *2012*).

The largest group of ^{14}C dates was obtained from Samarskoye and Ulyanovskoye Povolzhye sites and dates the Neolithic from the end of the 7th to the middle of the 6th millennium BC. The spread of Elshanskaya culture population from the western part of the River Volga to Primokshanye, the Oka area, and probably to Middle Posurye, can be dated to the turn of the 6th and 5th millennium BC (*Vybornov, Vasilieva 2012*). Most of the artefacts related to this chronological stage are connected to the second stage of the Elshanskaya culture that is characterised by the appearance of vessels with flat bottoms, bands of pearl-pits under the rim and no ornamentation (*Vasiliev, Vybornov 1988*). This confirms that the Elshanskaya culture lasted up to the beginning of the 5th millennium BC. We suggest that sites were occupied at least twice within an interval of 1000 years, or the artefact assemblages should be more precisely determined. Finally, a date for Lebyazhinka IV, obtained from pottery, which is typologically close to the data from the Ilyinka and Krasny Gorodok sites, corresponds with the chronological position of this group into the first half of the 5th millennium BC. Nevertheless, another set of dates, also obtained from pottery, dated this group to the beginning of the 4th millennium BC. Therefore, the ages of Elshanskaya culture from Lebyazhinka IV should be verified. Most of the dates for this culture were obtained at the Kiev radiocarbon laboratory.

The small amount of samples for radiocarbon dating found at Early Neolithic sites complicates the formation of the Neolithic chronological sequence. However, the existence of Elshanskaya culture at the turn of the 6th to the 5th millennium till the middle of the 5th millennium BP is supported by archaeological analysis. The formation and development of pottery of the second type can be connected with this chronological gap, as well as the spread of the Elshankaya population from this area to the west of the River Volga.

Recently obtained dates for Elshanskaya culture allow researchers to date the development of this culture to the end of the 5th millennium BC (*Vybornov 2011*). These dates present certain contradictions with traditional typological schemes and sets of other radiocarbon dates for the same sites. According to this data we assume that typologically and technologically similar pottery existed within 2000 years. Certain problems still exist regarding the early dates of this culture, obtained from pottery, shells, soils, charcoals and measured in different laboratories. This position can be clarified by dating the material from Chekalino IV, the Early Neolithic age of which was confirmed by some dates, but also technologically and typologically. Radiocarbon dates of soil, shells and pottery of this culture are known, but from a younger phase. As we have explained, the dates of the humus, obtained from pottery, are unreliable.

It is also interesting that in some laboratories samples of Elshanskaya pottery were dated to the Bronze Age. These younger dates were obtained from pottery traditionally dated to the Early Neolithic and gave results such as 4850±80 BP (Ki–17056) for Nizhnyaya Orlyanka II site from the Kiev laboratory, 4541±41 BP (AA96017) for Vjunovo lake I at the Arizona laboratory, and 4450±50 BP (Poz–42055) for Plautino I at the Poznan laboratory. We propose that specialist for radiocarbon dating should explain this phenomenon. We believe that this series of ra-

No.	Site	Index	Material	Culture	Age (BP)	Age, calBC (2 σ)
1	Chekalino IV	GIN 7085	Shells	Yelshanian	8680±120	8250–7500
2	Iliinskaya	Le–5839	Shells	Yelshanian	8510±60	7650–7370
3	Iliinskaya	Spb–589	Pottery carbon	Yelshanian	6820±150	6000–5450
4	Lebyazhinka IV	GIN 7088	Shells	Yelshanian	8470±140	7950–7050
5	Lebyazhinka IV	Ki 14	Pottery carbon	Yelshanian	6680±80	5720–5480
6	Chekalino IV	Le–4782	Shells	Yelshanian	8000±120	7350–6550
7	Chekalino IV	Le–4784	Shells	Yelshanian	7940±140	7300–6450
8	Chekalino IV	GIN 7084	Shells	Yelshanian	7950±130	7300–6450
9	Ivanovskaya	Le–2343	Animal bone	Yelshanian	8020±90	7300–6650
10	Ivanovskaya	Ki 14 568	Pottery carbon	Yelshanian	7930±90	7100–6550
11	Ivanovskaya	Ki 14 631	Pottery carbon	Yelshanian	7780±90	7050–6400
12	Ivanovskaya	SPb–587	Pottery carbon	Yelshanian	7560±70	6530–6240
13	Bolshaya Rakovka II	SPb–426	Pottery carbon	Yelshanian	7790±200	7184–6231
14	Chekalino IV	SPb–424	Pottery carbon	Yelshanian	7660±200	7047–6202
15	Chekalino IV	Poz 42 051	Crust	Yelshanian	7250±60	6229–6016
16	Vjunovo lake I	AA 96 017	Pottery carbon	Yelshanian	7222±58	6120–6010
17	Vjunovo lake I	Poz 47 870	Pottery carbon	Yelshanian	7160±40	6091–5981
18	Krasnyi Yar	SPb–755	Crust	Yelshanian	6700±70	5730–5490
19	Utyuzh I	Ua 44 377	Crust	Yelshanian	6568±49	5620–5470
20	Utyuzh I	Spb–834	Pottery carbon	Yelshanian	6500±100	5640–5290
21	Utyuzh I	Spb–586	Pottery carbon	Yelshanian	6500±100	5640–5290
22	Imerka VII	Ki 15 097	Pottery carbon	Yelshanian	6270±80	5380–4990
23	Imerka VII	Poz 52 651	Crust	Yelshanian	6200±50	5301–5026
24	Lebyazhinka IV	Ki 14 468	Pottery carbon	Yelshanian	5970±80	5100–4600
25	Chekalino IV	Ki 14 686	Pottery carbon	Yelshanian	5910±90	5000–4540
26	Nizhnaya Orlanka II	Ki 14 123	Pottery carbon	Yelshanian	5720±80	4730–4360

Tab. 2. ^{14}C dates of Neolithic sites in the Povolzhye forest-steppe region.

diocarbon dates of the Elshanskaya culture is incorrect and should be excluded from consideration of the Early Neolithic in the Povolzhye forest-steppe or at least used cautiously.

The valid dates for the genesis of the Elshanskaya culture are placed at the turn of the 7^{th} and 6^{th} millennium BC, which is confirmed by a considerable set of radiocarbon dates from different organic materials. According to the radiocarbon dates, Elshanskaya culture existed in the Povolzhye forest-steppe at least to the turn of the 6^{th} to the 5^{th} millennium BC, and perhaps even in the middle of the 5^{th} millennium BC. In the northwestern part of the Elshanskaya culture, in the forest zone of Primokshanie, this pottery tradition existed until the last quarter of the 5^{th} millennium BC. The formation and development of the second type of pottery and the beginning of occupation of western areas by Elshanskaya people relate to this time. At present, one group of dates of the Elshanskaya culture at the turn of the 6^{th} to 5^{th} millennium BC is probably incorrect, since it overly extends the period of the existence of the period of this culture. Regardless of the large number of radiocarbon dates for this culture, there are many questions about the chronological position of certain sites and stages of their development. Therefore, the elaboration of the absolute chronology of Elshanskaya culture should be continued.

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Towards configuring the neolithisation of Aegean Turkey

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ABSTRACT – *Increasing field work in the İzmir region has produced much sought tangible evidence about the ways in which food-producing communities emerged in the Aegean. Focusing on the archaeological and zooarchaeological data from Ulucak and neighboring sites, the authors discuss the possible mechanisms of initial farmer-herder dispersals into the region. The authors stress that the lack of pre-Neolithic strata in the eastern Aegean impedes a full understanding of forager-farmer interactions in the early Holocene.*

IZVLEČEK – *Intenzivno terensko delo na območju İzmirja je prineslo težko pričakovane oprijemljive dokaze o tem, kako so se v Egeji pojavile skupnosti, ki so proizvajale hrano. V članku predstavljava možne mehanizme, ki so jih uporabili prvi poljedelci – pastirji pri širitvi na tem območju, pri tem pa se osredotočava na arheološke in zoo-arheološke podatke iz Ulucaka in sosednjih regij. Pomanjkanje predneolitskih plasti na območju vzhodne Egeje ovira popolno razumevanje odnosov med lovci in nabiralci na eni in poljedelci na drugi strani v času zgodnjega holocena.*

KEY WORDS – *emergence of farmer-herders; Neolithic Aegean; West Turkey; leap-frog colonisation model*

Introduction

Recent ongoing research in Aegean Turkey has led to major progress on the emergence and development of early farming societies. A true *terra incognita* for Neolithic studies until the mid-1990s, the region is enjoying new archaeological investigations of its pre-Bronze Age heritage. Until very recently, the absence of systematic research on Neolithic cultures in this area prevented scholars focusing on neolithization of the Aegean and Southeastern Europe from basing their models on solid archaeological evidence. As a result, Aegean Turkey emerged as a missing link in discussions of the origins and development of the Neolithic way of life. Since the mid-1990s, systematic excavations have been opened at several mounds in the area containing cultural deposits dating to the 7th to early 6th millennia BC (Fig. 1). Besides Ulucak, research at the Yeşilova and Çukuriçi mounds are continuing (*Derin 2012; Horejs 2012*), whereas the field work at Ege Gübre and Dedecik Heybelitepe has ended (*Herling* et al. *2008; Sağlamtimur 2012*).

The longest stratigraphic sequence, found at Ulucak, extends from the first half of the 7th to the early 6th millennium BC (*Çilingiroğlu* et al. *2004; Çilingiroğlu, Çilingiroğlu 2007; Çilingiroğlu* et al. *2012*). Radiocarbon dates from Ulucak's Level VI have demonstrated that the earliest farmers appeared in the region between 7000–6600 calBC. Having domestic livestock and plants (*Çakırlar 2012a; 2012b; Çilingiroğlu* et al. *2012.150*), but no pottery, this community erected buildings with elaborate plaster floors. Current archaeological data indicate that food-producing sedentary communities did not arise independently in this area.

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The Pre-Neolithic background in West Turkey

Fig. 1. Sites mentioned in the text.

More satisfying answers on the neolithization processes in the region can only be formulated with problem-oriented research on the pre-Neolithic background. Any discussion on the neolithization of a given geographical unit should involve pre-Neolithic culture history of the region. Unfortunately, as extensive and intensive surveys focusing on pre-Neolithic ages are absent around İzmir, our knowledge on pre-Neolithic communities is confined to very limited data. Pre-Neolithic finds from the area are confined to two hand-axes of Lower Paleolithic type found in Urla and Narlıdere in the İzmir province (*Kansu 1963; 1969*). Recently, an open-air site east of İzmir, in Manisa province, is discovered by the Central Lydian Archaeological Survey (CLAS) of Boston University. The open-air site, called Bozyer, produced material mainly from the Lower Paleolithic era (*Roosevelt, Luke 2010*). About the early Holocene foragers we simply lack any sort of information.

The best investigated Epi-paleolithic findspots in Turkey are the Öküzini and Karain Caves on the southern coast near Antalya and Pınarbaşı B rock shelter in Konya. In the western Aegean, Franchthi Cave provides a reliable sequence from *c.* 11 000 to 7000 BC and there is promising new research. Below we will provide a glimpse at the general characteristics of these sites.

At Karain Chamber B and Öküzini's earlier Epi-paleolithic deposits, the chipped stones are characterized by non-geometric microliths. The quantity of geometric microliths shows a sudden increase at Öküzini after *c.* 13 000 BC. The archaeological units I to IV at Öküzini contain remains contemporary to Kebaran and Natufian periods in the Levant. The chipped stones assemblage is typically characterized by lunates, triangles, trapezes, retouched bladelets and backed blades (*Kartal 2003.39–40; 2009.158–159*). Unit II, dated to 14 000–13 000 BC, contained grinding slabs, hammer-stones, marine shell ornaments produced from *Dentalium*, *Columbella rustica* and *Arcularia gibossula*. Unit III, dated to *c.* 13 000–10 500 BC, is rich in bone industry such as awls, needles and spatulas. Several incised pebbles are also attributed to this phase (*Otte* et al. *1995.941*). The community hunted mainly wild ovicaprines and fallow deer (*Atıcı 2011*) and collected nuts, bulbs, roots and tubers (*Martinoli 2004*). The occurrence of grinding implements at Öküzini's later Epi-paleolithic strata as well as the nature of the plant remains suggest that the site was occupied for longer periods and plant processing was a crucial subsistence activity at this stage (*Otte* el al. *1995.937–941; Martinoli 2004*).

Looking at the the western Aegean, there is new research producing much sought evidence on the Early Holocene foragers (*Sampson 2005; Strasser* et al. *2010; Reingruber 2011.296*). Yet the best sequence of events encompassing the time period in question still comes from the Franchthi Cave in southern Argolid. The Final Paleolithic stratum at the cave is characterized by microliths and micro-burins which constitute the 75% of the chipped stones (*Perlès 2001.31*). The Early, Late and Final Mesolithic phases (*c.* 9000–7000 BC) at the cave show very different features in terms of material culture from Öküzini, Pınarbaşı B rock shelter and Natufian sites. Microliths and micro-burin technique disappear in the Early Mesolithic and, although the microliths re-appear around 8000–7500 BC, they are now produced on flakes and are non-geometric in shape. Around 7000 BC, crude flake tools and few arrowheads constitute the assemblage. In contrast to Natufian sites and Öküzini, grinding implements are very rare at Franchthi Cave (*Perlès 2001.34*). It seems like although the Franchthi community used the marine environment for fishing and obsidian procurement, most probably navigating with reed-bundle crafts (*Perlès 2001.36*), range of their social world did not expand much beyond the Aegean.

Such findspots containing pre-Neolithic sub-stratum of İzmir Region is virtually unknown due to lack of research. One can not help but wonder whether eastern Aegean early Holocene foragers were more engaged in relations with Anatolian or western Aegean social spheres. Alternatively, should we expect Aegean and Anatolian early Holocene components to merge and create something entirely different in West Turkey? As a result, further research is needed in the area to understand the nature of pre-Neolithic communities. Until more archaeological evidence is available, our questions regarding local foragers and their possible interactions with farming communities cannot be adequately addressed.

Ulucak VI and the first farmer-herders of İzmir region

Level VI at Ulucak contains the earliest archaeological record of early farmers in Aegean Turkey and encompasses the earliest occupation level on the mound. The occupation is dated to the first half of the 7th millennium BC in absolute terms. AMS determinations from this occupation level provide a calibrated range of 7040–6470 BC. Dates obtained on short-lived species from Ulucak VI provide ranges from 6690 to 6590 calBC at one sigma (*Çilingiroğlu* et al. *2012.153*). The data from Level VI are preliminary, but are potentially the first recorded instance of early farmers in eastern Aegean and offer a new insight into the spread and development of Neolithic culture in western Turkey and the Aegean.

The most striking characteristic of this occupation level is the presence of red-painted plaster floors. Such floors are attested in two separate buildings, the older No. 43 and the younger No. 42 (Fig. 2). Besides

Fig. 2. Building 42 with red plastered floor (Level VI, c. 6700–6600 BC).

these buildings, Level VI is comprised of open areas with cobblestone paving and circular hearths, typically surrounded by ashy deposits including large amounts of animal bone and plant remains (*Çevik 2013.148–150*).

Another interesting aspect of Level VI is the lack of typical Neolithic components of the material culture known from the Aegean and Southeast Europe such as figurines, sling missiles, polished axes and clay stamps. So far, neither pottery nor clay objects have been found in these deposists, which are approximately one metre deep. The pottery, which decreases in quantity throughout Level V, disappears completely with Level VI. Considering the good quality of the earliest pottery at the site, the introduction of pottery to the site seems to have been rather abrupt, at around 6400 calBC. Even if future research reveals clay containers from this level, it is clear that in the first half of the seventh millennium BC, containers and objects from fired clay did not have a significant function in the daily lives of these farmers. Stamps, figurines, clay weights or sling missiles, all very commonly found in the later levels IV–V, are completely absent from the Level VI assemblage so far. In fact, the material culture comprises very few elements in comparison to the upper occupation levels. Used and worked bone at various production stages is the most common artefact category beside chipped stones. Blank splinters, points, ad-hoc tools, awls, and gauges made of sheep and goat bones occur frequently. The bone tool-kit of both formal and informal tools has affinities with the Çatalhöyük bone tool assemblage (*Russell 2006*; but note that this is the only intensively studied Neolithic bone tool assemblage in Turkey). Interestingly, in Level VI, the quantity of marine molluscs is minute and the quantity of obsidian recovered is exceptionally small, which is again in sharp contrast with levels V and IV.

As mentioned above, the Ulucak VI community subsisted on farming and herding. The preliminary results of macrobotanical research indicate that the community cultivated a variety of cereals and pulses, the main crops being einkorn wheat (*Triticum monococcum*), emmer wheat (*Triticum turgidum ssp. dicoccon*), barley (*Hordeum sp.*), durum wheat (*Triticum aestivum/durum*) and free-threshing wheat (*Çilingiroğlu* et al. *2012.150*). Archaeozoological investigations show that domestic ungulates including sheep, goat, cattle and pig constitute the large majority of the animal bone assemblage (*Çakırlar 2012a*). While ancient DNA research traces the origins of domestic ruminants in Ulucak to lineages in Southwest

Asia (*Scheu* et al. *2012; in prep.*), the same line of evidence indicates that the domestic pigs of Ulucak derive from a western Anatolian haplotype that may have resulted from the interbreeding of local wild boar and Southwest Asian domesticated pigs (*Ottoni* et al. *2013*). This specific western Anatolian haplotype was ancestral to the earliest domesticated pig populations in Europe (*Ottoni* et al. *2013*). Demographic patterns of sheep and goat populations present no strong evidence for dairy production in this phase of Neolithic occupation at Ulucak (*Çakırlar 2012b*). The role of wild animals in subsistence appears to have been very limited. Deer, especially fallow deer (*Dama dama*) prevail among the targeted wild animals, whereas small game such as the European hare (*Lepus europaeus*) is present, but rare. On the whole, both agriculture and herding seem to have been at a well-established stage and the dominant form in Ulucak VI. The four-tiered herding system at Ulucak at the beginning of the 7th millennium BC has been evidenced only at Bademağacı in the Lake District (*De Cupere* et al. *2008*) and in the 'Aceramic Neolithic' in Knossos on Crete (*Isaakidou 2008*) among its contemporaries in the entire Aegean-Anatolian region.

The community that founded the basal occupation at Ulucak had fully mastered plaster floor technology. Ulucak's red plaster floors are technologically and conceptually well-matched with the other Anatolian examples at basal Hacılar, Aşıklı and Musular (*Özbaşaran 2003*). Earlier examples of red plaster floors are also very well known from Levantine and Syrian PPNB sites such as Halula and Ain Ghazal (*Garfinkel 1987; Bentur* et al. *1991*). It is clear that the idea and practice of painted plaster floors were transmitted over many generations in Neolithic southwest Asia. Considering the vast spatio-temporal distribution of this technology, the appearance of red plaster floors in Ulucak's earliest occupation level cannot be viewed as a mere coincidence and a local invention. It rather seems to be a technology and ritual practice introduced to the region from outside. This observation alone, however, does not suffice to understand how this process took place.

The important question of whether local hunter-gatherers had adopted food producing together with various technologies like plaster flooring as a result of interaction with farmers from the east (a frontier mobility model), or whether new farming communities entered the region and brought all the components characterising a food-producing economy has not been fully answered. In the frontier mobility model, farmers and foragers come into contact while using established social mechanisms and trade networks. In this model, very small-scale population movement is expected (*Zvelebil 2001.2*). We hold that the current evidence from Ulucak supports a leap-frog colonisation model rather than a frontier mobility model.

The so-called 'leap-frog colonisation' model described by Marek Zvelebil (*2001.2*) stands out as one of the major demographic mechanisms for the Neolithisation of Western Turkey. This model suggests that small groups of people search for ideal habitats that would support their populations while leaving some stretches of land unsettled. New communities founded the settlement following an initial examination of the targeted land and its resources. These communities may enter areas where other populations such as mobile foragers are already present. The interaction among these groups may result in mutual or assimilative relations. In the case of mutual interaction, various exchanges of raw materials, food or other objects may take place. Intermarriages are likewise possible. These interactions may eventually result in the assimilation of one of the groups. Foragers may decide to adopt a farming way of life or farmers become foragers. If conflict arises over local resources, it continues until one of the groups may decide to retreat or even abandon the area. Taking the current information provided by Ulucak VI, it seems plausible that the community initially settling at Ulucak might have originated from Inner-West Anatolia and moved along the east-west oriented Gediz Basin seeking suitable natural habitats for farming and herding, thereby bringing a variety of new technologies and practices such as the plaster floors, animal herding and farming.

Fig. 3. Wattle-and-daub building 30 from Ulucak Vb (c. 6200–6100 BC).

Fig. 4. Mud brick buildings 12 and 13 from Ulucak IVb (c. 5700– 5600 BC).

As mentioned above, it remains unknown whether mobile forager populations existed before the appearance of the first sedentary food-producing villages in the İzmir region, nor to what extent the local foragers interacted with, and contributed to, the sedentary farming way of life. Conclusive answers on Neolithisation in the İzmir region can be gained only through firm archaeological data on early Holocene forager populations.

The local development of Neolithic culture

Following the basal layers at Ulucak, we observe a continuous development of village life based on farming and herding on the mound. Single-roomed, free-standing wattle-and-daub houses with storage facilities, ovens and food preparation areas are eventually replaced by more substantially built mud-brick houses with occasional courtyards (Figs. 3–4). At Ulucak Levels V and IV, material culture consists of elements familiar from other contemporary sites in Turkey, Southwest Asia and Southeast Europe, such as clay stamps, prismatic blade cores, slings, bone spatulas, polished axes *etc*. (*Çilingiroğlu 2005; Özdoğan 2011*). The same elements are observed in the region at other contemporary sites at Ege Gübre, Yeşilova and Çukuriçi (*Sağlamtimur 2012; Derin 2012; Horejs 2012*). The homogeneous elements in material culture reflect close social-cultural ties on a supra-regional basis with both the inner Anatolian and Aegean communities. For instance, an obsidian network was sustained through centuries in the Aegean. Both eastern and western Neolithic communities had constant access to this important raw material. The transportation and distribution of Melian obsidian inevitably brought diverse people together and spurred cultural interactions. The appearance of impressed pottery around 6000 BC is yet another clue to the maritime connections between Aegean and Eastern Mediterranean people. Displaying an apparent coastal distribution, the practice of impressing pots with certain designs and techniques can be observed as a common phenomenon in the Aegean during the late 7th – early 6th millennia BC (*Çilingiroğlu 2010*).

The near absence of painted pottery and dominance of red-slipped and burnished pottery is distinctive of the region (Fig. 5). Observed at all sites in great quantity and ever increasing manner from mid-7th to the early 6th millennium BC, this ware group constitutes one of the most important local elements that distinguish the area from neighbouring regions where red-on-cream painted pottery is the defining pottery characteristic of early 6th millennium BC sites. In the İzmir region, painted pottery does not emerge as a defining feature at all. The few painted pieces identified in the assemblages do not amount to a strong tradition of painted pottery production. The İzmir communities did not choose to decorate their pots with painted designs. Other local features appear in the region through time. Vertically placed tubular lugs and thick flattened rims are very typical of the pots of the region (*Çilingiroğlu 2012*). A locally emergent character of West Anatolian sites can be grasped in many different aspects of the archaeological data.

Despite strong correlations between the material cultures of the İzmir region sites, these contemporary sites are also diverse. Circular architecture at Ege Gübre, a coastal settlement north of İzmir, is one of the most striking elements that contrast with the rectangular mud-based architecture of Ulucak and Yeşilova. The tholos-like structures or a combination of rectangular and circular architectural elements at Ege Gübre have no parallels inside the region. The function of these buildings, *i.e.* whether they are storage buildings or normal houses, is disputed. However, the fact that no hearths or ovens have been discovered inside the circular structures may indicate

Fig. 5. Plain burnished vessels from Ulucak Vb (c. 6200–6100 BC).

that they were not domestic dwellings (*Sağlamtimur 2007.374*; Fig. 5).

The house architecture at Ulucak and Yeşilova, rectilinear in plan at both sites, also reveals notable differences in building techniques. At Ulucak IV, the houses are built on a single row of stone foundations with standard-size, sun-dried and moulded mud bricks (*Çilingiroğlu, Çilingiroğlu 2007.364*). However, mud bricks are not found at the contemporary site at Yeşilova Late III. The houses have thick stone foundations and hand-shaped mud blocks, occasionally supported by wooden beams. The roof is carried by wooden posts placed inside the houses instead of the walls (*Derin 2010.317; Derin 2013 personal communication*). Such diverse architectural characteristics are functions of both local environmental conditions and cultural preferences. Apparently, every community and village created and sustained local characteristics in several aspects of daily life, although socially and culturally all communities were strongly bonded. Future research will create a better understanding of the locally developed Neolithic culture.

In the later phases of Neolithic occupation at Ulucak, subsistence continued to rely heavily on domestic technologies. Analyses of relative abundances indicate that pork gained importance in the meat supply (*Çakırlar 2012a*). Hunting activities became more frequent, while hare became an important target species alongside fallow deer. Marine resources, primarily molluscs, were brought to the site fresh, particularly from lagoonal and estuariane environments, presumably located in İzmir Bay. The empty shells of marine molluscs were secondarily used to make perforated objects. Inshore fish species such as gilthead sea bream (*Sparus aurata*) has been attested in both the hand-collected and sieved samples. Husbandry strategies changed significantly towards the end of Level V, most plausibly to integrate dairy and possibly fleece/wool production into the economy (*Çakırlar 2012b*). Although compatible archaeozoological datasets from the larger region are difficult to come by, developments in subsistence during Ulucak's later levels seem to accord well with patterns observed at contemporary sites (*De Cupere* et al. *2008; Galik, Horejs 2011*). Although the role of aquatic foraging differed with the site locations in relation to the coast, the similarity between the species compositions of the mollusc shell assemblages of coastal sites and that of inland Ulucak's is noteworthy (*Galik, Horejs 2011; Sağlamtimur 2011; Derin 2012*).

Concluding Remarks

Clues to the initial Neolithisation processes in Aegean Turkey have so far been found only in Ulucak's oldest occupational level VI. Dating in absolute terms to the first half of the 7th millennium calBC, Ulucak VI encompasses the oldest remains of a Neolithic village in Aegean Turkey and, together with Knossos X, is one of the oldest in the entire Aegean.

Recent preliminary studies indicate that the founder community was in possession of domesticated plants and animals. The precise spot where the mound is located was selected for its proximity to fertile agricultural land, fresh water and woodland. With domestic livestock and cereals as the basis of their survival, they created buildings with elaborately painted plaster floors. Outside these buildings, they laid out stone-paved hearths and fire installations where food was prepared and consumed. The early settlers might not have had the best of worlds. The archaeozoological assemblage shows traces of excessive intentional fragmentation, indicating time spent acquiring nutritious substances such as marrow or fat, even from the tiniest of body parts (*Çakırlar 2012a*). The material culture was probably composed mainly of organic materials. The archaeological remains are very few and limited in variability. Pottery is non-existent; bone objects, lithics, circular beads and grindstones constitute the material culture from this level.

Who were the earliest settlers at Ulucak? Where did they originate? These questions have no clear answers. As mentioned above, without any firm knowledge of the local foragers, the full range of possibilities cannot be explored. In any case, we have to be open-minded about human, animal and plant dispersals along both land and maritime routes. If we rely solely on the evidence from Ulucak VI, the local emergence of food producing is not evident. On the contrary, the community was fully equipped with all the techniques and knowledge required for subsistence based on farming and herding. The set of characteristics that this type of farming presents is so far unique to western Anatolian communities (Bademağacı and Ulucak) in early 7th millennium Turkey. Due to the delayed adoption of cattle and pigs, the four-tiered animal husbandry system does not become evident in Central Anatolia until the middle of the 5th millennium BC (*Arbuckle 2013*). At least for the dispersal of domestic herds, a littoral route must have been used. The appearance of red plaster floors at Ulucak VI is a cultural and, perhaps, a ritual practice that can be associated with some very early Neolithic sites in Inner-West Anatolia, Cappadocia and the Levant. The transfer of this technology and practice through time and space demonstrates its ritual character and may give us clues about the origins of the Ulucak community.

Recent excavations in Aegean Turkey have discovered locally developed Neolithic cultures with strong ties to Anatolian and Aegean communities. The local character of these communities is visible in various aspects of the material culture. The predominance of red-slipped and burnished wares as opposed to painted pottery in Aegean Turkey emerges as one of the most distinctive characteristics of the locally shaped Neolithic culture. Local features identified in the material record, however, should in no way be understood as reflecting the insular character of this area. Strong interactions with extra-local communities, such as via obsidian exchange, resulted in the cultural relatedness of these societies with those of the contemporary Aegean and Inner-West Anatolia. The similarity of the settlement patterns, subsistence, architectural techniques and material culture in this entire region is a clear manifestation of the close interactions among early farmer-herders. Land routes, river valleys and maritime routes across Anatolia, Aegean and Eastern Mediterranean were heavily used by prehistoric communities. The long-term circulation of Melian obsidian, the colonisation of the islands of Crete, Gökçeada (Imbros), Cyprus and the simultaneous appearance of impressed pottery around 6100–6000 calBC are clear signs of the continuous and intensive use of maritime routes across the Eastern Mediterranean and the Aegean. Considering the current state of the archaeological record, Aegean Turkey as a geographical unit is encircled by a dual interaction zone comprising the Inner Anatolian and West Aegean cultural spheres. As such, Aegean Turkey also played a key role in the mutual exchange of cultural features between Inner Anatolia and Greece.

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The role of Linear Pottery houses in the process of neolithisation

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ABSTRACT – *A Linear Pottery settlement represents on a certain scale a symbiosis of different socio-economic groups of inhabitants in one given space. The role and status of artefacts can be described according to individual types of houses. Stockbreeding is typical for large houses, while small houses manifest hunting as well as breeding. Three-part houses are the most significant buildings as the artefact assemblages display prestigious social roles. The assemblages in the single-part houses suggest household activities.*

IZVLEČEK – *Naselbina linearno-trakaste keramike predstavlja v določeni meri simbiozo med različnimi družbeno-gospodarskimi skupinami prebivalcev v danem prostoru. Vlogo in status najdb lahko opisujemo glede na posamezne tipe hiš. živinoreja je značilna za večje hiše, medtem ko sta za manjše hiše značilna tako lov kot živinoreja. Tridelne hiše so najbolj pomembne stavbe v naselbini in njihovo prestižno družbeno vlogo lahko prepoznamo na podlagi artefaktnih zbirov. Na drugi strani pa artefaktni zbiri iz enodelnih hiš kažejo na bolj gospodinjske aktivnosti.*

KEY WORDS – *Neolithic; Linear Pottery; ceramics; houses; society*

Typology of houses

We have only indirect evidence about the inhabitants of Neolithic settlements. We consider the ground plans of houses known since the 1930s as among the most important. The latest overview of Neolithic houses in Czech literature shows that the number of excavated buildings has been increasing recently in Bohemia as well as Moravia and other regions (*Podborský 2011*). Recent years have seen a thorough discussion of house typology; however, current propositions are still considered the most feasible explanation of the archaeologically well-documented situation of Neolithic houses (*Lenneis 2000*). The views of Pieter J. R. Modderman, who contributed significantly to the typology of Neolithic houses, serves best to illustrate their genesis and development. In the 1950s and 1960s, when Dutch findings in Limburg were published, Modderman defined three basic types of houses and several subtypes. Although his original objective was to use the typological studies to create a chronology, his basic typology remains usable to this day. A simpler typology was introduced later by Anick Coudart (*1998*). In the publication of large-scale excavations in the Elsoo and Stein localities in 1970, Modderman (*1970.109–112*) also offered an interpretation of individual parts of houses.

The significance of each of the three parts of the houses built in the earliest period of Linear Pottery was addressed in great detail by Harald Stäuble (*2005.191–198*). Above all, he disputes the possibility that thick inner posts of the houses could have supported a second storey, claiming that such a structure would be unstable. He also speculates that postholes connected into trenches suggest a possible lengthwise division of the interior which would allow for stabling of animals. However, he claims that the resulting space was a kind of roofed 'porch', a space open to the south which hosted various outdoor activities (*Stäuble 2005.194*). He also criticises

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previous arguments that claim that the solid structure of the northern part of the house was a 'bedroom'. He refuses the notion that this part was a stall, citing inconclusive data from a phosphate analysis. For him, the northern part of the house was used by the occupants for storing valuables or supplies, or for cult purposes. The differences in the sizes of the northern part in different houses reflect the extent to which the occupants were willing to exhibit their possessions (*Stäuble 2005.198*). Coudart had already used the variability of the size of northern house parts to modify her own typology. She retained the division into three house types, but defined it only by the number of constructional triads in the said part of the house. Furthermore, she denies that single-part houses were used throughout the whole Linear Pottery area (*Coudart 1998.57, note 9*).

Animal bones found in houses

One of the most extensive analyses of the distribution of animal bones in a Neolithic settlement was conducted in the locality of Cuiry-lès-Chaudardes (CCF) in the western border region of the European Linear Pottery area (*Hachem 2011*). The significance of the distribution of animal bone remains in the settlement as a whole is surpassed by the significance of their correspondence to different types of houses. The relation between the houses and different species of animal in the CCF locality is characterised by their quantitative ratio in the pits of individual houses. We can distinguish the main animal species and complementary ones. Livestock – cattle, as well as sheep and goat – predominates in the larger houses (constituting almost 90% of the contents of the pits). Complementary to these domestic animals, game animals are present, especially aurochs, and red and roe deer. More than 23% of hunted animals are found in small houses, wild boar being the most frequent. The complementary species in small houses is domesticated pig (*Hachem 2011.224–225*). In some smaller and larger houses, the predominant animals are game (80%), either deer combined with pigs and cows, or aurochs combined with sheep and goat. The variety of animal species found in different types of houses shows that the primary source of family subsistence, at least regarding meat consumption, varied widely.

The correspondence of different animal species to different types of houses is comparable at the Bylany- part 1 (BY1) settlement, although the ratio of animal bone remains at Bylany is much less favourable than at CCF (*Kovačiková* et al. *2012*). We can certainly state that in Bylany, game animals also relate mainly to small houses with a single area inside, while domesticated livestock prevails in large houses divided into three areas (Fig. 1). However, these relations do not mean that a specific species is exclusive to a specific type of house. Instead, we can agree with the interpretation of the CCF situation, where the occupants of small and large houses differed in their meat preferences, regardless of the fact that they had access to all the species at the time (*Hachem 2011.235*). Since the animal bone remains at the Bylany settlement are not very numerous and the bones of hunted animals are scarce, it was impossible to identify any specific part of the settlement with a higher concentration of houses where hunted animals were predominant (*Peške* et al. *1998*).

Pottery categories in the houses

Therefore, in Bylany, the relation between species and house type has no correspondence in the spatial division of the settlement, which leads us to another question (*Modderman 1986; 1988*). Is it possible that certain other artefacts are also significantly linked to the three different house types? We have studied the main categories of artefacts, especially their previously defined functional types, and a relation to different house types was indeed established. In pottery, these were: functional sets of containers, types of ornamentation and basic techniques of line-

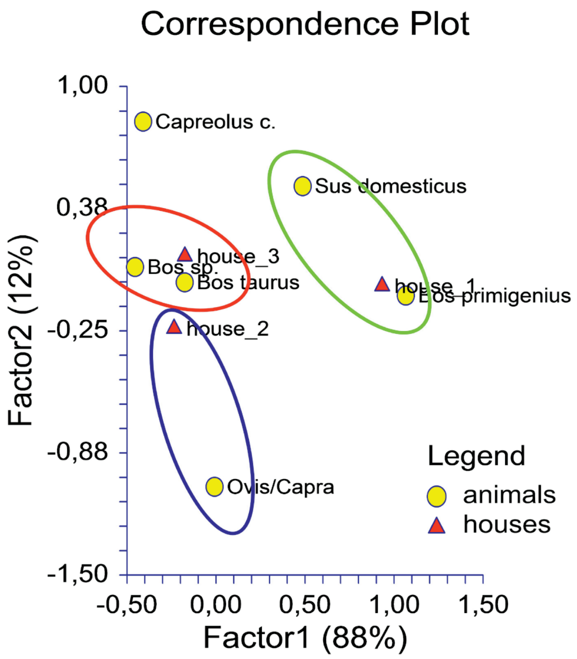

Fig. 1. Bylany, correspondence analysis of animal bones in houses: House 1 – single-part house; House 2 – two-part house; House 3 – three-part house.

ar decoration. It is necessary to stress that in some cases the relation to a specific house type was not interpreted unequivocally, especially in the category of ceramic technology.

The first category of pottery, with which we studied the relation of artefacts to house types, were the functional sets of containers (SHASI – shape and size) determined by the form and diameter of the mouth (*Pavlů 2000.119*). In both cases, the resulting two factors were established by the contrast between set number three, consisting of containers for serving food, and set number five, of large storage vessels (Fig. 2). The former is linked to single-part houses, while the latter relates to three-part houses. Two-part houses can be conclusively connected only to the small F11-type container. The remaining three functional sets of container (Types 1, 2, and 4) cannot be ascribed to any kind of house. However, the third set was surprisingly concentrated around single-part houses.

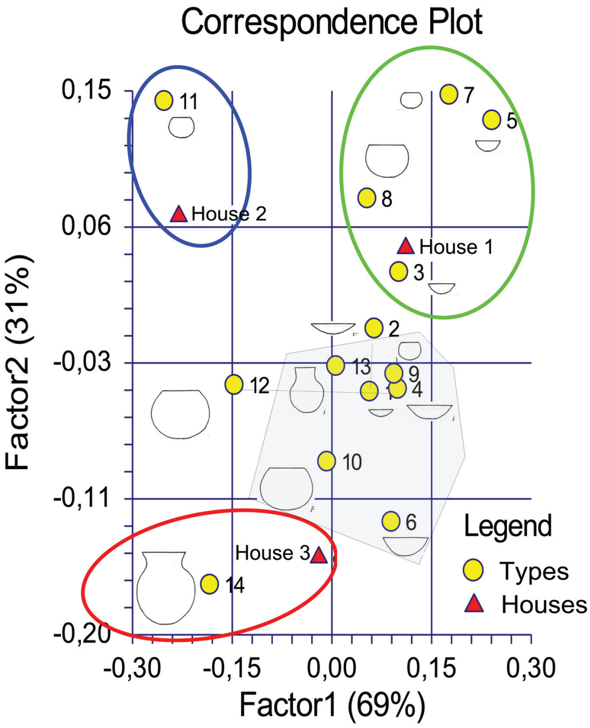

***Fig. 2. Bylany, correspondence analysis of functional types of containers in houses: Types 1–14 (functional types according to* Pavlů 2000.Fig. 4.5. 4.c).**

We also studied the relation between different types of house and the ornamentation of containers by way of analysing the main categories of ornamentation: linear decorated (LO), relief decorated (PO), technically decorated (TO), and undecorated ceramics (NO). In the first factor, there is an opposition between relief and technical decoration; in the second factor the opposition is between technical and relief decoration (Fig. 3). Linear decoration is closely related to two-part houses, while undecorated pottery predominates in single-part houses. Bipartite houses can be linked to undecorated pottery, as well as pottery with technical ornamentation. Relief decoration is not related to any specific type of house.

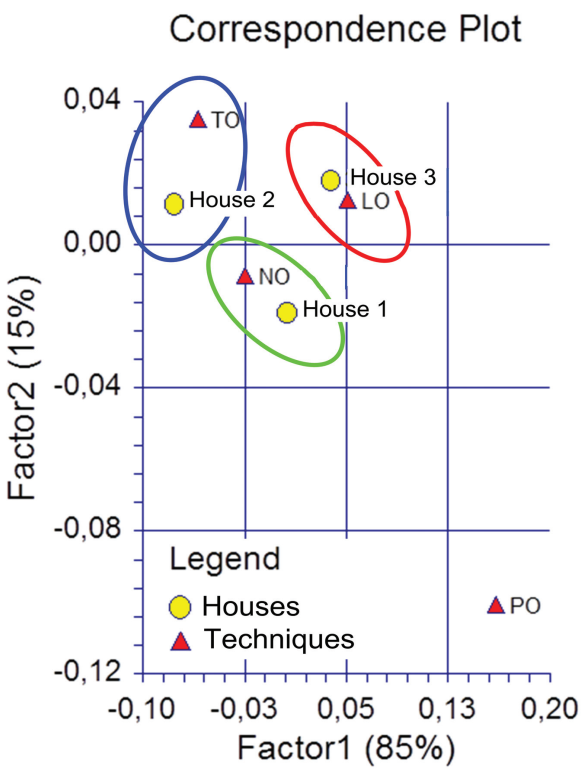

Fig. 3. Bylany, correspondence analysis of the main types of pottery ornamentation in houses: LO – linear; PO – relief; TO – technical; NO – undecorated.

Another category in which we studied the relation to specific house types was the technique of decoration. The results rendered by correspondence analysis enabled us to interpret the first factor as chronological and to some extent geographic, since early stepladders are separated from negative numbers on the factor score (Fig. 4). The second factor is also partially chronological in negative numbers, where we encountered the earliest three-line ribbon, while in positive numbers it tends to be structural, dividing filled band from music-note decoration technique.

Social significance of artefacts according to house type

The role of artefacts can be described according to individual types based on the results of the various artefacts analyses. At Neolithic settlements, three-part houses are the most significant buildings. This is demonstrated by their correspondence to rim fragments and close relation to pottery with linear decoration. The inhabitants of three-part houses preferred containers designed for storage, meaning that pottery was not only used for immediate everyday needs, but also for long-term use. We assume that these long-term purposes were related to a close group of inhabitants of a given house as well as to all the people at the settlement. If filled band was preferred, linear ornamentation represents the most progressive ornamentation technique within the Czech region. Stone tools demonstrate the specific functions of these houses: tools for sharpening belong to prestigious households; cutting tools (such as sickle blades and regular scrapers on medium sized blades) were used in ordinary houses for farming and food processing. In summary, apart from utility functions, artefacts related to three-part houses played important social roles corresponding to the prestige of the occupants of given houses. We can therefore conclude that the occupants of three-part houses had the specific role and status in the settlement. This treatment of artefacts corresponds well with existing interpretations of these buildings, which were based primarily on the precision of their construction (*Modderman 1970.112; Van de Velde 2007*).

The results obtained by studying the situation of single-part houses offer a completely different picture. Based on the prevailing amount of wall fragments and fragments of undecorated containers, we assume that pottery played no particular role in these houses. When it comes to the function of pottery, its usage in small houses was standard. The only indicator of specific food composition and role of pottery is the connection to the vessels of liquid food consumption, which is a certain metaphorical interpretation of its function. Decorated vessels were less important and vessels with simple engraving technique were preferred, therefore we assume that pottery played a secondary role for the inhabitants of single-part houses. The conservative decorative technique of engraved lines can be compared to the techniques of the earliest level of Linear Pottery from which it originated during the classic period of the Linear Pottery culture. Stone tools manifest preferred activities: wood working, manufacturing of wooden objects; arrows can be connected to hunting, and knives to food processing. Hand-stones were not used often, and only fragments of grind-stones were found in single-part houses, which shows that vegetable and plant processing was not significant.

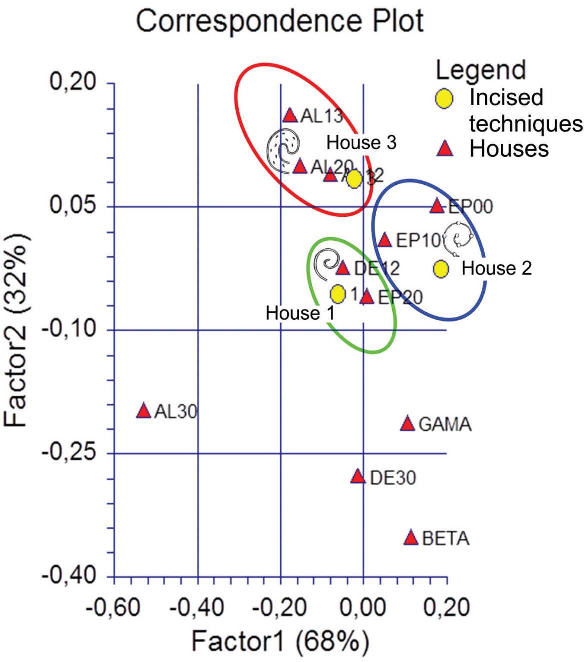

Fig. 4. Bylany, correspondence analysis of the techniques of linear decoration in houses: AL – filled line; EP – music-note decoration; DE – simple engraved line.

This implies that the occupants of single-part houses were of different high-ranking in society as the occupants of three-part houses.

The connection to artefacts is not so pronounced in two-part houses as in the two previous types. We would have expected the role of artefacts and the resulting status of occupants of bipartite houses to lie somewhere between three-part and single-part houses. However, pottery in two-part houses was less significant, similarly to the situation in single-part houses, as observed in the predominance of wall fragments as well as in the decoration of the pottery. Vessels from the bipartite houses were also technically ornamented, especially on rough cooking vessels or storage containers. The only functional type of a small bomb-shaped container does not represent a significant link with the role of pottery. On the other hand, the connection with the music-note decoration is very significant in its role of continuous ornamentation techniques, with an increasing tendency to subsequent socio-historical changes. In the last period of Linear Pottery, the leading line of the notes changes into a punctured line, a stylistic manifestation of the principal change in decoration leading to the Stroke-ornamented ware culture. Usage of stone tools is standard, the functions being woodworking and the manufacture of cutting tools and grind stones. The social role of these stone tools is not very pronounced; however, it shows certain particularities. The link to drilled celts is noteworthy, but not massively observed in relation to bipartite houses. This can be indicative of a certain degree of individual prestige of some inhabitants of the settlement. We can conclude that two-part houses had a specific role in the society of Neolithic settlements.

Social role and status of occupants according to house type

The analysis of animal bones at the BY1 settlement leads to similar conclusions, although they are not identical. Stockbreeding (with cattle being predominant) is typical of large houses, while small houses show evidence of hunting as well as animal husbandry (especially of sheep and goats). However, the occupants of houses with a northern part tended to keep pigs rather than cattle. The differentiation in means of subsistence is also similar, although as observed in the small amount of bones preserved, hunting was not of great significance. It is nevertheless important that we are able to document different means of subsistence as well as different farming methods and agricultural activities in one locality over a longer period. We can state that we are dealing not only with different types of farmers, but also hunters to a certain extent. We assume that the absence of a southern part in two types of houses indicates less or no participation of their occupants in the cultivation of vegetables and plants. This hypothesis would explain the different roles of certain artefacts found in bipartite and single-part houses. All the evidence therefore points to the existence of a variety of agricultural activities within one Neolithic settlement.

Lamys Hachem (*2011*), describing the processing of animal bone remains at the CCF locality, did not settle only for an economic hypothesis. She added a socio-ideological hypothesis based on the symbolic role of hunting. She explains the segmentation of village society into three parts by the differences between families and their different relations in the organisation of clans. Their affiliation was determined by their different origins. Different myths and animal symbolism are connected to different origins, which enables us to infer the origins of different groups of inhabitants (*Hachem 2011.207*). This symbolism is projected into different forms of subsistence, as well as the division of the space that the inhabitants occupy within the settlement. However, it is impossible to apply these hypotheses unambiguously to the situation at the BY1 settlement, because its archaeological structure is different. It is less pronounced in terms of spatial organisation, and the preserved animal bone remains are less abundant. We therefore believe that it is necessary to consider Neolithic society as highly differentiated in terms of its economy as well as ideology. The differences between the inhabitants of one settlement or one area ought to be assessed individually with regard to the condition of archaeological evidence.

Modderman stressed the social role of Neolithic houses as early as 1970, although his interpretation was not a very detailed. He considered that the quantities of the three types remained unchanged in the Early to Late period of Linear Pottery in Limburg, with the exception of the house type 1b with a gouge along the walls in the northern section of the building's circumference. The numbers of houses declined in the Late Neolithic. The steady number of buildings with a gouge around the whole perimeter (around 10%) leads him to establish the social need for houses of this type (*Modderman 1970.112*). The numbers of small houses and houses with a northern section increased only slightly in the Late Linear Pottery period.

With the analysis of individual categories of artefacts we can distinguish between two levels of social status of occupants of different house types. The occupants of three-part houses had the highest status, having a fully Neolithised economy based on animal husbandry and cereal farming. Intensive gardening (*Boggard 2004.164*) was probably situated on the southern side of the house, which in most cases is free of embedded objects. The occupants were bearers of a socio-historical trend which only later demonstrated the advantages of agriculture, since in the first centuries, when agricultural techniques had not yet stabilised, early types of agriculture might not have been fully self-supporting in some circumstances. Animals were kept on the northern side of the house. In some cases, we have evidence of a separate enclosure (BY1, house 912). The northern side of the house might not have served as an animal enclosure, but it was possibly used in winter to shelter smaller animals such as sheep or pigs.

The preferred role is attributed to the most solid constructed large houses built in Neolithic settlements. In the Netherlands, one such house always occurs among all the other contemporary houses, which shows its uniqueness (*Van de Velde 2007.226*). In the Bylany settlement, we identified similarly important houses in the earliest (house 2197) and later periods (houses 306, 41, 912, *etc.*). Their occurrence depended on the number of contemporary houses; they probably constituted a necessary organisational element at times when free self-government was not enough (*Pavlů 2000.254*).

In Bylany, single-part houses are the counterpart of three-part houses, and belonged to families of relatively particular social status. A house with one central residential space could be used only limited stockbreeding and would have no land for cultivation. Hunting would remain the primary means of subsistence for its occupants, with the possible addition of gathering and/or a small herd of sheep or goats kept outdoors. The inhabitants of such houses were not forced to remain permanently at the settlement; when the climate was favourable, they were able to live outside for some parts of the year and return only for the winter. However, they could also provide certain food supplies for other members of the society and thus ensure an alternative source of subsistence. They constituted a conservative element within the settlement, but an element which was a bearer of the tradition of a given place and settlement region.

In the Bylany settlement, artefacts from the bipartite houses bore signs of specific treatment. We could argue that the absence of the southern section of the house means its occupants did not engage in farming or gardening. The walls of the northern part of the house were often reinforced. The corresponding animal bones show that the occupants of bipartite houses were predominantly pig farmers, which would give them a specific status within the settlement. Individuals with significant prestige could originate from these houses, as manifested by drilled celts and battle-axes.

The role of Linear Pottery houses in the neolithisation process

The economic as well as social differentiation of the Neolithic houses and the differences between their occupants as interpreted by their social status and prestige lead to yet another conclusion. We have shown that the occupants of Neolithic houses were differentiated by the types of homes in which they lived, their subsistence (as observed in animal bones) and additional activities (as observed in preferences for artefacts and their functional types). This variability was not expected in Neolithic society, which can lead to reasonable assumptions about the different origins of the occupants. According to current theories, farmers with a complete agricultural system would always have occupied three-part houses, while those living in single-part houses would have been descendants of the original hunter-gatherers who joined the aforementioned group in the course of neolithisation and were only just beginning to farm. The remaining, third, group defies all existing theories about prehistoric agriculture. They could have been cattle farmers (*e.g.*, pigs, as documented in Bylany); however, this can also vary from region to region; at a French CCF settlement, these were hunters of wild boars. Further-more, we cannot rule out a connection with totemic animals, which has so far eluded all modern assumptions about the Neolithic.

We assume that families of different origins lived together in one settlement based on the analyses of the distribution of animal bones within the settlement and of the distribution of artefacts between the different types of houses. These results also require a revision of our previous theories about the Neolithic in Bohemia, as well as theories about the entire process of neolithisation in the Danube region. The abundant literature and the discussions that have continued for nearly a hundred years are not in accordance with our results. The integrationist theory comes closest (*Bickle, Whittle 2013.5*), although it assumes that the late Mesolithic was abruptly replaced by the early Neolithic in a homogeneous clash between two different societies. Opposing colonisation theories are manifested in different variants with the question "*... where is the late Mesolithic? ...*" (*Bogucki 2003.262*), since the archaeological visibility of this period has so far been minimal in the Czech Republic.

If we accept the theory that the two societies met in the same places and that their members lived in the same settlements, a number of issues instantly become easier to resolve. The Neolithic, represented in this period by Linear Pottery, was on a certain scale a symbiosis of different socio-economic groups of inhabitants in one given space. They lived next to each other in separate regions with different natural conditions, or in the same micro-regions with different variants of subsistence, or even in the same settlements in neighbouring houses. In such close coexistence, they might have used the same kinds of pottery, and it is therefore impossible to distinguish between the different groups according to the ceramics they used. The theory of cultural evolution in the form of social symbiosis takes its inspiration from the field of natural sciences, *i.e.* biological evolution (*Margulis 2008*). This idea could be applied almost entirely to the situation of the interactions of hunter-gatherers and farmers, and opens immense possibilities for new interpretations. These varied societies created a new social system, maintaining cultural identity and social solidarity, comparable to the aceramic Neolithic of the Near East before its collapse at the end of the 8th millennium BC (*Rollefson, Köhler-Rollefson 1989*). Therefore, the Neolithic Linear Pottery culture and the later Stroked Pottery culture did not replace the Mesolithic culture abruptly or at once. The assumption that neolithisation represents revolutionary change is the result of our poor knowledge of symbiogenesis in the Neolithic. The periods through which prehistoric society had to pass, at different times in different places, continued for several centuries or longer, and the transition was accompanied by genetic changes in domesticated animals and plants. We are only beginning to ascertain the brand new system created by the sedentation of society. It is obvious that modern terms cannot be used to describe this development, no matter how hard we try to extrapolate our theories about primitive history from our own post-modern society.

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Neolithic pots and potters in Europe: the end of 'demic diffusion' migratory model

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ABSTRACT – *In this paper we discuss the inventions and re-inventions of ceramic technology and pottery dispersals in foraging and farming contexts in Eurasia. We focus on narratives that operate within interpretative paradigms that suggest movements of unidirectional colonisation and 'demic' diffusion, and a correlation between pottery and human DNA haplogroup distributions in Europe in the Initial Neolithic. In addition, we present the results of ancient, Mesolithic and Neolithic mitochondrial DNA analyses, which suggest variations in population trajectories in prehistoric Europe. We comment on a hypothesis presented recently on the correlation between the distribution of the lactase (LCT) gene –13 910*T in the modern population of Europe, which has been shown to be associated with lactase persistence and dairying, and the Neolithic transition to farming in Central Europe.*

IZVLEČEK – *V članku obravnavamo večkratne izume keramične tehnologije in širitev lončarstva pri lovcih in nabiralcih ter poljedelcih v Evraziji. Osredotočamo se na različne intrepretacije v okviru interpretativne paradigme, ki temelji na predpostavki o kolonizaciji in 'demski' difuziji ter o korelaciji med distribucijami zgodnje neolitske keramike in človeških DNK haploskupin v Evropi. Predstavljamo rezultate analiz stare, mezolitike in neolitske mitohondrijske DNK, ki dokazujejo različne populacijske trajektorije v prazgodovinski Evropi. Komentiramo novo hipotezo o razširjenosti laktaznega gena –13 910*T pri modernih prebivalcih v Evropi. Povezana naj bi bila s prehodom na kmetovanje, mlekarstvom in laktazno persistenco v neolitiku v Srednji Evropi.*

KEY WORDS – *Eurasia; neolithisation; demic diffusion; pottery; human DNA and aDNA*

Introduction

The appearance and distribution of pottery have long been studied in conjunction with migrations of prehistoric populations and became highly ideologised by the Lex Kossinae that equates 'cultural province' with 'areas of particular people or tribes' (*Kossina 1911.3*). Gordon Childe agreed that Neolithic pottery was a universal indicator of both the 'cultural identities' and 'distributions of ethnic groups' (*Childe 1929.v–iv*), but he strongly disagreed that ceramic technology invention and its primary distribution can be found within Europe. He proposed that pottery arrived with Neolithic 'immigrants from South-Western Asia' who 'were not full-time specialists, but had complete mastery over their material'. The 'experienced farmers' in the Peloponnese and the Balkans thus produced 'extremely fine burnished and painted ware', whereas the 'Danubian I hoe-cultivators' in the Carpathian Basin and Central Europe produced 'unpainted and coarse and chaff-tempered vessels'. Beyond the agricultural frontier and pottery distribution on the North European plain, he recognised 'scattered bands of food-gatherers' (*Childe 1939.21, 25–26; 1958.58–60, 86–88*).

The introduction of physical anthropology and racial mapping into archaeology by Carleton Coon (*1939.82–86, 104–107, Map 2*) related Neolithic immigrants to 'Danubian' agriculturalists', a 'new branch of Mediterranean' population in Europe that had originated in the Near East and was associated with the

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Natufian cultural context. They migrated across Anatolia and/or the Aegean into Europe, and 'up the Danube Valley into the Carpathian basin, Central Europe and farther to the west, to the Paris basin, where they met with the second group of 'Mediterranean' population, 'which entered Europe from North Africa across the Straits of Gibraltar'. It has been suggested that the first group brought 'Danubian painted pottery' that shows 'definite Asiatic similarities' into Europe. The second was associated with the dispersal of 'incised pottery with banded decoration'. These streams have been recently recognised archaeogenetically (*Sampietro* et al. *2007.2165–2166; Deguilloux* et al. *2012.29, 32*), and re-actualised archaeologically as 'Danubian' and 'Occidental' groups (*Gronenborn 2011.68, 70*).

Childe (*1951.76–77*) recognised the invention of ceramic technology and pottery making as the "*the earliest conscious utilization by man of a chemical change... in the quality of the material*" that happened in the Near East in the context of the Neolithic revolution. It later became a constituent part of the Neolithic package.

The geographical correlation of painted pottery and ceramic female figurine distribution, and the distribution of genetically identified Y-chromosome haplogroups in the modern paternal lineages of European and Near Eastern populations were hypothesised decades later to be 'the best material culture and genetic markers' of a demographic event that radically reshaped the European population structure (*King, Underhill 2002.707*). It was argued that the majority of the hunter-gatherer population in Europe was replaced in the Early Neolithic by a Near-Eastern farming population. Ceramic female figurines in this context mark the new 'expansionist' ideology that enabled the transition to the 'agricultural way of life' in the Near East first. Europe did not become neolithicised until figurines reached the Balkans (*Cauvin 2000.22–29, 204–205, 207–208*).

Childe and Coon both suggested an interpretative paradigm in which the gradual migration of farmers and the spread of agricultural frontier into Europe correlates with the boundary – that has been recognised since Herodotus – between the barbarian West and the civilized East. In this perception, the Mesolithic-Neolithic transition and/or the transition to farming in Europe correlates with the transition from barbarism to civilisation (see *Budja 1996; 1999; 2009*).

How the civilised East colonised the barbarian West

Indeed, Southeast Europe was recognised as a "*western province of Near Eastern peasant culture, created by the processes of colonisation and acculturation*" that was mirrored in the distribution of "*common traditions in pottery styles, oriental stamp-seals and female figurines, and sometimes of animals, which may relate to religious cults*" (*Piggott 1965.49–50*; see also *Roden 1965*). In John Nandris's (*1970.193, 202*) view the dispersal of the same set of artefacts marked "*cultural unity, greater than was ever subsequently achieved in this area of southeast Europe, down to the present day*".

The perception of the dichotomy of the civilised/barbarian population continued to be highly significant. The 'monochrome'**1** and painted (red, black and white) vessels achieved paradigmatic status in tracing 'waves of migrations from Asia Minor' (*Schachermeyr 1976.43–46*), and in marking the cultural and ethnic identity of the earliest Neolithic farmer diasporas in Europe (*Milojčić 1962; Theocharis 1973; Nikolov 1987; Bogucki 1996*). At the same time, coarse, 'impressed' and 'barbotine' pottery was recognised as "*so local to the Balkans that we do not believe that this primitive pottery was introduced from Asia Minor*" (*Theocharis 1967.173; cf. Thissen 2000.163*). It was, indeed, linked to 'barbarian local production' that showed 'a clear regression in pottery production' (*Milojčić 1960.32; Nandris 1970.200; Milojčić-von Zumbusch, Milojčić 1971. 34, 151*).

It was suggested that the second wave of migration correlated with a 'breakthrough' of white painted pottery along the Vardar, Morava and Struma rivers (*Garašanin, Radovanović 2001; Luca, Suciu 2008; Krauß 2011*), and with the "*rapid expansion of red-slipped pottery along the Black Sea coastline through the Danube River valley*" (*Özdoğan 2011. S426*). This migration resulted in the creation of a cluster of cultures in the northern and eastern Balkans and in the Carpathian Basin which shared an identical 'Neolithic package' originating in Central Anatolia and consisting of "*tubular lugs, plastic decoration in relief, anthropomorphic or zoomorphic vessels, steatopygic figurines, pintaderas, and so forth*" (*Özdoğan 2011.S425*). Differences in vessel shapes and ornamental composition, however, constituted regionally bounded Early Neolithic cultures

1 Vessels have been coated with a clay slip that gives red or brown colours after firing.

such as Starčevo, Körös, Criş and Karanovo (see *Budja 2001; Krauß 2011*).

It has been suggested recently that the new strontium isotope data from the Danube Gorges in the northern Balkans show female migration to the region in the contexts of the spread of Neolithic communities from Central Anatolia along the Black Sea coast into the Danube in the Mesolithic-Neolithic transitional phase at 6200–6000 calBC. Physical 'differences between populations' and a 'dramatic increase in the numbers of non-local, first-generation migrants' were also proposed, as five of the 45 individuals at Lepenski vir are non-local. All but one of these individuals are female; thus 'social exchange' and 'population blending' at the mobile agricultural frontier are hypothesised (*Borić, Price 2013.3301–3302, 3299*). However, such a scenario could only have happened within already established social networks (*e.g.*, kinship ties, marriage alliances, exchange partnerships and other social ties of reciprocity and obligations) between hunter-gatherers and the first farming settlements in the region (see *Zvelebil, Lillie 2000; Zvelebil 2001; 2004*). The direction and rapidity of expansion suggest the importance of existing hunter-gatherers' social contexts and routes of communication, as do the conditions of farming communities and the scale of the migration.

The third wave of migration was related to the genesis of the Linear Pottery culture (LBK) in the Carpathian Basin and its westward expansion (*Gronenborn 2007; Lünning 2007; Oross, Banffy 2009; Burger, Thomas 2011*).

The rate of spread was calculated from a series of standard ^{14}C dates available at the time. Breunig (*1987*) allocated them to temporal zones of 500-year intervals, running from the Near East to Atlantic Europe and through the 7th millennium in Southeast Europe and the 6th millennium BC in Western Europe. The southeast-northwest temporal gradient of the 'spread of the Neolithic way of life' from the Near East across Europe was thus broadly accepted (see *Biagi* et al. *2005*). A less gradual movement was hypothesised in a demographic model suggesting migrations from one suitable environment to another. Van Andel and Runnels (*1995*) suggested that Anatolian farmers first settled in small numbers on the Larissa Plain in Thessaly, as they thought this was the only region in the southern Balkans that could provide a secure and large enough harvest for significant population growth 'at the wave front' that led to the next migratory move (*i.e.*, 'leap-frog')[2] towards the Danube and Carpathian Basin. They calculated that farmers needed 1500 years to reach saturation at a 'jumping-off point' and to migrate to the northern Balkans. Paolo Biagi and Michela Spataro (*2001*), on the other hand, reviewed the radiocarbon dates from selected cave sites in the central Mediterranean and believed they had found evidence of a hiatus between the latest Mesolithic and earliest Neolithic occupations in every case. From this, it was suggested that the late Mesolithic was a period of population decline, with hunter-gatherers disappearing altogether soon after the arrival of farming (*Biagi 2003.148–150; Rowley-Conwy* et al. *2013*; for discussion see *Mlekuž* et al. *2008; Bonsall* et al. *2013; Forenbaher* et al. *2013*).

The earliest pottery productions in Southeast Europe are embedded in time spans at *c.* 6500–6200 calBC in the southern Balkans and Peloponnese, at *c.* 6440–6028 calBC in the northern and eastern Balkans (*Perlès 2001; Thissen 2005; 2009; Reingruber, Thissen 2009; Müller 1991; 1994; Budja 2009; 2010; Reingruber 2011a; b*). (Fig. 1). The southeast-northwest temporal gradient thus found no confirmation in the radiocarbon chronology of the initial Neolithic pottery distribution in Southeast Europe. The data suggest the contemporaneous appearance of pottery in regions where gradual colonisation was hypothesised.

While pottery in the southern Balkans was found in farming settlement contexts, it also appeared in the north in hunter-gatherer and farmer contexts (*Perlès 2001; Budja 2009*). At Lepenski Vir, vessels were contextualised within hunter-gatherers' burial practices and symbolic behaviour. They were embedded in trapezoidal built structures and associated with neonate burials and secondary burials (or depositions) of human and dog mandibles (*Budja 1999; 2009; Garašanin, Radovanović 2001; Stefanović, Borić 2008*)[3].

The distributions of material items such as female figurines (sometimes exaggerated in form), stamp

2 João Zilhão (*1993.37, 49*) introduced the 'leapfrog' colonization model suggesting rapid migration of east Mediterranean farmers to the West Mediterranean. The model was recently actualized in palaeogenetic studies (*Deguilloux* et al. *2011.32–34*).

3 Pottery was placed in trapezoidal built structures (Nos. 4, 24, 36 and 54). It was associated with stone sculptures, neonate burials and intentional placement of disarticulated human and dog mandibles. Neonates were buried in the rear of the structures under the red limestone floors. The burial pits were either cut into floors or dug immediately of the floor edge between the construction stones (*Stefanović, Borić 2008.139, 145–146, 149–150; Budja 2009.126–127*).

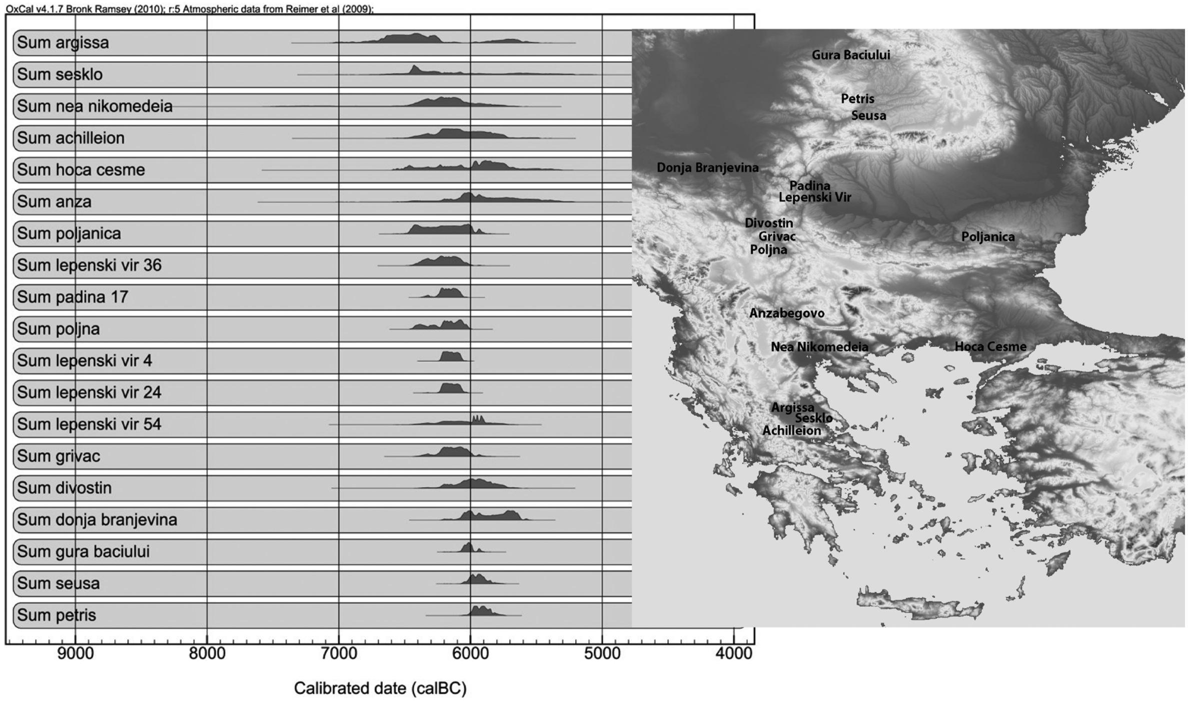

Fig. 1. Site distribution and Sum probability plot of initial Neolithic pottery distribution in Southeastern Europe (modified from* Budja 2009.Tab. 2*).

seals, anthropomorphic, zoomorphic and polypod vessels, which do indeed connect Southeast Europe and western Anatolia, support the perception of migrating farmers and the gradual distribution of the 'Near Eastern Neolithic package' (*Lichter 2005; Özdoğan 2007; 2008; 2011*). Yet it is worth remembering that the beginning of the Neolithic in Southeast Europe was marked neither by stamp seals nor ceramic female figurines. No single stamp has been found in EN I, and none of the clay figurines can be securely dated to this period. Figurines do appear in secure contexts in EN II, and stamp seals can securely be dated to EN III/MN I[4] on the southern tip of the Balkan Peninsula and in the Peloponnese (*Reingruber 2011a.301; 2011b. 135*). When figurines appeared in Southeast Europe, they remained highly schematised, sometimes to the extent that their identification as anthropomorphic is debatable (*Vajsov 1998.131; Perlès 2001.257*; for a general overview, see *Hansen 2007*).

The pottery assemblages in Southeast Europe show local and regional differences in production techniques, vessel shapes and ornaments. The combined petrographic and chemical compositional analyses of clay matrix and ceramic fabrics clearly indicate differences in pottery production. Pottery in the northern Balkans was consistently manufactured according to a single recipe, using non-calcareous micaceous clay pastes, characterised by fine well-sorted alluvial quartz sand with feldspar, and heavily tempered with organic matter (*i.e.* chaff). In the Adriatic, however, pottery was heavily tempered with crushed calcite on the east coast, and with mineral resources (*e.g.*, flint) and grog (recycled pottery) on the west coast (*Spataro 2009; 2011*). From the outset in the Aegean, pottery was made locally at a number of sites and exchanged regularly between neighbouring settlements. Some fine ware paste recipes show that pottery may have been transported over a distance of around 200km and that it may have been an item in maritime exchange networks. The unchanged ceramic matrix in some cases reflects significant continuity in pottery technology over the millennium (*Tomkins* et al. *2004; Quinn* et al. *2010*).

Two basic ornamental principles are recognised in the dispersal of pottery in Southeast Europe in the Early Neolithic. While painted motifs are limited to the Peloponnese, the Balkans and the southern Carpathian Basin, Cardium impressed ornaments mark the Adriatic coast. It is not before the Middle Neolithic that painted pottery appears on the east cost of

4 The abbreviations denote the Thessalian Early Neolithic sequence. They were introduced by Theocharis (*1967*). They were suggested to replace Milojčić's (*1959.19*) terms 'Frühkeramikum', 'Proto-Sesklo' and 'Vor-Sesklo'.

the Adriatic (*Müller 1994; Schubert 1999; Budja 2001*).

The pottery assemblages in the earliest settlement contexts on the Peloponnese and the southernmost tip of the Balkan Peninsula consist of monochrome (red-slipped) pottery, and 'a very limited use of painting' (*Perlès 2001.112*; see also *Krauß 2011.119*). Unpainted vessels were clearly the first to appear in settlements in the northern and eastern Balkans. They still prevail in the latter contexts, as painted vessels comprise from 0.2% to less than 10% of the total quantity of ceramics (*Budja 2009.126; Krauß 2009.122*). However, we cannot ignore the regionalisation evident in vessel forms (*Thissen 2009*) and ornamentation in later painted pottery (*Schubert 1999; 2005*). In southern parts of the region (Thessaly and the Peloponnese) ornaments appeared in red and black. Further to the north, in Macedonia, white was added. In northern and eastern regions of the Balkans, white ornamentation predominates in the earliest pottery assemblages. A similar pattern is seen in regional ornamental motifs distribution, as dots and grids predominate in the northern and eastern Balkans, and triangles, squares, zigzags and floral motifs in the southern Balkans and the Peloponnese.

The hypothesised southeast-northwest temporal gradient of the spread of the pottery package was broadly accepted as an indication of the spread of a Neolithic cultural identity and way of life into Europe. It was correlated with the boundaries of Early Neolithic cultures (*e.g.*, farming enclaves) and associated with the agricultural frontiers and 'demic diffusion' (see *Lünning 2007; Özdoğan 2007; Guilaine 2007; Burger, Thomas 2011*) (Fig. 2). Northeast and East Europe were marginalised, having no point of entry and remaining a blank through the period (but see *Dolukhanov* et al. *2005; 2009; Gronenborn 2007*). It is worth remembering the frontier thesis had been entertained since Herodotus recognised it as the agricultural frontier and the boundary between the civilised East and barbarian West (see *Budja 2009*).

Inventions and re-inventions of ceramic technologies

Hunter-gatherers used diverse ceramic technologies long before the transition to farming began. The invention of ceramic technology in Europe was associated with the making of female and animal figurines in Gravettian, Epigravettian and Pavlovian complexes in Central Europe within a period that ranges from *c.* 30 000 to 27 000 calBC[5]. It was followed in North Africa at 23 000 – 21 000 calBC and Southern

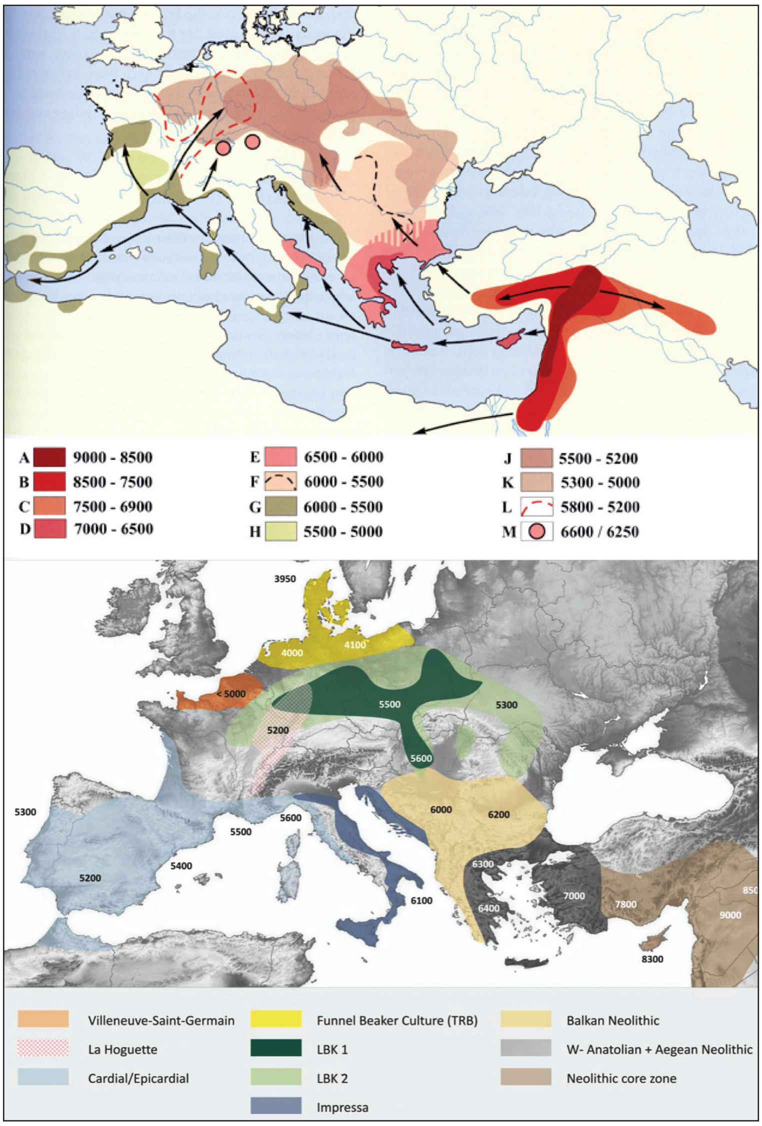

Fig. 2. The hypothesised southeast-northwest temporal gradient of the spread of the Neolithic package, cultural identities and 'demic diffusion' (from* Zimmerman 2002 *and* Burger 2010*).

5 All the ^{14}C data in the text have been calibrated at 68.2% probability (2σ), using the OxCal 4.2 programme.

Siberia at 18 000 – 17 000 calBC. In Southeast Europe, it appeared at *c.* 19 000 – 16 000 calBC in an Epigravettian context at the Vela Spila cave site on Korčula island in the Adriatic (*Verpoorte 2001.40, 59, 90; Vasil'ev 2001.10; Einwögerer, Simon 2008. 39; Farbstein* et al. *2012.4–5*) (Fig. 3).

In Central Europe, an assemblage of 16 000 ceramic objects – more than 850 figural ceramics – have been found in Gravettian and Pavlovian hunter-gatherer camps at Dolní Věstonice, Předmostí, Pavlov I and Krems-Wachtberg (*Verpoorte 2001.95–100, Tab. 5.1*). At Dolní Věstonice and Pavlov, the ceramic distributions seem to be associated with the central position of oven-like hearths. 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 (*Verpoorte 2001.56, 69, 95–100, Tab. 5.1*). Recently, 36 ceramic artefacts (fragments of horse or deer figurines) from the cave site at Vela Spila on Korčula Island offer the first evidence of ceramic technology in the Epigravettian in the Adriatic (*Farbstein 2012*). However, more than 10 000 years separate the Palaeolithic ceramics and the earliest Neolithic pottery in the region.

The anthropomorphic ceramic figurine at the Palaeolithic site Maininskaia (Maina) in Southern Siberia predates the introduction of the first fired-clay vessels in East Eurasian hunter-gatherer contexts by less than a millennium. The introduction of ceramic vessels first occurred among small-scale sedentary or semi-sedentary hunter-gatherer communities in Southern China (Yuchanyan Cave) at *c.* 16 500 – 15 500 calBC (*Boaretto* et al. *2009; Lu 2010*). On the Japanese archipelago, it appeared at *c.* 14 000–13 100 calBC (*Taniguchi 2009.38*). In the Russian Far East, the time span is much broader, from 15 990 to 7710 calBC (*Keally* et al. *2003; Kuzmin 2006; Kuzmin* et al. *2007*).

In western Siberia, the initial distribution of pottery was hypothesised as lying within the time span *c.* 8300–6400 calBC (*Zakh 2006.77*). Further to the west, in the Western Urals and Middle Volga River, the oldest pottery was contextualised in small seasonal Elshanka (Yelshanian) sites scattered over a vast forest-steppe area. Vessels with conic and flat bases were made from salty clay tempered with organic matter, fish scales and crushed animal bones. They are decorated with imprints of pits, notches and incised lines. The earliest dates, based on freshwater mollusc shells, range between *c.* 8300 and 7300 calBC. However, they should be considered too old, as the reservoir age value for the East European Plain is not known. However, the dates on bone samples and carbonised food residuals range between 7070–6509 calBC (*Viskalin 2006; Zaitseva* et al. *2009.799–800, Tab. 1; Vybornov* et al. *2013. 15–18*).

In the northern East European Plain, on the Upper Volga and Oka rivers, the earliest pottery sites are embedded in a time span of 6218–5811 calBC (*Tsetlin 2008.234, Tab. 66; Zaretskaya, Kostyliova 2008. Tab 1*). Further north, in Karelia, the early pottery was contextualised at hunter-gatherer sites on the southern shores of Lake Onega. The earliest context (Tudozero V) is dated to *c.* 6209 – 6049 calBC, and the later (Sperrings) to *c.* 5512 – 4947 calBC. The

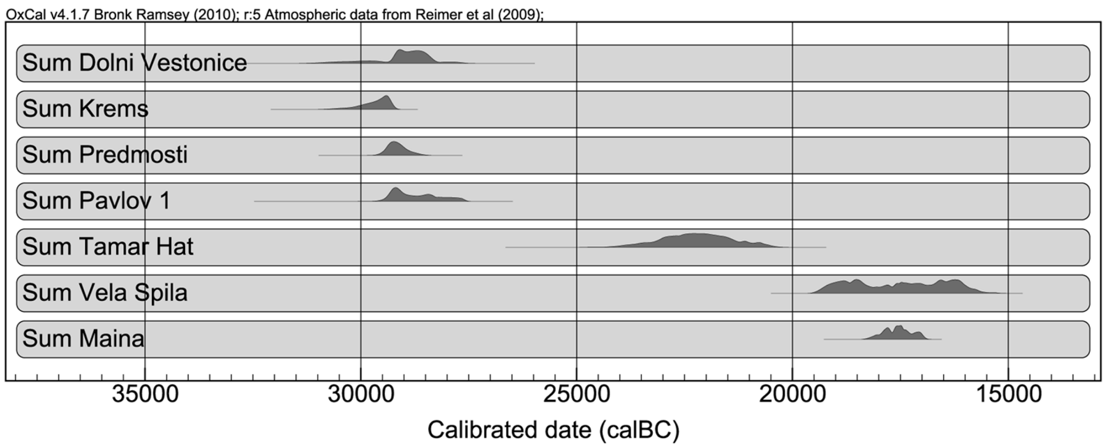

Fig. 3. The ^{14}C distribution of ceramic figurines in pre-Neolithic contexts in Eurasia. The sequence is based on ^{14}C data sets from Dolní Věstonice, Pavlov I, Předmostí and Krems-Wachtberg in central Europe (**Verpoorte 2001.40, 59, 90; Einwögerer, Simon 2008.39*****), from Vela Spila on the Korčula Island in Adriatic (*****Farbstein 2012.4–5*****), from Tamar Hat in northern Africa and Maina in Siberia (*****Farbstein 2012.11*****).***

point-based vessels were decorated with impressions of fish vertebrae, later replaced by comb and punctuated lines (*German 2009*). In the southern Baltic, early pottery dispersals are embedded in a time span of c. 5462 – 5303 on the east coast (Narva), *c.* 5611 – 5471 on the central coast (Neman), and *c.* 5466 – 5316 calBC on the west coast (Ertebølle) (*Hallgren 2009*) (Fig. 4). The pottery assemblages in all cultural contexts show similarities in having common features such as sparse and simple decoration, coiling techniques and pointed vessel bases (*Piezonka 2012*).

The earliest pottery production in the Near East was embedded in farming social contexts. The pottery was painted and dated at 7066 – 6840 calBC (*Özdoğan 2009; Nieuwenhuyse* et al. *2010*).

All these data indicate that ceramic technology was invented and reinvented more than once in different Palaeolithic and Neolithic contexts, and that hunter-gatherer communities made ceramic vessels elsewhere in Eurasia. The various pottery-making techniques, vessel shaping and ornamentation reflect different, but parallel production methods and distributions before and after the transition to farming. Thus, in Western Eurasia, initial pottery distributions occurred in two almost contemporaneous, but geographically and culturally distinct areas. The northern distribution was embedded in mobile and semi-mobile hunter-gatherer contexts on the East European Plain; the southern is associated with subsistence farming in the Near East. It is worth remembering that, while the first was ignored for much of the time (but see *Davison* et al. *2007; 2009; Gronenborn 2011*), the latter is constantly discussed in archaeogenetic studies (*King* et al. *2008; Battaglia* et al. *2009; Burger 2010; Thomas* et al. *2013*). As mentioned above, the first was associated with the distribution of the genetically determined Y-chromosome haplogroup (hg) J in modern European populations. The second then correlates, paraphrasing King and Underhill, with the 'best genetic predictors': the Y-chromosome hg N in modern populations (*McDonald 2005; Rootsi* et al. *2007; Derenko* et al. *2007*) and the ancient mitochondrial hg U4, U5 and H (*Der Sarkissian* et al. *2013*) (Figs. 5 and 6).

The southeast-northwest temporal gradient of the spread of the pottery package has been correlated with frequency gradients of genetic marker distributions in modern populations in Western Eurasia since Luigi Cavalli-Sforza and Albert Ammerman introduced demographic and genetic studies into archaeology. They postulated a continuous southeast-northwest oriented movement of Early Neolithic Levantine farmers across Europe, a 'demic diffusion' at an average of 1km per year (*Ammerman, Cavalli-Sforza 1971; 1984*; but see *Currat 2012*).

The geneticists shifted the focus from phenotypes to genotypes, from cranial characteristics to classic genetic markers, from races to populations. They linked the first principal component (PC) of 38 gene frequencies of 'classic' marker distributions in modern European populations with the Early Neolithic

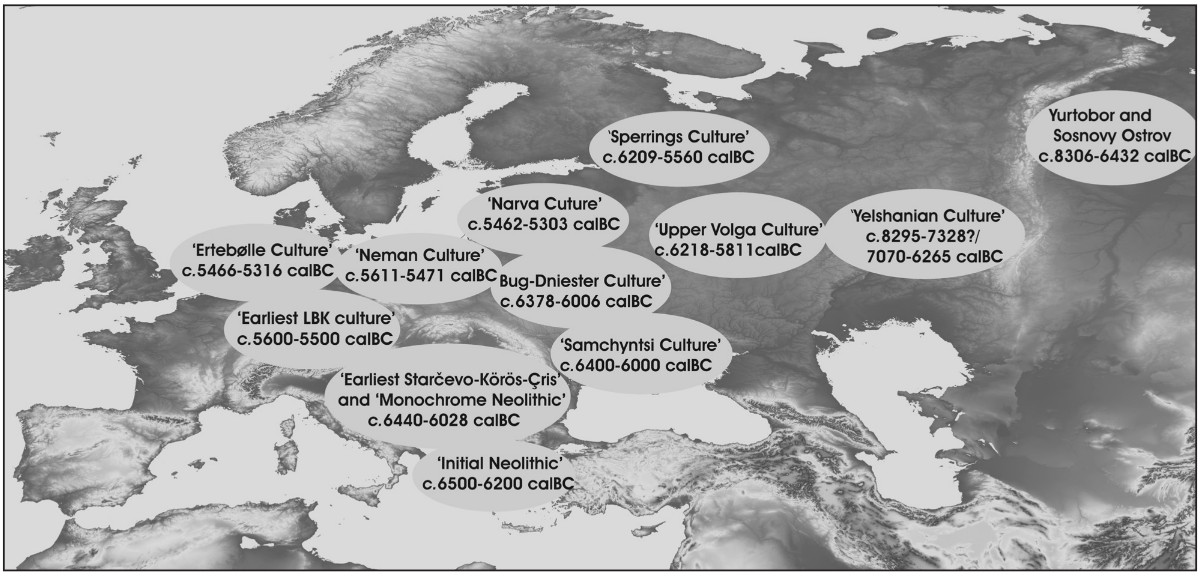

Fig. 4. The ^{14}C time spans of initial pottery distributions in hunter- gatherer groups in northeastern and eastern Europe, and in farming groups in southeastern, central and western Europe. For cultural contexts and ^{14}C dates see text with references.

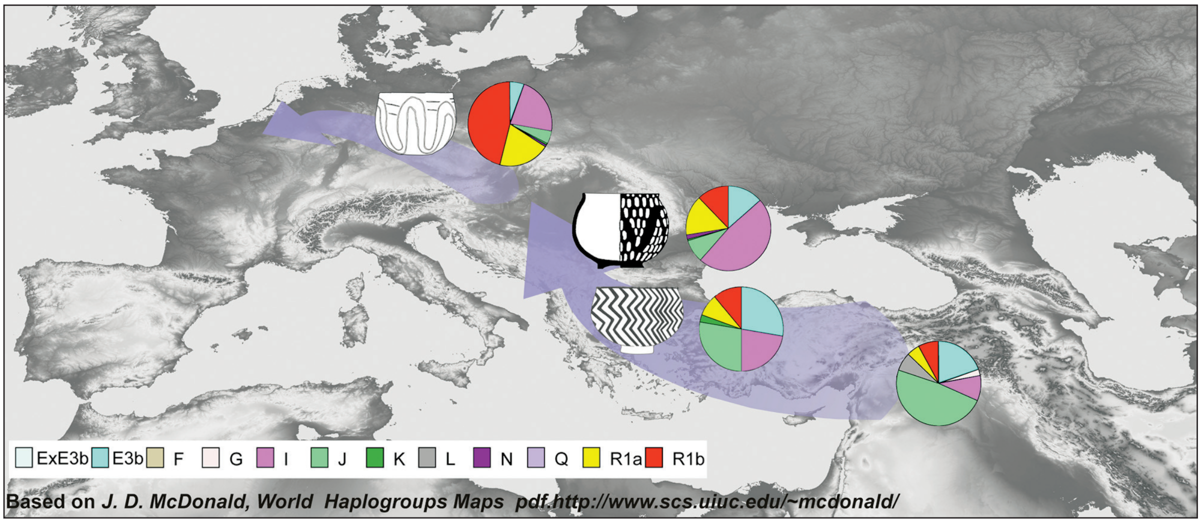

Fig. 5. The southeast-northwest cline of frequencies for Y-chromosome haplogroups J and E within modern European populations were hypothesised to be associated with Levantine male contribution to the European Neolithic. It was suggested they geographically overlap with the distribution of Early Neolithic painted pottery and settlements distributions in Southestern Europe. Northeast and East Europe were marginalised, having no point of entry and remaining a blank through the period. The haplogroups distribution is based on McDonald's World Haplogroups Maps (**McDonald 2005*****).***

'wave of advance' or 'demic diffusion' of farmers from the Near East into Europe. The gradual changes in allele frequencies summarised on spatially interpolated 'synthetic maps' of allele-frequency distributions are due to the absorption of local hunter-gatherer populations into farming communities. During the 'demic diffusion' process, the local admixture of indigenous hunter-gatherers in the advancing wave of farmers was hypothesised as minimal. The 'first demic event' was believed to have significantly reshaped European population structure, and the current European gene pool was interpreted as consisting mainly of genetic variations originating in Near Eastern Neolithic populations, with only a small contribution from Mesolithic Europeans. It was suggested that 'demic diffusion' generated a genetic continuity between the Neolithic and modern populations of Europe (*Menozzi* et al. *1978; Cavalli-Sforza* et al. *1994*). However, the 'demic diffusion' model was criticised because the local features of the PC 'synthetic maps' are mathematical artefacts that "*do not necessarily indicate specific localized historical migration events*" (*Novembre, Stephens 2008.646*). The PC gradients can occur even in the context of cultural diffusion, when there is no population expansion, and paradoxically, a 'very large level of Paleolithic ancestry' is necessary to produce the southeast-northwest gradient axis (*Arenas* et al. *2013.60*). The highest haplotype diversity in European population is found not in Southeast Europe, but on the Iberian Peninsula, thus suggesting a south-north gradient and trans-Mediterranean gene flow with northern Africa (*Novembre, Ramachandran 2011.259–260*).

The end of 'demic diffusion' migratory model

Since the revolution in the study of the human genome, studies have focussed on nuclear genetic DNA markers, *i.e.* mitochondrial (mt) and Y-chromosomal (*Renfrew 2000; Renfrew* et al. *2000; Thomas* et al. *2013*). The first is present in both sexes, but inherited only through the maternal line, while the latter is present only in males, and inherited exclusively through the male line (see *Jobling* et al. *2004*). Because they are non-recombinant and highly polymorphic, they are seen as ideal for reconstructing human population history and migration patterns. Thus different human nuclear DNA polymorphic markers (polymorphisms) of modern populations have been used to study genomic diversity, to define maternal and paternal lineage clusters (haplogroups), and to trace their (pre)historic genealogical trees, and chronological and spatial trajectories (*Goldstein, Chikhi 2002; O'Rourke 2003; Richards 2003; Torroni* et al. *2006; Olivieri* et al. *2013*). Particular attention has been drawn to the power of Y-chromosome biallelic markers, as they allow the construction of intact haplotypes and thus male-mediated migration can be readily recognised. We already mentioned above, it was hypothesised that the southeast-northwest cline of frequencies for selected Y-chromosome markers and related haplogroups indicates the movement of men with Levantine genetic ancestry, and

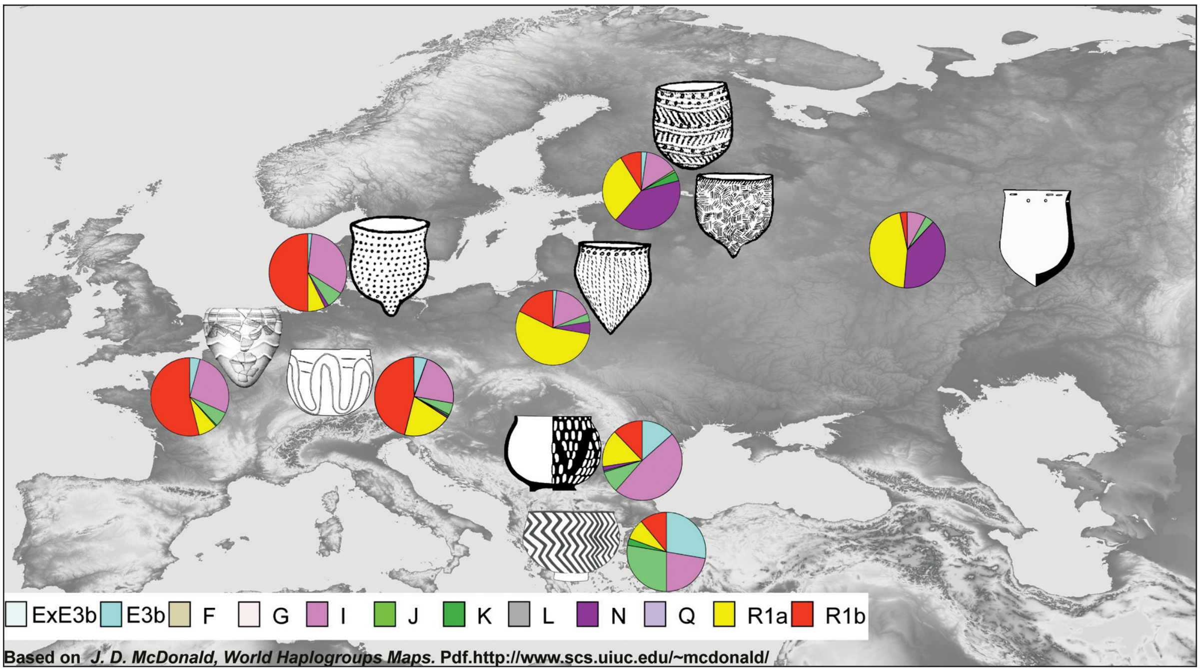

Fig. 6. The parallel clines of frequencies of Y-chromosome haplogroups J, E and N in modern populations in Europe and initial pottery distributions in Neolithic Europe. The haplogroup distribution is based on McDonald's World Haplogroups Maps (*McDonald 2005*).

that this coincides with the distribution of Early Neolithic painted pottery and ceramic female figurine distributions in Europe (*King, Underhill 2002*).

Indeed, recent genetic studies suggest that the modern peopling of Europe was a complex process, and that the view of a single demic event in the Early Neolithic is too simplistic (*Pinhasi 2012*). The paternal heritage of the modern population of Southeast Europe reveals that the region was both an important source and recipient of continuous gene flows. The studies of the Y-chromosomal hg J1 (M267), J2 (M172), E (M78) and I (M423) strongly suggest continuous Mesolithic, Neolithic and post-Neolithic gene flows within Southeast Europe and between Europe and the Near East in both directions. In addition, the low frequency and variance associated with I and E clades in Anatolia and the Middle East support the European Mesolithic origin of these two haplogroups. The Neolithic and post-Neolithic components in the gene pool are most clearly marked by the presence of J lineages. Its frequency in Southeast European populations ranges from 2% to 20%, although some lineages may have arrived earlier than the Neolithic, which has led to the level of Neolithic immigration being overestimated (*King* et al. *2008; Battaglia* et al. *2009*). However, the mitochondrial genome dataset and timescale for lineages show that possible candidates for Neolithic immigration from the Near East would include hg J2a1a and K2a. It seems, however, that the immigration was minor (*Soares* et al. *2010*).

The lactase persistence paradox

Dairying and lactose tolerance in European populations, marked by the –13 910*T allele, are thought to have evolved in a relatively short period in the northern Balkans and were introduced to Central Europe by lactase-persistent farmers within the 'first demic event' at 'around 6256–8683 years BP' (*Itan* et al. *2009.7;* see also *Itan* et al. *2010; Burger, Thomas 2011; Gerbault* et al. *2011. Leonardi* et al. *2012;* for discussion see *Budja* et al. *2013*). A simulation model of the evolution of lactase persistence suggests that natural selection began to act on a few lactase persistent individuals of the Starčevo and Körös cultures in the northern Balkans. Lactase persistence frequencies rose rapidly in the 'gene-culture co-evolutionary process on the wave front of a demographic expansion into central Europe' and overlap well with the region where Linear Pottery culture (LBK) developed (*Itan* et al. *2009. 8; Leonardi* et al. *2012.95*). The raw milk fats and dairy fat residues (*i.e.*, lipids) preserved in ceramic vessels indeed show that milk was exploited in the Carpathian Basin between 6000–5500 calBC (*Evershed* et al. *2008*). However, the scenario of lactase-persistent farmers in Central Europe seems to be unrealistic. The palaeogenetic analysis of Neolithic skeletons suggests "*that lactase persistence frequency* *was significantly lower in early Neolithic Europeans than it is today, and may have been zero*" (*Leonardi* et al. *2012. 93*). Indeed, the analysis revealed an absence of the –13 910*T allele in Central Europe, in western Mediterranean and the Baltic (*Burger* et al. *2007; Burger, Thomas 2011; Lacan 2011; Linderholm 2011; Nagy* et al. *2011*).

Mesolithic and Neolithic human DNA

Recent phylogenetic analyses of ancient mitochondrial and Y-chromosomal DNA (aDNA), extracted from Mesolithic and Neolithic human remains have revealed a genetic structure that cannot be explained by a southeast-northwest oriented 'wave of advance' or 'demic diffusion' of Near Eastern farmers and hunter-gatherer population replacements. Advances in aDNA methods and next-generation sequencing allow new approaches which can directly assess the genetic structure of past populations and related migration patterns. Mitochondrial aDNA analyses thus suggest variations in population trajectories in Europe. In central Europe, Neolithic farmers differed in various genetic markers from both Mesolithic hunter-gatherers and from modern European populations (*Haak* et al. *2005; 2010; Bramanti* et al. *2009; Burger, Thomas 2011*). The characteristic mtDNA type N1a, with a frequency distribution of 25% among Neolithic LBK farmers in Central Europe, is in contrast with the low frequency of 0.2% in modern mtDNA samples in the same area (*Haak* et al. *2005*). It was not observed in hunter-gatherer samples from Western and Northern Europe. On the contrary, hg H dominates (40%) present-day Central and Western European mitochondrial DNA variability. It was less common among Early Neolithic farmers and virtually absent in Mesolithic hunter-gatherers. Phylogeographic studies suggest that it arrived in Europe from the Near East before the Last Glacial Maximum, and survived in glacial refuges in Southwest Europe before undergoing a post-glacial re-expansion. Recently published analyses of the maternal population history of modern Europeans and hg H mitochondrial genomes from ancient human remains show that Early Neolithic lineages "*do not appear to have contributed significantly*" to present-day Central Europe's hg H diversity and distribution (*Brotherton* et al. *2013.7*). The hg H was associated with LBK culture, but lineages were lost during a short phase of population decline after 5000 calBC. The current diversity and distribution were largely established by the strong post-LBK population growth and by "*substantial genetic contributions from subsequent pan-European cultures such as the Bell Beakers expanding out of Iberia in the Late Neolithic, ... after which there appears to have been substantial genetic continuity to the present-day in Central Europe*" (*ibid. 7*; see also *Lee* et al. *2012.577*).

A rather different picture emerges from the Iberian Peninsula, where the Neolithic composition of the haplogroup population (*e.g.*, hg H, T2, J1c, I1, U4, W1) "*is not significantly different from that found in the current population from the Iberian Peninsula*", but differs from the Near Eastern groups (*Sampietro* et al. *2007.2165*). Interestingly, there is no evidence of the mt aDNA hg N1a in either Spain or France (*Lacan* et al. *2011*). Two Mesolithic individuals, on the contrary, carried a mitochondrial U5b haplotype which does not cluster with modern populations from Southern Europe (including Basques), as suggested recently (*Sánchez-Quinto* et al. *2012; Behar* et al. *2012*).

The mt aDNA sequences from contemporary hunter-gatherer and farmer populations in Scandinavia and the Baltic differ significantly. These populations are unlikely to be the main ancestors of either modern Scandinavians or Saami, but indicate greater similarity between hunter-gatherers and modern eastern Baltic populations (*Linderholm 2011*). It has also been suggested that Scandinavian Neolithic hunter-gatherers shared most alleles with modern Finnish and northern Europeans, and the lowest allele sharing was with populations from Southeast Europe. In contrast, Neolithic farmers shared the greatest fraction of alleles with modern Southeast European populations, but were differentiated from Levantine populations and showed a pattern of decreasing genetic similarity to 'populations from the northwest and northeast extremes of Europe' (*Skoglund* et al. *2012. 469*). The most recent arhaeogenetic study reveals an extensive 'heterogeneity in the geographical, temporal and cultural distribution of the mtDNA diversity' in Northeast Europe. While some mt aDNA sequences from hunter-gatherer sites show a genetic continuity in some maternal lineages (*e.g.*, hg U4, U5 and H) in Northeast Europe since the Mesolithic, and also genetic affinities with extant populations in Western Siberia, the precise genetic origins of the others is more difficult to identify. They all display clear haplotypic differences with contemporary Saami populations. The major prehistoric migration in the area was thought to have been associated with 'the spread of early pottery from the East' (*Der Sarkissian* et al. *2013.10–12*).

Unfortunately, we still do not know what happened to the Mesolithic hunter-gatherer and Neolithic populations in Southeast Europe, as no aDNA studies have yet been carried out in the region.

Instead of concluding remarks

Initial pottery distribution in Europe shows two almost contemporary, but geographically distinct, trajectories. While the northern is embedded in hunter-gatherer contexts, it has been suggested that the southern was associated with the expansion of farming into the region. The pottery assemblages in both contexts differ in terms of vessel shapes, production techniques and decoration. While vessels with conic bases were not modelled in Southeast Europe, coloured ornaments were never attached to vessels in the north-east or north-west. Unpainted vessels were clearly the first to appear in Europe in the 7th millennium calBC. Since coloured ornaments were attached to pots in Southeast Europe, a dichotomy of colour and motif applications 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.

Geneticists suggest that the processes of peopling Europe in prehistory were far more complex and variable than was first thought. The palimpsest of Y-chromosomal paternal and mitochondrial maternal lineages in modern populations reveals the signatures of several demographic expansions within Europe over millennia, and gene flows between Europe and western Asia in both directions. These processes have been suggested 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 analyses of ancient DNA and palaeodemographic reconstructions show a complex picture of varied population trajectories elsewhere in Europe, and while such studies have yet to be conducted for Southeast Europe, a similar picture may be expected.

We suggest that the Mesolithic-Neolithic transformation, too, was also a far more complex and variable process than previously hypothesised. The introduction of ceramic technology and initial pottery distributions in Eurasia show a wide-spread appearance of different pottery-making techniques and ornamental principles in different cultural and chronological contexts. The pattern cannot be explained by way of a narrow and gradual southeast/northwest oriented spread of both people and vessels across Europe in a 'wave of advance' and within a 'first demic event'. We suggest that both were embedded in continuous social networks established long before the advent of the Neolithic in the Levant.

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Flesh or fish? First results of archaeometric research of prehistoric burials from Sakhtysh IIa, Upper Volga region, Russia

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ABSTRACT – *Graves and their human remains not only shed light on burial customs and social structures of past populations, but also constitute an excellent archive of prehistoric environmental and living conditions. Especially $^{13}C/^{15}N$ isotope analysis has recently opened up promising perspectives for reconstructing changes in diet and their social, cultural and economic background. Such investigations have been started on material from the Stone and Early Metal Age hunter-gatherer cemetery of Sakhtysh IIa in the Upper Volga region of Central Russia, where 15 burials associated with the early Lyalovo culture (5th mill. calBC) and 57 graves of the Volosovo culture (4th – 3rd mill. calBC) have been excavated. In this paper, we present new AMS dates and isotopic data from four burials, two from the earlier and two from the later group. The results are discussed against the background of existing dates from Sakhtysh IIa burials and compared with information from other burial sites of Northern Europe.*

IZVLEČEK – *Grobovi in človeški ostanki v njih ne osvetlijo le preteklih pogrebnih praks in družbenih struktur, ampak predstavljajo tudi čudovit arhiv prazgodovinskih okoljskih in življenjskih pogojev. Predvsem analize izotopov ^{13}C in ^{15}N omogočajo rekonstrukcijo sprememb v prehrani ljudi in nudijo podatke o njihovem družbenem, kulturnem in gospodarskem izvoru. Takšne raziskave smo opravili na materialu iz kamene in zgodnje kovinske dobe na lovsko-nabiralniškem grobišču Sakhtysh IIa na področju zgornje Volge v centralni Rusiji, kjer smo izkopali 15 grobov iz zgodnje kulture Lyalovo (5. tisočletje calBC) in 57 grobov iz kulture Volosovo (4. do 3. tisočletje calBC). V članku predstavljamo nove AMS radiokarbonske datume in izotopske podatke iz štirih grobov, po dva iz zgodnje in pozne faze na najdišču. Rezultate nato primerjamo z že znanimi datumi iz najdišča Sakhtysh IIa in jih primerjamo z datumi iz drugih grobišč v Severni Evropi.*

KEY WORDS – *Northeastern Europe; Stone and Early Metal Age; hunter-gatherer burials; chronology; diet*

Introduction: Prehistoric cemeteries in the Eastern European forest zone

In post-glacial Europe, cemeteries of Stone Age hunter-gather communities are known from Portugal and Brittany in the west, across southern Scandinavia to the eastern Baltic. Well-studied burial sites have enabled archaeologists to draw a detailed picture of the development of funerary rites over space and time and their interdependency with other spheres of life such as settlement, subsistence and economy (*Grünberg 2000; Terberger 2010.46–50*). In southeastern Europe, two clusters of Mesolithic burial sites have been the focus of long-term multidisciplinary research: the graves of the Lepenski Vir

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culture at the Iron Gates (*Bonsall* et al. *2004*) and the Stone Age cemeteries at the Dnepr rapids in Ukraine (*Lillie* et al. *2011*). In the eastern Baltic, the Latvian cemetery at Zvejnieki has been the focus of international research in recent years (*Larsson, Zagorska 2006*).

Fig. 1. Holocene hunter-gatherer burial sites in the Northern European forest zone (modified and supplemented after* Kostyleva, Utkin 2010.Fig. 124 *and* Terberger 2010.Fig. 51*).

Further northeast in the vast expanses of the Eastern European forest zone, a substantial number of Stone Age cemeteries has been discovered (*Oshibkina 2006; Kostyleva, Utkin 2010*) (Fig. 1). Due to political constraints of recent history, however, they have remained virtually unknown to the Western European scientific community. This is a sore gap in Pan-European prehistory, as the sites include outstanding complexes such as the uniquely equipped Mesolithic hunter-fisher burials of Oleni Ostrov in Lake Onega and the Late Stone/Early Metal Age Volosovo amber graves of Central Russia, with hundreds of ornaments made from 'Baltic gold'. The systematic multidisciplinary study of the Eastern European burial sites can contribute valuable insights into local cultural developments, as well as supra-regional contacts and interactions. The use of modern archaeometric analysis of human remains in particular opens up new perspectives: AMS dating enables the construction of a more reliable chronological framework, and stable carbon and nitrogen isotope analysis yields information on diet and at the same time helps to identify possible reservoir effects in the radiocarbon dates.

The present paper introduces the large multi-phase prehistoric cemetery of Sakhtysh IIa in the Upper Volga region of Central Russia. The first results of archaeometric analyses (AMS dating and isotope analysis) of human bone samples of four graves from two different phases are discussed.

Sakhtysh IIa – A Neolithic and Early Metal Age cemetery in the Upper Volga region

Site context

The Sakhtysh peat bog is located in Teikovo district of Ivanovo region on the southern slope of the Volga-Klyazma watershed in the Volga-Oka interfluve and is the source of the River Koika (Figs. 1, 2). The area of the peat bog encompasses approx. 50km², and until recently a residual lake of about 8km² was preserved in its central part. The extension of the gyttia deposits clearly indicates that in ancient times, the lake was much larger.

The first archaeological investigations were conducted in 1930, and a more systematic study of the Sakhtysh archaeological complex was started in 1962 by the Academy of Sciences of the USSR (later the Russian Academy of Sciences) directed by D. A. Krainov, and from 1993 to 2006 by M. G. Zhilin (*Kostyleva, Utkin 2010.9*).

The archaeological sites detected in the Sakhtysh peat bog are situated on the narrow banks of the old Koika riverbed along a three-kilometre segment from its source (Fig. 2). Five of the sites were of considerable size and have been interpreted as long-term settlements (Sakhtysh I, II, IIa, VII, VIII); six were seasonal stations (Sakhtysh III, IV, IX–XI, XIV), and four were artefact scatters (Sakhtysh V, VI, XII, XIII). Thick accumulations of archaeological material on the larger sites attest to several chronological stages from the Early Mesolithic to the Early Iron Age. The Neolithic in the Russian scientific tradition is defined by the appearance of pottery, not by a transition to a productive economy (*Oshibkina 2006*).

In the Volga-Oka region, it starts with the Upper Volga culture at around 6000 calBC and continues with the Middle Neolithic Lyalovo culture evolving at the end of the 6th millennium calBC (Fig. 3). In the Late Neolithic, just after 4000 calBC, the transition to the Volosovo culture takes place and this continues to develop into the Early Metal Age.

Apart from the settlement remains, altogether 149 burials from five different sites have come to light in the Sakhtysh archaeological complex, thus accounting for more than 50% of all prehistoric graves known in the Upper Volga and Volga-Oka interfluve region (*Kostyleva, Utkin 2008b; 2010.11*). Chronologically, they encompass 20 Neolithic, 128 Late Neolithic/Early Metal Age and one Late Bronze Age interment. While the burial complexes at Sakhtysh II, IIa and VIII have been excavated more or less completely, the graves at Sakhtysh VII were partly destroyed by modern agriculture, and at Sakhtysh I, the main part of a large cemetery is still awaiting investigation.

Within the Sakhtysh complex, Sakhtysh IIa has yielded the largest number of burials. The site occupies an elongated ridge on the left bank of the River Koika (*Zaretskaya, Kostyleva 2008.7–8*). More than 700m² have been archaeologically investigated at this site. Apart from a cultural layer containing finds from the Mesolithic to the Bronze Age, 72 burials of the Lyalovo and Volosovo cultures were discovered. The cemetery of Sakhtysh IIa is distinguished from the other burial sites by a stratification of the graves and the comparatively good preservation of the skeletons. The graves can be grouped into two burial complexes, one cemetery each of the Middle Neolithic Lyalovo culture, and of the Late Neolithic/Early Metal Age Volosovo culture (*Kostyleva, Utkin 2010.37*).

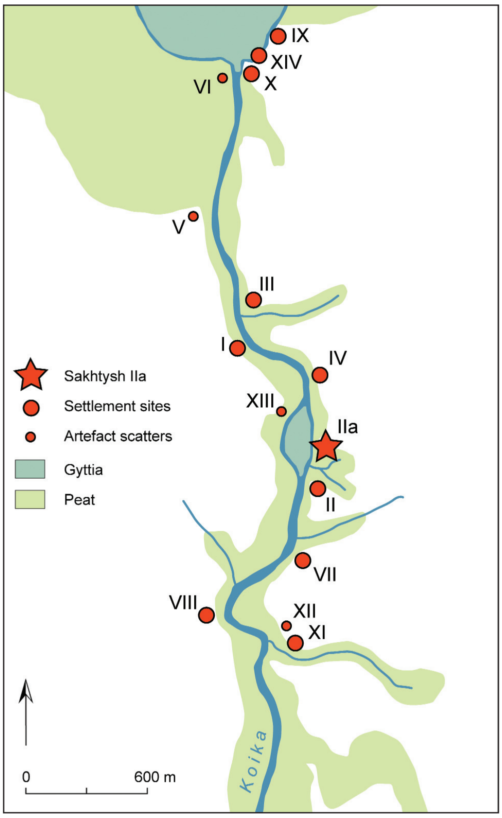

Fig. 2. Archaeological sites in the southern area of the Sakhtysh peat bog (after* Kostyleva, Utkin 2010. Fig. 2*).

The Lyalovo cemetery

The Middle Neolithic cemetery is represented by 15 inhumation burials, and it is likely that the entire burial field of this phase has been captured (*Kostyleva, Utkin 2010.41*) (Fig. 4). The association of the burials with the early Lyalovo phase is attested to by stratigraphy: the burial pits have been cut from the lower part of the Lyalovo cultural layer through the underlying Upper Volga cultural layer (*Kostyleva, Utkin 2010.246*). The later dating of the Late Neolithic/Early Metal Age burials is confirmed by Middle Neolithic graves that were cut by burial pits (n = 3) or partly overlain (n = 3) by graves of the Volosovo cemetery. The Lyalovo burial pits had an elongated sub-rectangular or elliptical shape and ranged in size from 0.9 x 0.47m (small infant burial) to 2.12 x 0.65m (large adult burial). The maximum depth of the skeletons below the modern surface was 0.7m (*Kostyleva, Utkin 2010.37*). Most of the burial pits were orientated along a northwest-southeast axis, thus following the long axis of the ridge. In the central part of the cemetery, the graves were arranged in four short rows of two to three burials.

The majority of the graves were individual burials, and only two contained two individuals (no. 59: two children; no. 61: young woman with 2-year-old infant). In eight cases, the deceased lay in an extended supine position; in graves no. 12 and 22 the bodies were positioned face down. Grave no. 11 is the only example of a crouched burial. Most of the bodies were placed in the burial pits with their heads towards the southeast, while in four cases (nos. 12. 40, 61a.b) an opposite orientation was chosen and in two cases (nos. 11, 59) the heads lay to the east. The anthropological composition of the group of individuals buried in the Lyalovo cemetery resembles a normal palaeo-population of hunter-gatherers: seven individuals were sub-adults, most of whom had died as infants; among the remaining individuals, six

Lab no.	Burial no.	Sex (m/f), age (yr)	Cultural affiliation	Collagen yield %	$\delta^{13}C$ (CF–CN)	$\delta^{15}N$ (CF–CN)	C:N	^{14}C age yr bp	Age cal BC (1σ, 68,2 %)	Age cal BC (2σ, 95,4 %)	Reliability according to *Kostyleva, Utkin 2010*
GIN–6587	43	?, 5–6	Lyalovo					8700±800	9114–6771	10430–6117	not reliable
AAR–15050	**40**	**m, 50–60**	**Lyalovo**	**4.3**	**–20.92±0.1**	**13.39±0.11**	**3.2**	**6406±24**	**5467–5345**	**5469–5325**	
AAR–15052	**61**	**f, 20–25**	**Lyalovo**	**3.9**	**–21.05±0.1**	**14.6±0.11**	**3.1**	**6356±23**	**5360–5314**	**5464–5233**	
GIN–7492	16	f, 20–25	Lyalovo					6130±120	5219–4911	5342–4777	
GIN–7185	12	m, 30–40	Lyalovo					6110±200	5297–4804	5475–4589	
GIN–6586	42	m, 20–25	Lyalovo					6060±150	5207–4826	5325–4609	
GIN–7195	29	f, 40–45	Lyalovo					5820±200	4932–4458	5216–4271	
GIN–7187	14	m, *c.* 40	Volosovo (early)					5380±140	4341–4050	4521–3825	not reliable
GIN–6237	5	m, 40–45	Volosovo (early)					4800±200	3908–3354	4038–3021	
GIN–7190	28	m, 35–40	Volosovo (early)					4740±110	3638–3376	3775–3119	
GIN–7490	64	f, 45–50	Volosovo (early)					4550±350	3706–2778	4223–2309	
GIN–6234	10	f, 20–25	Volosovo (early)					4540±160	3505–3019	3637–2897	
GIN–7276	34	m, 50–55	Volosovo (early)					4540±150	3499–3023	3633–2906	
GIN–7274	32A	m, ?	Volosovo (late)					7730±70	6631–6485	6686–6445	not reliable
GIN–7275	31	f, ?	Volosovo (late)					5540±150	4580–4180	4717–4042	not reliable
GIN–7270	36	m, 20–25	Volosovo (late)					5090±90	3976–3781	4145–3658	not reliable
AAR–15053	**66**	**f, 20–25**	**Volosovo (late)**	**1.8**	**–23±0.1**	**12.57±0.11**	**3.2**	**5033±24**	**3936–3782**	**3946–3716**	
AAR–15051	**54**	**f, 45–50**	**Volosovo (late)**	**1.9**	**–21.38±0.1**	**12.39±0.11**	**3.1**	**4964±23**	**3767–3708**	**3792–3666**	
GIN–7189	13A	f, 35–40	Volosovo (late)					4200±240	3309–2466	3507–2140	
GIN–7273	35	m, 35–40	Volosovo (late)					4080±180	2895–2351	3264–2050	
GIN–7277	33	m, 50–55	Volosovo (late)					3550±200	2195–1634	2465–1451	not reliable
GIN–7271	32B	m, 40–45	Volosovo (late)					3040±200	1497–1016	1740–815	not reliable
GIN–7272	36A	m, 40–45	Volosovo (late)					2030±260	381–235AD	761–532AD	not reliable

Tab. 1. Sakhtysh IIa. Results of radiocarbon dating and isotope analysis. Fat – new AMS dating results, regular – conventional radiocarbon dates.

were identified as women and three as men (one adult: sex unknown) (*Kostyleva, Utkin 2010.40*).

The fills of the burial pits contained various finds, such as animal bones, stone artefacts, tooth pendants of elk and bear, and sherds of Upper Volga and early Lyalovo ceramics; later phases of the Lyalovo culture were not represented (*Kostyleva, Utkin 2010.37*). Traces of red ochre were documented in four graves (nos. 29, 43, 59, 61); grave goods were present in only four burials (*Kostyleva, Utkin 2010. 39*). The most extensive set of artefacts (two bone daggers, a harpoon and an animal tooth pendant) had been given to the 20- to 25-year-old woman in grave no. 22. One of the daggers bears a human face carved with a few well-placed incisions at the handle end (Fig. 5). In grave no. 40, the burial of a 50 to 60 year old man, a pointed tool made from an elk metatarsal was found close to the left shoulder (Fig. 6). The young woman in grave 61 was equipped with three bone artefacts, among them a pointed bone and a knife (Fig. 7). A small embryo-shaped clay figurine came to light under the chest of the 35 to 45 year old woman in grave no. 65 (Fig. 12.1). Similar clay images are widely known in the northeastern European forest zone from Finland to the Eastern Baltic and Northern Russia, where they are associated with Middle Neolithic Comb Ceramic complexes. In the area of the Pit-Comb Ceramic groups further south which include the Lyalovo culture, they are less common (*Kashina 2004; Nunez 1986*). The limited set of grave goods encompassing merely bone tools and animal tooth ornaments and the large portion of burials with no artefacts observed at Sakhtysh IIa are in accordance with the burial customs documented at the few other known early Lyalovo cemeteries Sakhtysh II, Yazykovo 1 and Lovcy (*Kostyleva, Utkin 2010.39; 2012.233–234*).

Four conventional radiocarbon dates on human bone determined at the radiocarbon laboratory of the Geological Institute of the Russian Academy of Sciences in Moscow range between *c.* 5500 and 4500 calBC (Tab. 1; Fig. 13) and are in general agreement with the proposed early Lyalovo context (*Engovatova 1998; Zaretskaya, Kostyleva 2010*). A further conventional radiocarbon date from this complex (GIN-6587) would appear several millennia too old and must be regarded as unreliable due to its large standard deviation (±800) (*Kostyleva, Utkin 2010.41*).

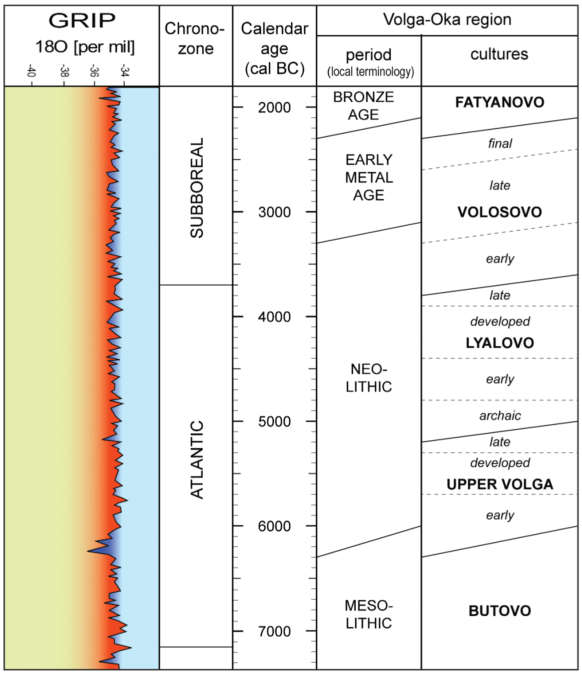

Fig. 3. Chronology of prehistoric cultural groups in the Volga-Oka region, Central Russia, and climatic development according to Greenland ice core data (GRIP project,* Johnsen *et al.* 1992; 1997*) showing the 6.2ka event.

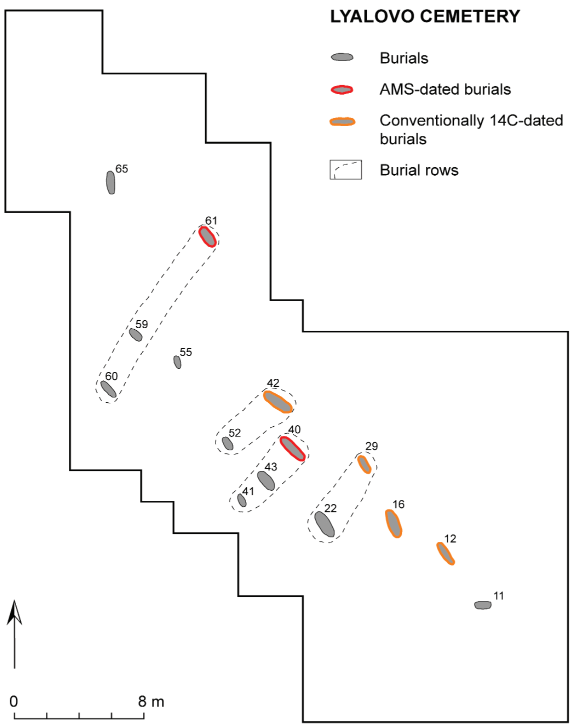

Fig. 4. Sakhtysh IIa. Middle Neolithic cemetery of the Lyalovo culture (modified after* Kostyleva, Utkin 2010.Fig. 36*).

The Volosovo cemetery

The 57 burials of the Late Neolithic/Early Metal Age phase are distinguished from the earlier burials by their higher stratigraphic position and by a different spatial arrangement (Fig. 8). Associated with this phase were two ritual hoards and a structure interpreted as a 'sanctuary' (*Kostyleva, Utkin 2010.49–50*). This consisted of a pentagonal construction with a large pit inside which a unique life-size human mask made of elk antler was discovered (Fig. 12.3).

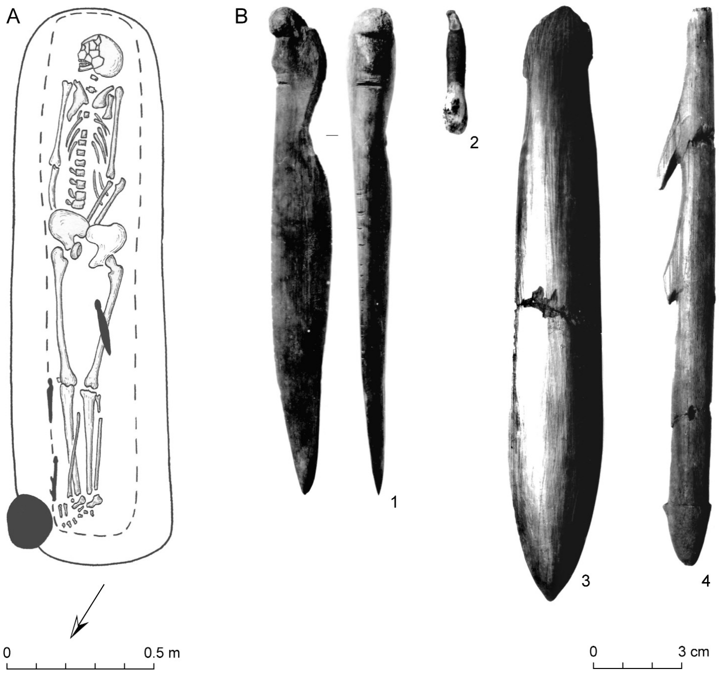

Fig. 5. Sakhtysh IIa. Burial no. 22. A – plan of burial; B – grave goods (1, 3, 4 – bone; 2 – animal tooth) (after* Kostyleva, Utkin 2010.Fig. 39. 1–4*).

The burials were found at a maximum depth of 0.53m below the modern surface within the Volosovo cultural layer (*Kostyleva, Utkin 2010.41*). No traces of burial pits were detectable, and the preservation conditions of the skeletal remains are generally poorer. Only about twenty skeletons were preserved more or less completely, while eight interments had been entirely destroyed. Dislocated human bone fragments and typical Volosovo amber ornaments found in the cultural layer indicate an even higher number of destroyed graves (*Kostyleva, Utkin 2010.42*). The Volosovo burials were positioned perpendicular to the course of the River Koika (see Fig. 8) and formed rows of varying length, mostly orientated NW-SE (*Kostyleva, Utkin 2010.46*). Four of the graves (nos. 8, 44, 49, 54) do not seem to be connected to any of the rows. From the spatial and stratigraphic position of the graves and the adornment with grave goods, a subdivision into two phases has been suggested for the Volosovo cemetery: among the early graves are rows А, Б, and Е (0.25 to 0.5 m below modern ground surface) while rows В, Г, Д and Ж are associated with a younger sub-phase (0.15 to 0.25m below modern ground surface) (*Kostyleva, Utkin 2010.46*).

The graves contained single burials, the only possible exception being grave no. 50, where some infant bones were found together with the skeletal remains of an adult woman (*Kostyleva, Utkin 2010.42*). All of the 51 deceased whose position in the grave could be determined had been buried in an extended supine position, 49 of them with the head to the SW towards the river (no. 47: head to NW; no. 49: head to the N). The results of the anthropological study suggest that here, too, a normal population was buried with the ratio between adult males and females more or less balanced (26 men, 23 women) (*Kostyleva, Utkin 2010.51–53, Tab. 5*). Children are represented by only five individuals (one infant). However, this low number might be due to the less favorable preservation conditions compared to the Lyalovo burials.

In the Volosovo graves, no evidence of the use of ochre in the burial rites was found (*Kostyleva, Utkin 2010.42*). In 36 graves, pendants and buttons made of amber, stone, bone and animal teeth were found and, according to their position in association with the skeletal remains, it is likely that most of these ornaments had been attached to the clothing. Almost 90% of the 367 amber artefacts stem from two graves, among them grave no. 15, where the original arrangement of the buttons on the clothing of a 20- to 25-year-old man was still preserved (Fig. 9). Such extensive adornment with amber ornaments has been identified as a characteristic trait of the early phase of Volosovo burial rites (*Kostyleva, Utkin 2010.256*). For the second phase, a simpler adornment with just a few tooth and stone pendants seems to be typical (*Kostyleva, Utkin 2010.256*) (Figs. 10, 11). In several graves, animal remains such as bear fangs, beaver jaws and elk antler were present close to the human bones. An anthropomorphic bone pendant was discovered in the burial of a 40- to 45-year-old woman (grave no. 58) (Fig. 12.2).

To determine the absolute chronology of the Volosovo cemetery, a series of 32 samples of human bone from 29 graves were analysed by conventional radiocarbon dating at the Russian Academy of Sciences (Tab. 1). Fifteen of the samples did not provide sufficient collagen, and seven dates gave results that are not in accordance with the established chronolo-

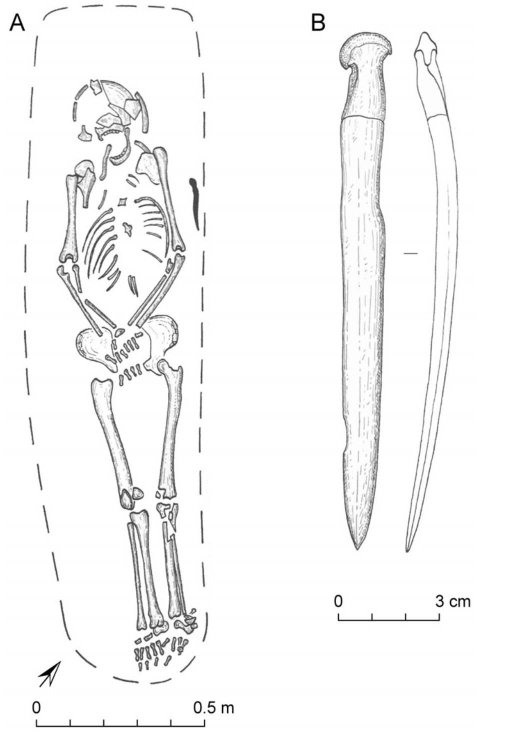

Fig. 6. Sakhtysh IIa. Burial no. 40. A – plan of burial; B – bone tool (after **Kostyleva, Utkin 2010. Fig. 41.1–2*).***

gical framework of the Volosovo culture and/or the stratigraphic situation at the site (Fig. 13)[1]. Only five dates for the early phase (4th millennium calBC) and two for the later phase (*c.* 3500–2500 calBC) have been regarded as reliable by the excavators (*Kostyleva, Utkin 2010.48*) (Fig. 13).

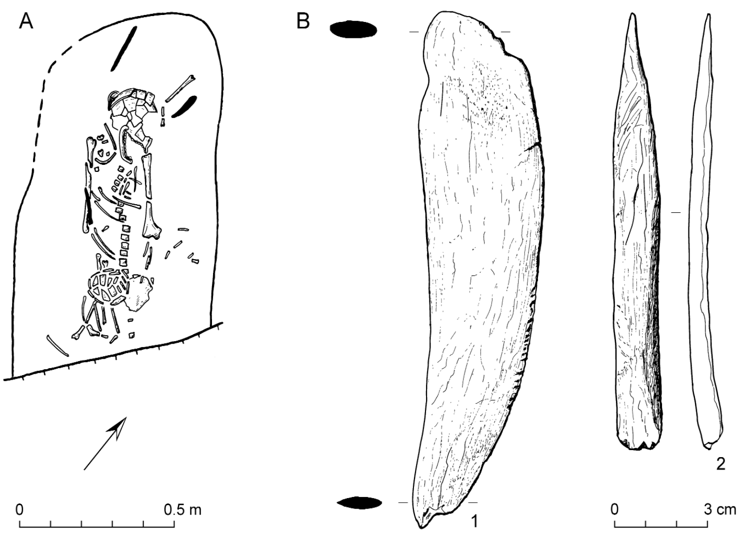

Fig. 7. Sakhtysh IIa. Burial no. 61. A – plan of burial; B – grave goods (bone) (after **Kostyleva, Utkin 2010.Fig. 43.2–3, 5*).***

AMS dating and isotopic analyses of human remains from Sakhtysh IIa

Methods

The archaeometric analyses conducted on Sakhtysh IIa human bone samples encompassed AMS radiocarbon dating and the determination of stable carbon and nitrogen isotope ratios.

Measurements of carbon and nitrogen isotope ratios in bone collagen are among the most important methods in archaeological research for acquiring information on dietary components in the subsistence of individuals and investigating more general questions concerning variations in diet between groups, temporal developments such as the introduction of new food stuffs, breastfeeding patterns *etc.* (*Eriksson 2006.184; Fischer* et al. *2007*). Body tissue is synthesised out of dietary components, and the isotopic composition of collagen from compact bones of adult humans reflects the average diet over approximately two decades prior to death (*Olsen, Heinemeier 2007.340*). The carbon isotope ratio ($\delta^{13}C$) yields information on the proportion of marine (higher values) versus terrestrial food components (more negative values), while a differentiation between terrestrial and freshwater components can be more problematic due to overlapping ranges (see Figs. 14–17). The nitrogen isotope ratio ($\delta^{15}N$) reflects the trophic level of the consumer, which increases by *c.* 3.5‰ in each step up the food chain. Thus, carnivores have higher $\delta^{15}N$ values than herbivores from the same ecological system. Marine and freshwater diets generally result in higher $\delta^{15}N$ values than diets based on terrestrial food, because aquatic food webs are longer than terrestrial ones (*Eriksson 2006.185, Fig 1; Olsen, Heinemeier 2007.340*). A slight increase in the $\delta^{13}C$ of *c.* 1‰ can also be observed with each trophic level shift (*Olsen, Heinemeier 2007.340*).

An important method for more precisely reconstructing the composition of the diet of prehistoric people in a certain region from their stable carbon and nitrogen isotopic ratios is the comparison with local faunal isotopic data derived preferably from

1 For example, the dates for the overlapping graves 32 A and Б resulted in a 'Mesolithic age' for the upper and a 'Late Bronze Age' date for the lower skeleton (*Kostyleva, Utkin 2010.47*; see Tab. 1).

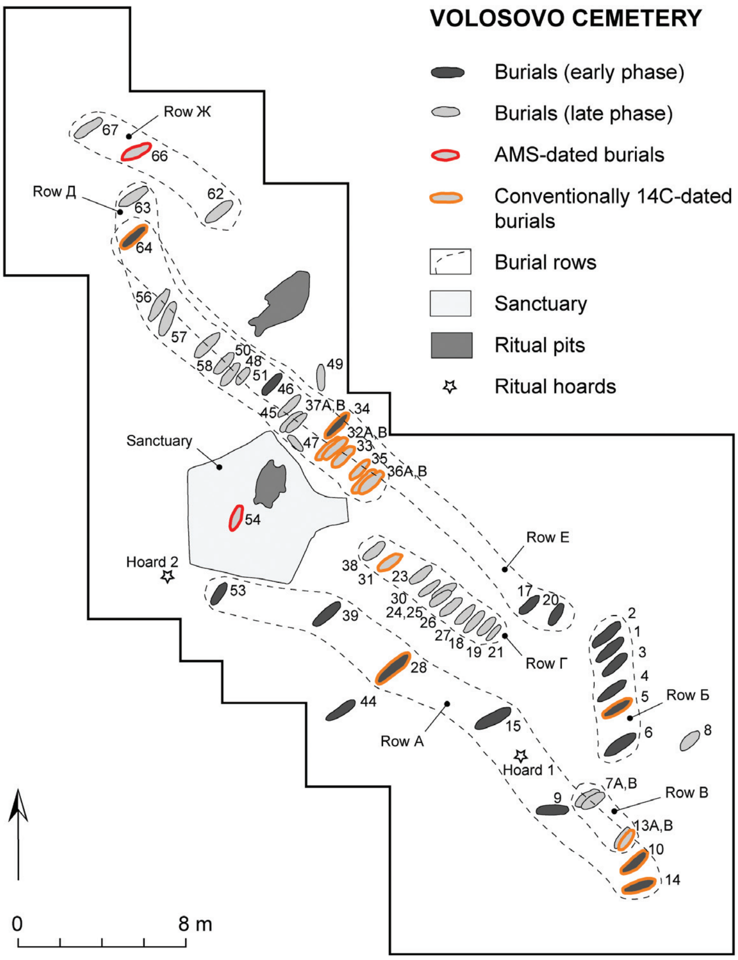

Fig. 8. Sakhtysh IIa. Late Neolithic/Early Metal Age cemetery of the Volosovo culture (modified after* Kostyleva, Utkin 2010.Fig. 44*).

the same chronological context (*Eriksson 2006.185; Olsen* et al. *2010*). Such data provide the isotopic ranges of various food stuffs people could have consumed and show the ranges in which human consumers would have to be expected one level up in the food chain.

Due to this information on dietary components, the stable isotope ratios can help to address the problem of whether the radiocarbon ages of the sampled individuals have been affected by a reservoir effect. Both the marine and the freshwater reservoir effects are caused by the fact that aquatic organisms are depleted in ^{14}C relative to the atmosphere, which leads to unduly old radiocarbon ages compared to contemporaneous terrestrial creatures (*Olsen, Heinemeier 2007.340*). The freshwater reservoir age, which is of interest in the inland context of the Sakhtysh IIa samples, is the result of dissolved $CaCO_3$ from fossil carbonate deposits. Depending on the amount and the age of the carbonate in the water, freshwater reservoir ages can vary considerably with time and geographical location (*Fischer* et al. *2007; Olsen* et al. *2010*). Organisms such as molluscs and fish are affected by the reservoir age of their aquatic habitat, and humans, whose diet includes organisms from the aquatic food web, will also show varying reservoir ages, depending on the portion the aquatic food makes up in their entire nutrition.

For the detection of the presence and also the absolute value of a possible reservoir age in human bones from graves, a good method is to compare radiocarbon dates of human remains and remains of terrestrial animals from the same burials (*i.e.,* grave goods made of bone). Due to their land-based diet, terrestrial animals such as red deer and aurochs have most probably not been influenced by aquatic reservoir effects and can therefore serve as proxies for determining the true date of the graves and the humans buried in them (see *e.g., Olsen, Heinemeier 2007. 345; Olsen* et al. *2010*).

AMS dating and isotopic analyses of the Sakhtysh IIa samples were carried out at the AMS ^{14}C Dating Centre at the University of Århus.[2] The $\delta^{13}C$ and $\delta^{15}N$ isotopic values of the samples were measured by high-precision stable isotope mass spectrometry.

Results

Samples of human remains from two graves of the Lyalovo cemetery (graves 40 and 61) and from two graves supposedly associated with the younger phase of the Volosovo cemetery (graves 54 and 66) were analysed (Tab. 1, Fig. 13). All four samples provided sufficient collagen after ultra-filtration, with the Lyalovo samples being in better condition (3.9–4.3%; Volosovo samples: 1.8–1.9%).

2 Collagen was extracted from the bone matter following the protocol of DeNiro and Epstein (*DeNiro, Epstein 1981; Jørkov* et al. *2007*). The collagen was then checked according to the guidelines by DeNiro and van Klinken (*DeNiro 1985; van Klinken 1999*). The results of the AMS measurement are reported in accordance with international convention (*Stuiver, Polach 1977; Reimer* et al. *2009*) as conventional radiocarbon years bp (before present = 1950). The dates have been corrected for the natural isotopic fractionation by normalizing the result to the standard $\delta^{13}C$ value of wood (–25‰) (*Andersen* et al. *1989*).

The stable carbon and nitrogen isotope values represent the first such information for the Sakhtysh complex and, indeed, Stone Age burial sites of northwestern Russia in general. All four samples show comparatively negative $\delta^{13}C$ values between –20 and –23‰; their $\delta^{15}N$ values are rather high, ranging from 12.4 to 14.6‰ (Tab. 1). These values indicate an aquatic component in the diet, and on this background we might expect possible reservoir effects in the dating results. Irrespective of this potential problem, the AMS radiocarbon dates confirm the presence of two phases at the burial site. The dates from the Lyalovo graves 40 and 61 fall into a narrow range of 5469–5233 calBC (95.4% probability), with an overlap from 5464–5325 calBC, while the dates from the Volosovo graves 54 and 66 are approx. 1500 years younger, covering a range of 3946–3666 calBC (95.4% probability) overlapping from 3792–3716 calBC.

Discussion

Stable carbon and nitrogen isotope ratios: human diet and the freshwater reservoir effect

Because isotopic data for the background fauna and the humans of the Upper Volga region are not yet available, it is necessary to use information from the neighboring territories. On the basis of data from the Baltic and Northern Europe, $\delta^{15}N$ values of ≥ 11‰ in human bone show an increasing portion of aquatic food in the diet. In combination with $\delta^{13}C$ values of ≤ –22‰, they can be related to freshwater organism-dominated diet, while values from *c.* –17 to –12‰ indicate the increasing consumption of marine food (*Fischer* et al. *2007*).

The isotopic signatures of the four Sakhtysh samples with their $\delta^{13}C$ values between –20.9 and –23.0‰, and $\delta^{15}N$ values from 12.4 to 14.6‰, strongly indicate a considerable intake of freshwater-derived food by these individuals. No great differences in the stable carbon and nitrogen isotope ratios can be observed between the Lyalovo and the Volosovo samples. Only when a larger set of data is available can it be decided whether the slightly lower $\delta^{13}C$ values of the two Volosovo samples have a more systematic significance.

Data published recently for the burial sites at Minino I and II provide an excellent opportunity to test this interpretation (Fig. 1). The sites yielded 39 graves from the Mesolithic and Neolithic period, and 22 faunal bones and 35 humans were analysed for carbon and nitrogen stable isotopes (*Wood* et al. *2013*). The isotopes for herbivores are in the expected range, with a $\delta^{15}N$ of *c.* 2 to 6‰, while samples of pike and waterfowl show $\delta^{15}N$ of *c.* 9.0‰. Because the values for the human bone collagen are enriched in $\delta^{15}N$ by *c.* 4.2‰ above the fish and waterfowl (11.7 to 16.2‰), there is no doubt that herbivores were of little relevance, and aquatic resources played a very important role in the human diet at Minino (*Wood* et al. *2013.169*). The data from Minino correspond very well with the values obtained on the Sakhtych burials (Figs. 14–15) and strongly support the interpretation of the Sakhtych values to be caused by the high proportion of fresh water fish or aquatic food consumption.

If we view the isotopic values from the four Sakhtysh IIa burials against the background of the data from the famous prehistoric cemetery of Zvejnieki in Latvia (*Eriksson 2006*) (Fig. 16), we see that their high nitrogen ratio strongly argues for a substantial freshwater component in the diet combined with some terrestrial protein intake. The humans show nitrogen isotopic values similar to the otter, with its diet dominated by freshwater fish, while the values for brown bear, a typical omnivore, are located much lower in the terrestrial range. The Sakhtysh humans can also be well compared to the Zvejnieki human remains (Fig. 17). With one exception indicating a substantial marine input in the diet, all other human samples from Zvejnieki are in the region of terrestrial and freshwater food consumers. An interesting chronological trend can be noted that involves a shift from a more freshwater-species orientated diet in the Mesolithic towards a higher input of terrestrial animal and plant food in the Late Neolithic and Bronze Age (*Eriksson 2006.193–196*). The Sakhtysh IIa samples, with their high nitrogen isotope values, are in accordance with the first dietary type, and there is no doubt that they had a Mesolithic way of life as hunter-fisher-gatherers.

An analogous picture evolves when the Sakhtysh IIa isotopic data is compared to evidence from Central and Northern Europe. In Figure 18, the Russian samples are plotted against isotopic data from Denmark. Here, the Sakhtysh values are even more clearly located in the area where humans with a diet based on freshwater protein would be expected. The Sakhtysh samples fall into almost exactly the same range as the human samples from the Ostorf cemetery in northern Germany, a burial community of fishers and hunters thriving in the late 4th millennium calBC in a Neolithic farming environment (*Lübke* et al. *2007; Olsen* et al. *2010*) (Fig. 19). For the Ostorf hu-

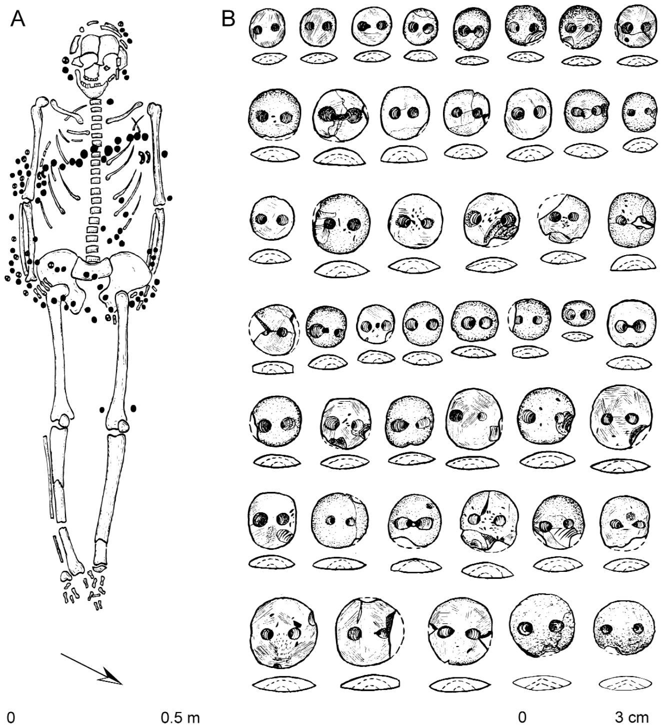

Fig. 9. Sakhtysh IIa. Burial no. 15. A – plan of burial; B – grave goods (amber) (after* Kostyleva, Utkin 2010.Fig. 53*).

mans, reservoir ages of up to *c.* 700 years have been detected, which are thought to be the result of a freshwater reservoir effect (*Olsen, Heinemeier 2007. 345–347*). In contrast, human bone data from megalithic tombs and Late Neolithic and Early Bronze Age burials from the same region show substantially lower nitrogen isotope ratios indicating a shift in the diet towards the terrestrial plants and animals typical of farming communities.

In summary, we can conclude on the basis of data from other sites of the European forest zone that the stable carbon and nitrogen isotope signals measured in the Sakhtysh IIa human samples are in accordance with a diet largely based on freshwater food while terrestrial food played a less prominent role in the subsistence. This means that the AMS radiocarbon dates received for the human bone samples are probably too old due to a freshwater reservoir effect.

The dating of the Sakhtysh IIa burials

Compared to the set of existing conventional radiocarbon dates, the four new AMS dates are outstanding by their high precision with standard deviations of no more than ±24 radiocarbon years (Tab. 1, Fig. 13). In the 95.4% probability range, the calibrated AMS dates thus cover just over two centuries, compared to more than a millennium for many of the conventional dates. Also, the reliability of the AMS dates appears to be altogether higher, as both dates in each culturally determined pair (Lyalovo and Volosovo, respectively) lie close together, and outliers, as can be seen among the conventional dates (Fig. 13: grey-shaded dates) are not present. A third observation concerns the absolute dates of the new samples: for both the Lyalovo and the Volosovo groups, they are somewhat older than the respective ranges of those dates which were regarded as reliable by Kostyleva and Utkin (*2010*) (Fig. 13: black-shaded dates). For the Lyalovo burials, the age offset from the next-younger conventional dates encompasses more than 200 radiocarbon years (although due to the large standard deviation of the conventional dates, the calibrated ranges do overlap), and for the Volosovo samples supposedly belonging to the younger phase, even the four 'reliable' conventional dates of the early Volosovo phase are all more than 150 radiocarbon years younger than the new dates.

These slightly older – compared to the existing dates – absolute ages of the AMS dates might be due to improved methods of bone sample preparation, which have significantly advanced in recent years: contaminations caused *e.g.* by intrusive younger carbon can now be removed more effectively (*e.g., Jacobi* et al. *2009*). Reservoir effects, on the other hand, should not be responsible for this particular age offset, as it can be presumed that the conventional dates on human remains of the respective phases would have reservoir ages more or less similar to the new samples, because it is likely that the diet

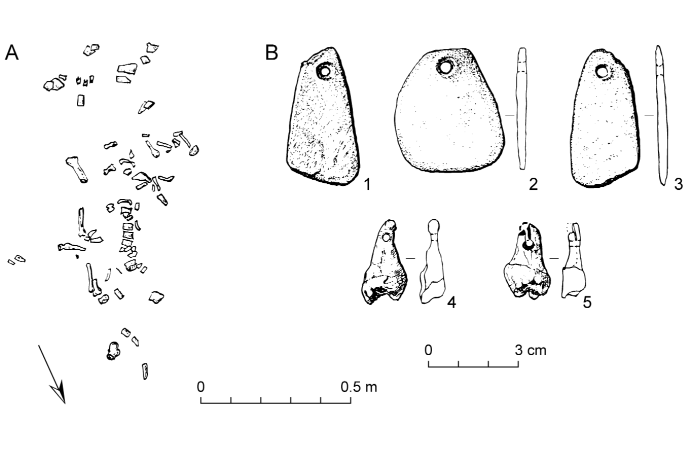

Fig. 10. Sakhtysh IIa. Burial no. 54. A – plan of burial; B – grave goods (1–3 – stone; 4, 5 – animal tooth) (after* Kostyleva, Utkin 2010. Fig. 62. 4–9*).

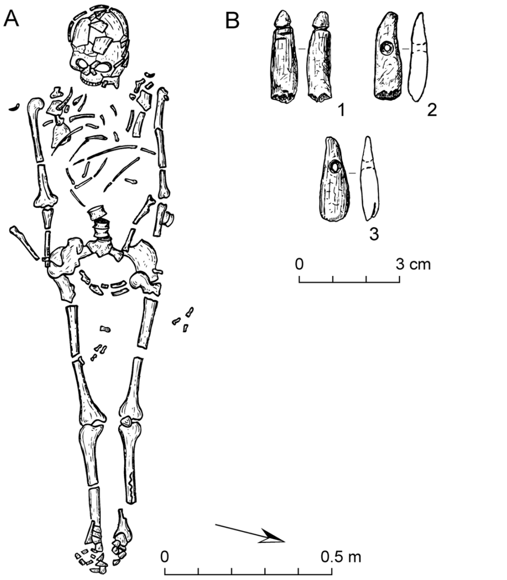

Fig. 11. Sakhtysh IIa. Burial no. 66. A – plan of burial; B – grave goods (animal tooth) (after* Kostyleva, Utkin 2010.Fig. 64.4–7*).

within each funerary community did not differ very much.

That significant reservoir ages can be expected in the radiocarbon dates of human individuals from this period is also suggested by results from the Stone Age cemetery of Minino at Lake Kubeno approx. 300km north of Sakhtysh. At this site, paired samples of human remains and animal bone grave goods have been radiocarbon dated from Neolithic graves (*Kostyleva, Utkin 2012.238*). In most cases the human bone yielded much earlier results than the bones of herbivores and the age offset varies between *c.* 350 and 650 years (*Wood* et al. *2013*) with an average of *c.* 490 years. The animal bone samples suggest a dating of the graves to the turn of the 6th to the 5th millennium calBC.[3] The substantial reservoir effects are comparable to those observed in the hunter-fisher population at Ostorf, northern Germany, which has been described above. Unfortunately, it is not yet possible to see a correlation between the isotope values and the age offset. In Minino the reservoir age seems to be similar in cases where the carbon and nitrogen stable isotope values are rather different (*Wood* et al. *2013; Olsen* et al. *2010*).

Lyalovo graves

If we assume that the new AMS dates are the more reliable results, then burials no. 40 and 61 of the Lyalovo phase are now dated to the third quarter of the 6th millennium calBC. According to the established chronological framework, based on radiocarbon dates from various contexts and materials, the Lyalovo culture is subdivided into the four phases (archaic, early, developed, late), the first two of them being relevant for the discussion of the early Lyalovo graves of Sakhtysh IIa (*Zaretskaya, Kostyleva 2010*). In this scheme, the archaic phase is assigned to a time frame of 6200–5900 bp (*c.* 5220–4730 calBC) and the early phase to the period of 5900–5600 bp (*c.* 4790–4370 calBC). Of the five dates older than 6000 bp, however, three stem from Sakhtysh IIa burials. Dates of terrestrial samples securely associated with archaic Lyalovo cultural layers start at 6100 bp (*c.* 5030 calBC) (*Zaretskaya, Kostyleva 2010.Tab. 1*).

Therefore, the two new AMS dates for the burials of the early part of Lyalovo culture from Sakhtysh IIa appear 200 to 400 years too old compared to the onset of the Lyalovo culture, and three of the four conventional dates of the graves cover the very beginning of its archaic phase. The most likely explanation for these very or too early ages within the chronological framework is a freshwater reservoir effect

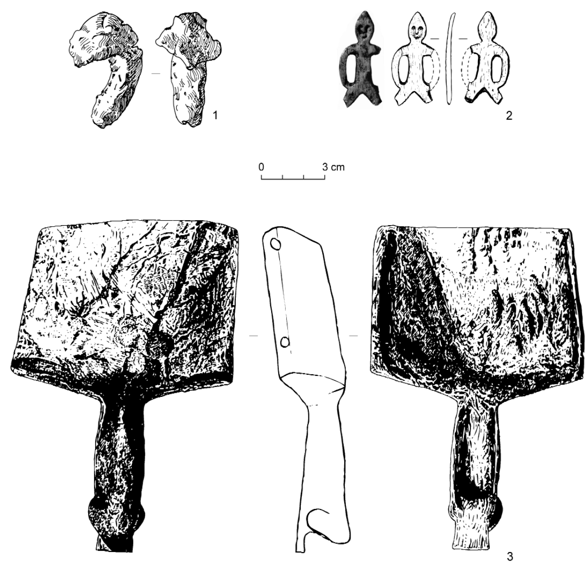

Fig. 12. Sakhtysh IIa. Anthropomorphic images. 1 – Embryo-shaped clay figurine from Lyalovo burial no. 65; 2 – anthropomorphic bone pendant from Volosovo burial no. 58; 3 – elk antler mask with life-size human facial features from Volosovo sanctuary (after* Kostyleva, Utkin 2010.1, Fig. 43.4, 2, Fig. 63.3; 3, Fig. 69*).

3 In grave no. 4, the results were 6590±50 bp (AAR-5789; 5618–5479 calBC at 95.4% probability) for the human and 6165±45 bp (AAR-5788; 5286–4988 calBC at 95.4% probability) for the animal sample; in grave no. 14 the human bone gave an age of 6680±50 (AAR-5787; 5706–5511 calBC at 95.4% probability) and the animal bone an age of 6140±50 bp (AAR-5790; 5217–4947 calBC at 95.4% probability).

(see above). As the archaeological situation at Sakhtysh IIa does not suggest a particularly early chronological position of the graves within the early part of the Lyalovo culture – the burial pits were cut from the Lyalovo cultural layer which had already had some time to accumulate – rather substantial reservoir offsets of 500 years seem possible. To reliably identify and quantify the reservoir ages of the human remains, paired dates of human bone and terrestrial animal bone from the same burials are necessary.

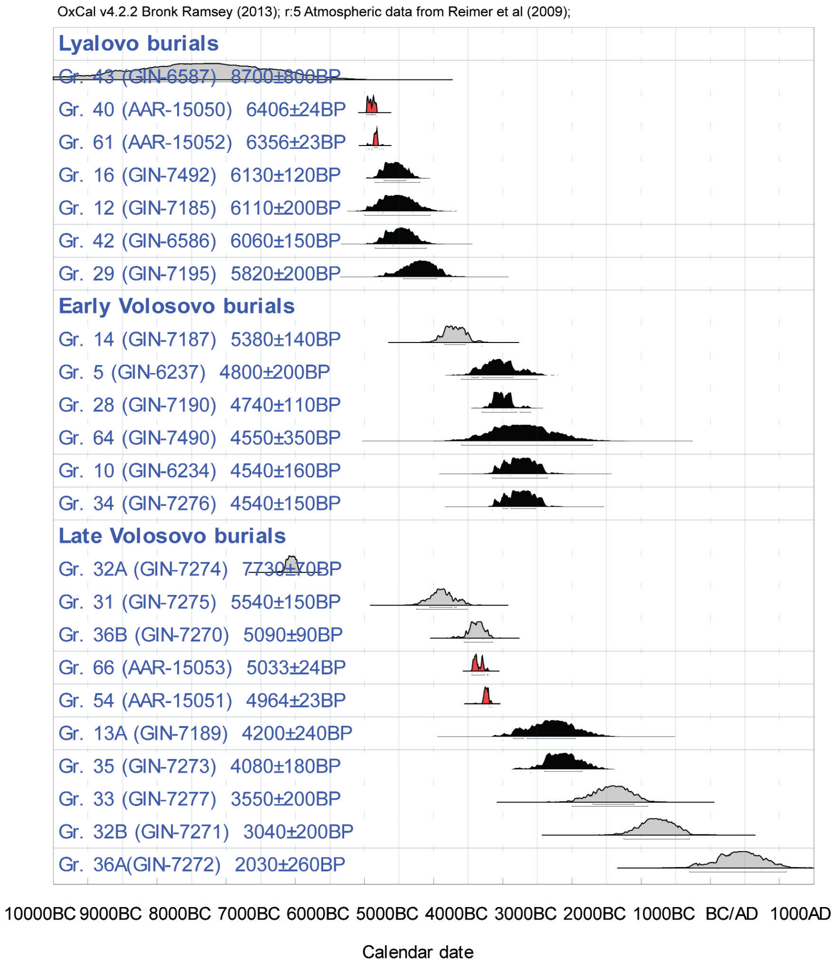

Fig. 13. Sakhtysh IIa. Radiocarbon dating results. Red – AMS dates; black – conventional radiocarbon dates (regarded as reliable on archaeological grounds by Kostyleva, Utkin 2010*); grey – conventional radiocarbon dates (regarded as unreliable on archaeological grounds by* Kostyleva, Utkin 2010*).*

Volosovo graves

The absolute chronology of a three-phase model for burial customs in the Late Neolithic/Early Metal Age Volosovo culture is based almost exclusively on conventional radiocarbon dates from Sakhtysh IIa (*Kostyleva, Utkin 2008a.233*) (Tab. 1, Fig. 13). The earliest group is supposed to range from 4750–4500 BP (*c.* 3630–3100 calBC), the second group dates between 4250–4000 BP (*c.* 2900–2480 calBC), and the youngest group, which is not represented at Sakhtysh IIa, is thought to have existed between 4000–3750 BP (*c.* 2570–2140 calBC). However, due to sometimes problematic conventional dates of the Sakhtysh IIa burials (Fig. 13), this chronological framework cannot be regarded as entirely reliable.

On archaeological grounds, the two AMS-dated graves, No. 54 and 66, have been assigned to the second phase of the Volosovo culture cemetery. The dates, however, fall into the first half of the 4th millennium calBC and are somewhat older than the conventional dates of the early Volosovo phase at Sakhtysh IIa; the divergence from the two accepted conventional dates of the younger phase accounts to *c.* 750–1000 radiocarbon years. Therefore, the AMS dates either put a question mark on the association of the AMS-dated graves with the younger phase, or they even challenge the subdivision of the Volosovo graves at Sakhtysh IIa into two chronological phases. At the same time, freshwater reservoir effects of approx. 500 years have to be expected for the radiocarbon dates of the Volosovo human remains, as the stable isotopes of the two analysed samples indicate a high freshwater-derived protein component in the diet equal to that of the Lyalovo samples.

In conclusion, the archaeometric analyses of four human bone samples from Sakhtysh IIa have yielded new information both on the chronology of the cemetery and on the diet and economy of the buried population. The presence of two distinct chronological phases (Lyalovo and Volosovo) was able to be confirmed, while the details of sub-division of the Volosovo phase into two sub-phases are now put into question, and only the early sub-phase has been confirmed by the AMS dates. Analysis of the stable carbon and nitrogen isotope ratios in the samples suggests a high freshwater protein component in the diet both of the Lyalovo and Volosovo individuals. Together with the observation that the radiocarbon dates of the Sakhtysh graves appear altogether too old compared to the established chronological frameworks, these findings suggest considerable reservoir ages of about 500 years in the dating results of the human samples due to freshwater reservoir effects.

The important role that freshwater resources played in the life and subsistence of the Stone and Early Metal Age population of the Upper Volga region is confirmed by a range of archaeological findings and other indicators. In the Mesolithic Butovo and the Early Neolithic Upper Volga cultures, the importance of fishing in the economy is attested to by the choice of settlement places on the banks of lakes and rivers and also by archaeological and faunal materials (*Krainov 1996.171; Zhilin 2006*). The sites of the Lyalovo culture of the Middle and Late Neolithic yielded numerous remains of fishing gear and constructions, as well as large quantities of fish bones and scales, and it is presumed that fishing had become the most important subsistence strategy for providing daily nutrition (*Gurina, Krainov 1996.180*). For the Volosovo culture, even ceramic technology shows the prominent position of aquatic resources in everyday life: molluscs and fishbones but also feathers of aquatic birds, were frequently used as tempering material (*Petrova 2008*).

Future perspectives

First results on human bone from the Sakhtysh IIa cemetery illustrate the important role of modern archaeometric methods for the study of Stone Age burial sites and the lifestyle in the Eastern European forest zone.

The new dating and isotopic results show clearly that radiocarbon dates derived from Stone and Early Metal Age human remains from this region must be interpreted with caution because of reservoir ages and should by no means be regarded as true ages on which a reliable absolute chronology can be built. A central future task will therefore be the production of paired dates on human remains and terrestrial animal bone from closed grave contexts in order to more precisely judge the presence and also the degree of possible reservoir ages in the radiocarbon dates.

The determination of stable carbon and nitrogen isotopes in further archaeological samples will shed light on developments in the diet of individuals and groups over the course of time, and on the basis of this information, continuities and changes in subsistence strategy and economy can be traced. The chronological range should be extended to younger periods (Bronze Age, Iron Age) to identify fundamental innovations such as the transition to agriculture and animal husbandry. Of crucial importance will be the determination of isotope ratios in local animal and plant species from various habitats in order to build up a better reference data base to interpret the respective isotope values in humans.

ACKNOWLEDGEMENTS

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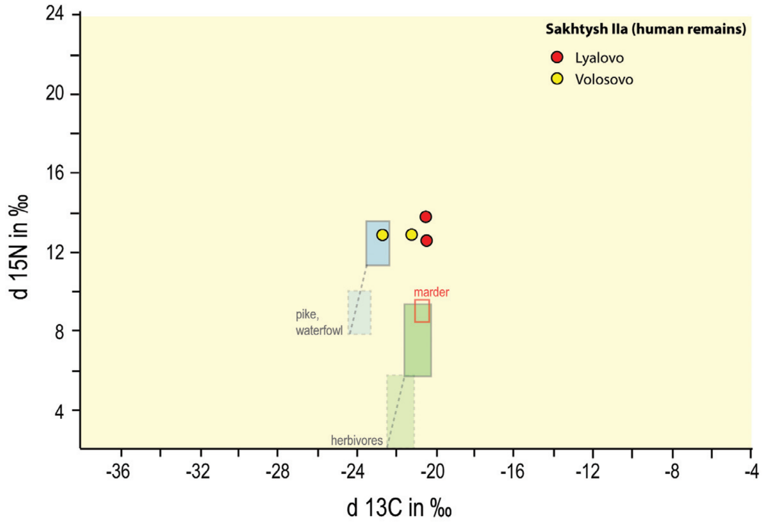


Fig. 14. Carbon and nitrogen isotope values of the Sakhtysh IIa humans against the background of isotope ranges of animals from the mixed cultural layer at Minino, north-west Russia (light-shaded boxes) depicted together with the ranges of their consumers (dark-shaded boxes) after a standard trophic level shift of 1‰ for δ13C and 3.5 ‰ for δ15N. Isotope range of marten is depicted separately (red frame) (Minino isotope ranges: after* Wood *et al.* 2013*).

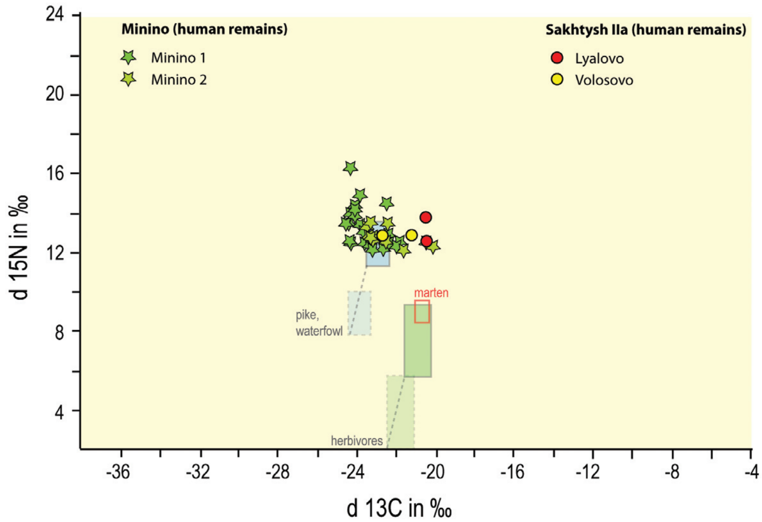


Fig. 15. Carbon and nitrogen isotope values of the Sakhtysh IIa humans and humans from Minino 1 and 2, against the background of isotope ranges of animals from the mixed cultural layer at Minino, north-west Russia (light-shaded boxes) depicted together with the ranges of their consumers (dark-shaded boxes) after a standard trophic level shift of 1‰ for δ13C and 3.5 ‰ for δ15N. Isotope range of marten is depicted separately (red frame) (Minino isotope ranges: after* Wood *et al.* 2013*).

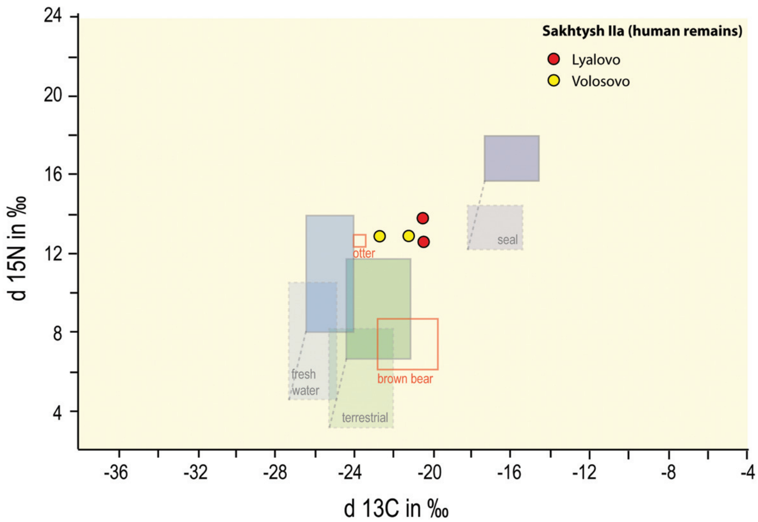


Fig. 16. Carbon and nitrogen isotope values of the Sakhtysh IIa humans against the background of isotope ranges of animals from Zvejnieki, Latvia (light-shaded boxes) depicted together with the ranges of their consumers (dark-shaded boxes) after a standard trophic level shift of 1‰ for δ13C and 3.5 ‰ for δ15N. Isotope ranges of brown bear and otter are depicted separately (red frames) (Zvejnieki isotope ranges: after* Eriksson 2006*).

Fig. 17. Carbon and nitrogen isotope values of the Sakhtysh IIa humans and humans from Zvejnieki, Latvia, against the background of isotope ranges of animals from Zvejnieki (light-shaded boxes) depicted together with the ranges of their consumers (dark-shaded boxes) after a standard trophic level shift of 1‰ for δ¹³C and 3.5 ‰ for δ¹⁵N. Isotope ranges of brown bear and otter are depicted separately (red frames) (Zvejnieki isotopic ranges and values: after Eriksson 2006*).*

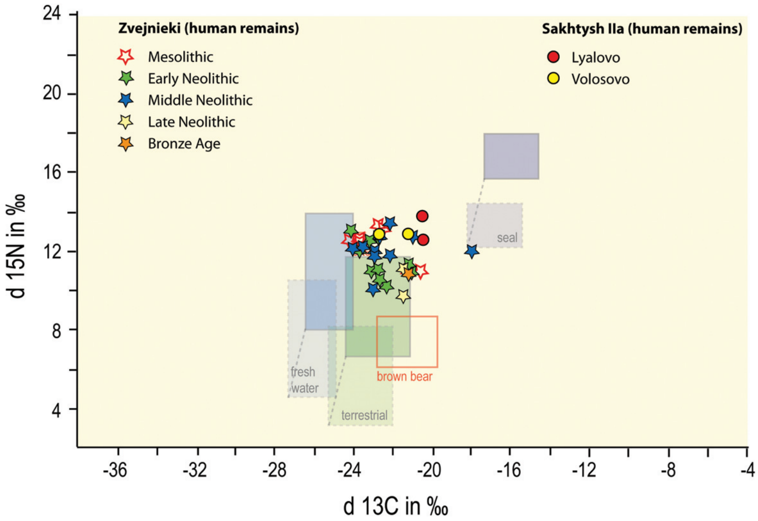


Fig. 18. Carbon and nitrogen isotope values of the Sakhtysh IIa humans against the background of isotope ranges of animals from Denmark (light-shaded boxes) depicted together with the ranges of their consumers (dark-shaded boxes) after a standard trophic level shift of 1‰ for δ¹³C and 3.5 ‰ for δ¹⁵N (Danish faunal isotopic ranges: after Fischer *et al.* 2007*).*

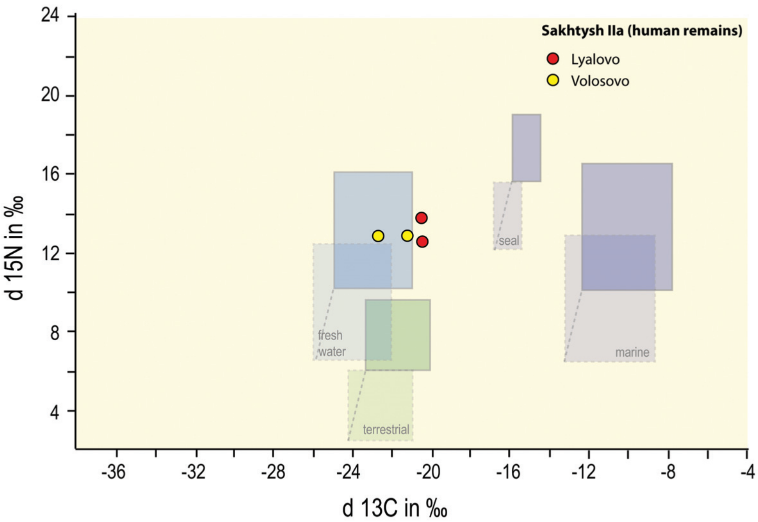
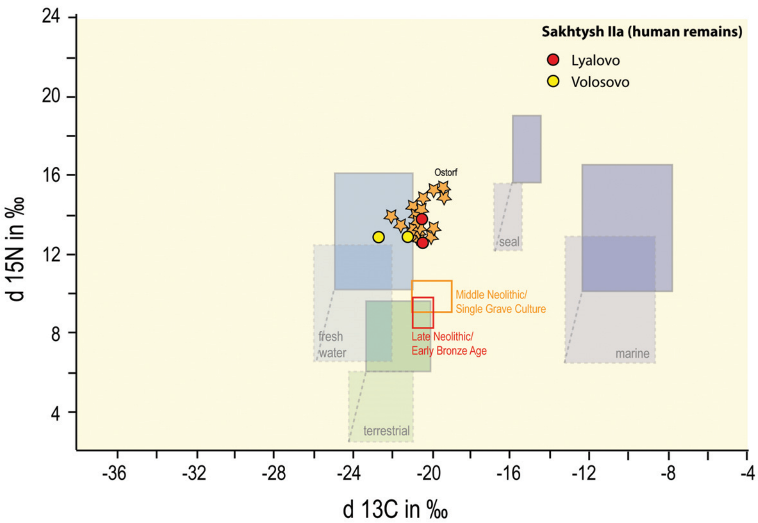


Fig. 19. Carbon and nitrogen isotope values of the Sakhtysh IIa humans and humans from Ostorf, Germany (orange stars) and isotope ranges of Middle Neolithic (orange frame) and Late Neolithic/Bronze Age (red frame) human remains from German sites, against the background of isotope ranges of animals from Denmark (light-shaded boxes) depicted together with the ranges of their consumers (dark-shaded boxes) after a standard trophic level shift of 1‰ for δ¹³C and 3.5 ‰ for δ¹⁵N (Ostorf human isotope values: after Olsen, Heinemeier 2007*; German Neolithic and Bronze Age isotope ranges: unpublished, publication by* Terberger *et al.* in preparation*; Danish faunal isotope ranges: after* Fischer *et al.* 2007*).*



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The bioarchaeology of the Neolithic transition: evidence of dental pathologies at Lepenski Vir (Serbia)

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ABSTRACT – *The Neolithic transition affected human biology, which is visible as a series of interrelated skeletal and dental pathological conditions. The population of Lepenski vir culture, which inhabited the region of the Danube Gorges between 9500–5500 BC, also went through the neolithisation process. In this study, the dental pathological conditions of 32 adult individuals from the Lepenski Vir site were examined for the incidence of enamel hypoplasia, the rate of dental wear, dental caries and ante-mortem tooth loss. The results indicate changes in biology and diet of this population in the Neolithic which were associated with the introduction of non-local identities in the region.*

IZVLEČEK – *Prehod v neolitik je vplival na človeško biologijo, kar prepoznamo kot serijo med seboj povezanih skeletnih in zobnih patologij. Prebivalci kulture Lepenski Vir, ki so poseljevali območje soteske Džerdap med 9500 – 5500 BC, so bili prav tako priča procesu neolitizacije. V članku predstavljava analizo zobnih patologij na 32 odraslih posameznikih iz Lepenskega Vira, na katerih sva iskali sledi hipoplazije sklenine, stopnjo obrabe zob in izgubo zob pred smrtjo. Rezultati kažejo na spremembe v biologiji in prehrani tega prebivalstva v neolitiku, kar se povezuje z uvedbo ne-lokalnih identitet na to območje.*

KEY WORDS – *neolithisation; human biology; dental pathology; Lepenski Vir; the Danube Gorges*

Introduction

The term Neolithic transition refers to the major changes in lifestyle of communities. The stabilisation of these changes includes the transition from hunter-gatherer lifestyles to agricultural production in the Holocene. The Neolithic transition presents the beginning of human control of the reproduction and evolution of plants and animals (*Childe 1936*). Rather than adapt to the natural environment, people became the drivers of changes that adapted the environment to their own needs. Considerable effort in researching these processes has been made to understand the consequences of the emergence of agriculture and their impact on human health. Some authors (*Cohen, Armelagos 1984; Cohen 1989*) argue that a shift from a varied diet secured by hunting and gathering to the monotonous diet based on complex carbohydrates can have a range of adverse effects on human health, reflected in deficiencies in diet and dental caries. According to these authors, a sedentary lifestyle in permanent or semi-permanent settlements and in proximity of domestic animals leads to poor hygiene conditions and the increased prevalence of zoonotic diseases. These theories lead to a paradox in interpreting the significance of the Neolithic transition for the evolution of humans. If cultivation and domestication led to population growth, how can we explain these negative paleopathological patterns? Is there a trade-off between reproductive capacity and health (*Stock, Pinhasi 2011. 3*)? The answers to these questions lie in studying the Neolithic transition in different regions, because this process did not occur uniformly throughout Europe and was characterised by a number of regional variations.

Several archaeological sites critical for understanding the transition between the Mesolithic and Neolithic in southeastern Europe have been discovered in

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the Danube Gorges between Serbia and Romania during rescue excavations in the 1960s. In particular, several preserved burial sites (Vlasac, Lepenski Vir, Padina and Hajdučka Vodenica), containing around 500 individual skeletal remains and dated to around 9500 to 5500 BC, offer a unique opportunity to examine the ways of life and death of these communities. Through an analysis of dental remains, this paper discusses changes in health status and diet throughout the neolithisation period, as well as questions of local versus non-local identities. A single site in particular, Lepenski Vir, was the basis for this research. This study concludes that dental evidence suggests relatively good health of these communities in contrast to other populations in the forager-farmer transition. The results also indicate that changes in the biology of this population led to an improvement in general health, although these changes were not the same for females and males.

Materials

The Danube Gorges is a magnificent gorge system in the Danube River where it exits from the Hungarian plain. This whole area is characterised by a special microclimate different from surrounding areas (*Mišić* et al. *1969.210*): the location, altitude, configuration of the terrain and bedrock protected this area from harsh climatic fluctuations during the Pleistocene. For these reasons, even the biggest drop in temperature during the last ice age did not influence vegetation. Numerous relict species have survived in the Danube Gorges from the Tertiary to the present day. The special climate and geomorphologic characteristics may well have attracted Mesolithic/Neolithic populations to settle in the area. The Lepenski Vir site is located in the second, Upper Gorge, which is an inaccessible area of the Gorges due to the height of the hills (up to 500m) and the narrow width of the Danube, which is only about 200m.

Based on 300 radiocarbon measurements from 14 Mesolithic and Neolithic sites in the Gorges, 83 AMS dates have been established from human bones, with 67 dates obtained from the key site of Lepenski Vir (*Borić 2008; Borić, Price 2013*). These dates reveal a long duration of the Mesolithic (*c.* 9400–7400 calBC). The early dates are grouped into two distinct periods, which may indicate two different stages in the framework of the two millennia, but without continuity of settlement. However, the possibility remains that there were many more episodes of occupation not presented with these dates. The phase with trapezoidal buildings probably began *c.* 6200 calBC, and most of the buildings had been abandoned by about 5950 calBC, making this phase in the Danube Gorges entirely contemporary with early Neolithic sites in the Morava, middle Danube and Tisza valleys (*Whittle* et al. *2002*) In this paper, this phase will be termed the Mesolithic/Neolithic transformation phase in the Early Neolithic chronological span. This terminology has been proposed by Dušan Borić, who claims that this is the most appropriate term for this key period of the Lepenski Vir culture (*Borić 2008.17*). Remarkable art in the form of sculpted boulders and innovative architectural features such as the trapezoidal buildings floors found at the site of Lepenski Vir are attributed to this phase. Early Neolithic pottery, polished stone axes, Neolithic types of osseous tool were found associated with trapezoidal buildings at this site. Furthermore, strontium isotope ratios indicate a dramatic increase in the number of non-local, first-generation migrants buried in this region, of which five were buried at Lepenski Vir (*Borić, Price 2013*). On the other hand, lack of domestic animals (with the exception of dogs) and extended supine burials remained as indigenous elements in the material culture of this phase. The period after 5950 calBC is a period of significant change in the lifestyle of these people: a change in mortuary practice (first flexed inhumations appear) and in subsistence (the first domesticated animals appear – goat/sheep, cattle and pigs (*Borić, Dimitrijević 2007.52*), but the trend of increasing numbers of non-local individuals being buried in this region continued, with seven non-locals females buried at the site (*Borić, Price 2013*). During this final Neolithic phase, which ended *c.* 5700 calBC, trapezoidal buildings were abandoned at Lepenski Vir, which had become dominant by the Early/Middle Neolithic pattern of habitation (*Borić 2011*).

Permanent teeth from Lepenski Vir were included in the present study; the material was drawn from the Danube Gorges Anthropological Collection of Laboratory for Bioarchaeology, Belgrade University. Lepenski Vir yielded 134 graves with 190 individuals, in addition to 42 individuals from various unspecified contexts (*Roksandić 1996.78*). Only teeth (500) that could be related to specific individuals were included in this study (Tab. 1). The remains of 32 adults were available (17 males, 13 females and 2 of unidentified sex). Eight of these individuals were dated to the Mesolithic (1♀, 6♂ and one of unidentified sex), 15 to the transformation phase (6♀ and 9♂) and 9 to the Neolithic (7♀, 1♂ and one of unidentified sex). Two individuals in this sample dated to the transformation phase, and five dated to the Neolithic were of non-local origin (*Borić, Price 2013*; Table 2.).

Methods

Four dental parameters were recorded: the prevalence of enamel hypoplasia (LEH) for physiological stress and growth disturbance in childhood; the rate of dental wear for dental use; dental caries and antemortem tooth loss as indices of oral; and general health in relation to diet. Note that a dental calculus was not recorded due to the previous inspection of the sample which showed that a certain amount of this dental plaque had been cleaned after the excavations, which would distort the results. It was not possible to make sex-related observations due to imbalance in the numbers of males and females dating to different periods in the sample: only one female individual is dated to the Mesolithic and one male to the Neolithic.

Enamel hypoplasia is a surface defect of the tooth crown caused by a disturbance in enamel matrix secretion. The prevalence of enamel hypolasia is frequently used to assess the nutritional status and/or the health status of past and present human populations (*Goodman* et al. *1980; Cohen, Armelagos 1984; Larsen 1997; Hilson 2005; Papathanasiou 2005*). Different types of hypopplasia have been identified: pit, plane, furrow, and linear (*Hillson 2005*). Linear enamel hypoplasia (LEH) was analysed in this study. The prevalence of LEH is analysed as an indicator of physiological stress and growth disturbance in the childhood of individuals examined in this study. By measuring the position of LEH defects on the forming tooth crowns, the common age at which these defects began was also estimated. LEH defects were observed on upper and lower incisors and canines by using the macroscopic method of subdividing the tooth crown surface into zones (*Reid, Dean 2000; Hilson 2005.169–176*; Fig. 1). The total number of teeth inspected to estimate LEH defects is 239 (Tab. 1) The prevalence of LEH defects is estimated in diversity over chronology and sex.

Tooth wear is caused by teeth grinding and contact with food, cheeks and tongue. This process begins as soon as the tooth emerges from the gingivae and may occur during chewing, but it also occurs at other times, even during sleep (*Hilson 2005*). The effects of wear are most apparent on the *occlusal* surfaces, where the teeth of the upper and lower jaws meet. The rate of wear may depend on many

	maxilla	mandible
incisors	39	46
canines	127	27
premolars	64	70
molars	94	133
TOTAL	**224**	**276**

Tab. 1. Types of teeth of individuals from Lepenski Vir analysed in the study.

factors: the overall morphology of the crown, developmental defects, the structure of the tooth's hard tissue, the chewing mechanism, diet, and non-feeding behaviours (using the teeth as tools, bruxism *etc.*). In this study, the nature of dental use of the inhabitants of Lepenski Vir was analysed by recording the rate and patterns of tooth wear. Wear rates (degrees) were recorded on a scale of 0–4, using the scoring systems suggested by Smith and Brothwell (*Smith 1983; Brothwell 1981*), where 0 refers to no evidence of wear and the 4th degree denotes the total destruction of the crown by wear. The rates of tooth wear were recorded on lower molars (as the first lower molar is the first permanent tooth to erupt and therefore is exposed for a longer time to

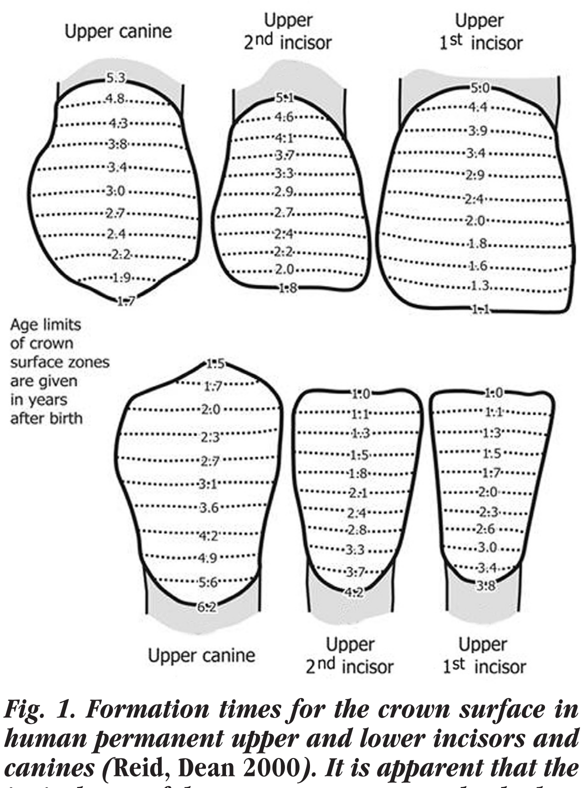

Fig. 1. Formation times for the crown surface in human permanent upper and lower incisors and canines (**Reid, Dean 2000*****). It is apparent that the incisal part of the crowns grows more slowly than the cervical part. The timing of enamel defects is estimated by matching them across the different teeth. Altogether, these tooth crown surfaces provide a sequence from one year after birth, to about six years (redrawn from*** **Hilson 2005.173*****).***

abrasion caused by diet, whereas the third molar is the last tooth to erupt). The number of teeth available in this sample was 133 (Tab. 1). The results are given in chronological and sex diversity in tooth wear patterns.

Dental caries is a slowly progressive dental disease causing decay of the enamel, dentine and cement. The demineralisation of dental caries is caused by organic acids which form during the fermentation of carbohydrates by plaque bacteria. The strongest association is with the proportion of sugars in the diet. The relationship of other carbohydrates, such as starch, with caries is less clear, but they do seem to have a role (*Hilson 2005*). Proteins and fats in the diet do not seem to be involved, although there is some evidence that casein, a protein present in milk products, has a protective effect (*Bowen, Pearson 1993; Mundorff-Shrestha* et al. *1994*). In this study, caries lesions were recorded as defined by Hilson (*Hilson 2005*); a magnifying glass was used for observation. The scoring system records different types of caries lesions: coronal caries, root surface caries and gross caries. These lesions were observed in the whole dentition of individuals from Lepenski Vir (500 teeth in total).

Ante-mortem tooth loss (AMTL) was recorded with the tooth socket both partially and fully healed (*Hilson 1996*). Ante-mortem tooth loss could be caused by numerous factors, such as dental and periodontal diseases, trauma, high rate of attrition *etc*. It has been distinguished from post-mortem tooth loss (the tooth has fallen out of the socket) and congenitally absent teeth (*i.e.* the tooth did not form at all). The calculation of AMTL frequencies was based on the number of absent teeth (per dentition).

Grave	Sex	Age	Dating	Origins
lv 7/I	♂	50–60	T	
lv 7/II	♂	~60	T	non-local
lv 8	♀	50–60	N	non-local
lv 14	♀	30–40	T	
L 17	♀	~15	N	non-local
lv 16	♂	oko 30	T	
lv 20	♀	40–60	N	
lv 21	♀	>25	M	
lv 22	♂	40–60	M	
lv 26	♂	20–25	T	
lv 27d	♂	?	T	
lv 28	♀	~ 40	T	
lv 32a	♀	50-60	N	non-local
lv 37	?	?	N	
lv 47	♂	~25	T	
lv 48	♀	~15	N	
lv 50	♂	35–50	M	
lv 54d	♀	40–50	T	
lv 54e	♀	~20	T	non-local
lv 60	♂	20–30	M	
lv 64	♂	~50	M	
lv 64(1)	?	?	M	
lv 66	♀	~25	N	non-local
lv 69	♂	~60	M	
lv 73	♂	45–60	N	
lv 79b	♂	~30	T	
lv 82	♂	~30	T	
lv 88	♀	~35	N	non-local
lv 91	♂	30–40	T	
lv 93	♀	~ 30	T	
lv 105	♂	35–40	M	
lv 122	♀	15–18	T	non-local

Tab. 2. Structure of the sample: lv – Lepenski Vir; M – Mesolithic; T – transformational phase; N – Neolithic.

Results

Linear enamel hypoplasia

The prevalence of linear enamel hypoplasia (LEH) in the teeth of the inhabitants of Lepenski Vir varies from moderate during the Mesolithic and transformation period to relatively low during the Neolithic (Fig. 2). Differences between males and females in the prevalence of LEH were not observable (as the sample included only one female dated to the Mesolithic, and one male dated to the Neolithic). During the Mesolithic, 36.8% of teeth were affected by LEH defects (14/38); in the transformation phase 33.3% of teeth were affected by LEH defects (16/48). An evident decline in the prevalence of LEH with 15.5% of affected teeth (9/58) is recorded in individuals dating to the Neolithic The common individual age at which most LEH defects began was between 2 and 5 years (Fig. 3). Only three LEH defects were recorded as beginning at the age of 6 years (all of them belonged to individuals in the transformation phase). The number of LEH defects (multiple lines per tooth) was highest in individuals dated to the transformation phase. No individuals with single crisis episodes were recorded.

Tooth wear

The analysis of tooth wear showed a high degree of tooth wear in each period. The average wear for all the teeth inspected (lower left and right molars) is slightly higher in the transformation phase than in the Mesolithic and Neolithic (Tab. 3). This trend is more marked on first and second molars (both side), with the exception of right third molars, which are the least worn teeth in the transformation phase compared to the other two periods. The highest rate of wear was recorded in the first molars on each side in each period. A certain degree of asymmetry in the rate of tooth wear in the left and right sides of the dentitions was recorded only in individuals dated to the Neolithic.

Dental caries

The most common pathological condition in archeological samples, dental caries, was infrequent among the inhabitants of Lepenski Vir. Of 500 inspected teeth, only 7 were affected by dental caries (1.4%), two premolars and five molars. When analysed by jaw, similar results were obtained: in maxillary teeth, the caries rate was 1.3% (3/224), and 1.4% (4/276) in mandible teeth. We recorded two caries lesions on occlusal surfaces and five on root surfaces; no evidence of gross caries was found.

When analysed as groups of individuals dated to three different periods and by individual teeth, significant differences appear. No caries were detected among the individuals dated to the Mesolithic. One female individual dated to the transformation phase showed evidence of caries (Lepenski Vir, grave 47) and two females dated to the Neolithic (Lepenski Vir, graves 32a and 88). The two females dated to the Neolithic were individuals of non-local origin (*Borić, Price 2013*).

Ante-mortem tooth loss

Ante-mortem tooth loss (AMTL) among the inhabitants of Lepenski Vir is infrequent: 1.5% (8/524) of all missing teeth is lost before death (antemortem). Similar results were obtained for maxilary teeth – 1.7% (5/288), and mandibles 1.2% (3/236). AMTL was observed only in individuals dated to the Neolithic, one male and four females (Lepenski Vir, graves

Side	Mesolithic	Transformations	Neolithic
Left			
M1	2,7	2,9	2,6
M2	1,7	2,2	1,7
M3	1,5	1,5	1,7
Right			
M1	2,6	2,8	2,4
M2	1,8	2,3	1,7
M3	1,4	1	2

Tab. 3. Average rate of tooth wear (scored 0–4) by tooth and period.

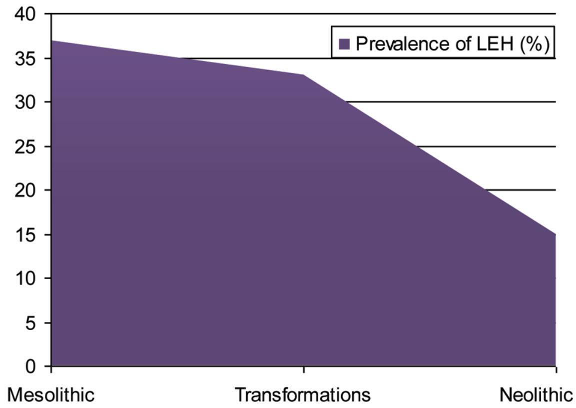

Fig. 2. Prevalence of linear enamel hypoplasia in the teeth of inhabitants of Lepenski Vir (results given in % of affected teeth).

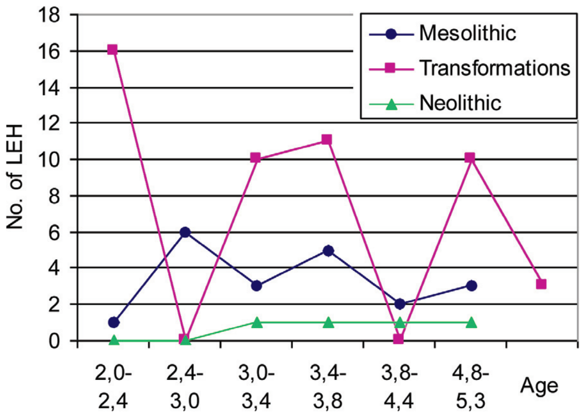

Fig. 3. Number of LEH defects in relation to individuals' age when defects appeared in the Mesolithic, transformation phase and Neolithic at Lepenski Vir.

7/I, 20, 83A, 32a and 88). Three of the females with AMTL were of non-local origin (*Borić, Price 2013*).

Disscusion

Recording the incidence and severity of enamel hypoplasia is a standard procedure in physical anthropology (*Buikstra, Ubelaker 1994; Hilson 1996; Larsen 1997*), and enamel hypoplasia has been widely used to assess stress levels in past and present humans. LEH frequencies can be used to obtain information on health, nutritional status, and periods of transition in subsistence and changes in environmental conditions among both individuals and populations. Because LEH is a non-specific stress marker, the precise nature of a stressful event leading to its formation cannot be deduced from this kind of analysis. But what can be traced are models of stress events through time in an observed population, the number of stress episodes and an individual's age when these stress events occurred. The results of the present study demonstrate a reduction in systematic childhood stress from the Mesolithic to the Neolithic in this population. Hypoplasia is recorded as most frequent in the Mesolithic. During the transformation phase, the level of childhood stress decreased very slightly, but the severity of individuals' stress increased according to the number of lines observed per single tooth (Fig. 4). An evident reduction in childhood stress events was recorded for the Neolithic. These results imply that during the Mesolithic and transformation phase, the period of childhood, which is anyway a sensitive period, was worse due to living conditions (*i.e.* no solid houses, hunting and gathering as relatively insecure means of food supply *etc.*). The most age at which most of these stress events occurred was between 2 and 5 years, which could be related to weaning stress.

The association between subsistence and diet in correlation with the rate of tooth wear has been studied around the world in various populations (*Anderson 1965; Molnar 1971; Scott 1979; Smith 1984; Eshed* et al. *2006*). All these studies concluded that tooth wear and wear patterns could be used to reconstruct a population's behaviour and diet. The degree of tooth wear in the teeth of Lepenski Vir inhabitants was high in all periods, which suggests no significant changes occurred in the of type of food consumed or the method of food preparation. Since sand tends to grind down teeth surfaces, as described in studies of prehistoric fishing communities on the coast of California (*Jurmain 1990*), it is not surprising we found marked teeth wear at this site located on a sandy shore. It is also believed that the ingestion of fish, particularly dried fish, encourages a higher rate of tooth wear, as seen in Eskimo groups (*Elvery* et al. *1998*). The Lepenski Vir site is known for its high quantities of fish bones, probably processed by the inhabitants for consumption. The two factors that led to a high rate of tooth wear in this coastal population were sand and dried fish were the same in each period (the Mesolithic, transformation, the Neolithic). The asymmetry of tooth wear rates in the left and right side of the dentitions recorded only in individuals dated to the Neolithic suggests the possible use of teeth in paramasticatory behaviours (Fig. 5). This hypothesis is confirmed by an analysis of non-masticatory traits in this population (*Radović in preparation*), which shows that the inhabitants of Lepenski Vir used their teeth as tools, especially after the Mesolithic.

Although there were no significant differences in tooth wear rates among the inhabitants of Lepenski

Fig. 4. Burial 50, Lepenski Vir (Early Mesolithic) – multiple LEH defects on upper incisors.

Vir, there was a difference in the appearance of dental caries. Dental caries was detected in the teeth of only three individuals (one female dated to the transformation phase and two non-local women dated to the Neolithic) (Fig. 6). But the incidence of caries nevertheless remains very low. Low rates of caries correlate with a low carbohydrate diet, while high levels of proteins and fat are thought to inhibit caries. A diet not rich in carbohydrates and abrasive food (causing high rates of tooth wear) probably inhibited the development of caries in these people. Average frequencies of teeth affected by caries based on a global population study were reported by Turner (*1979*): 1.7% for forager populations, 4.8% for mixed foraging/farming, and 8.6% for fully agricultural populations. According to these facts, even during the Neolithic the population of Lepenski Vir still depended on foraging – the incidence of caries is no higher than 1.4%, suggesting low levels of carbohydrates in the diet. As a global phenomenon, the dramatic increase in caries rates (>15%) was due to the level of sugar products and products high in carbohydrates, including sticky textures, that were included in the diet (*Hilson 1979; Sreebny 1983; Kashekt* et al. *1994; Larsen 1995*). In the Neolithic of Lepenski Vir, this phenomenon was not observed and remains below Turner's average frequencies of teeth affected by caries (4.8%) for mixed economies (agriculture + foraging) (*Turner 1979*). Furthermore, caries lesions in Neolithic individuals are detected only among females of non-local origin, which implies that the intake of more carbohydrates could have been related to earlier periods in their lives (and therefore a different subsistence in their places of origin). The analysis of $\delta^{15}N$ for these two non-local women showed values below 12.0‰ (*Bonsall* et al. *1997*), which indicates a diet based predominantly on terrestrial, or at least combined terrestrial + aquatic, sources. These values of $\delta^{15}N$ are

Fig. 5. Burial 31, Lepenski Vir (Early Neolithic) – approximal groove on tooth 37.

Fig. 6. Burial 32a, Lepenski Vir (Early Neolithic) – caries of root surface in first upper molar.

significantly lower than the values of $\delta^{15}N$ in individuals from the Mesolithic at Lepenski vir, whose diet was based on aquatic proteins. Evidence of caries in the teeth of these two Neolithic women combined with different dietary patterns indicated by the $\delta^{15}N$ values probably correlates with their non-local origin.

The lack of evidence of ante-mortem tooth loss in individuals dated to the Mesolithic and transformation is in accordance with the absence or low rate of dental caries as one of the major factors associated with tooth loss (*Hillson 1986; Armelagos, Rose 1972; Cook 1984; Luckas 1992*). Among the Neolithic people, AMTL was detected in seven individuals, only two of whom had teeth affected by caries (graves 32A and 88). The relatively frequent incidence of AMTL in these people can be attributed to the use of teeth as tools (*Radović in preparation*).

Conclusions

To summarise, the incidence of linear enamel hypoplasia demonstrates a reduction in systematic childhood stress from the Mesolithic to the Neolithic in this population. These results imply possible changes in living conditions that were more suitable for the inhabitants of Lepenski Vir, especially during the Neolithic. The common age at which most stress events began was between 2 and 5 years, which may have been related to weaning stress. On the other hand, the high rate of tooth wear and low rate of caries (with an absence of caries in the Mesolithic) characteristic for this population, suggests a diet poor in carbohydrates and rich in protein and fat. The incidence of caries can be related to the appearance of non-local individuals in this region. These results also imply that there were no major changes in the food production of this community. A combined terrestrial/fresh water diet and the use of teeth as tools are probably the main reasons for high wear rates in this population.

The results of the present study show that there were no dramatic changes in the biology of the inhabitants of Lepenski Vir over a long period (9500– *c.* 5950 calBC). Protein remained the staple of the diet, but a reduction in childhood stress, the appearance of dental pathologies and increased activities involving teeth as tools after the Mesolithic suggest a certain level of adaptation to the new life style which was brought to the region by the Balkans' earliest farming and stock-breeding communities.

ACKNOWLEDGEMENTS

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Lactase persistence and milk consumption in Europe: an interdisciplinary approach involving genetics and archaeology

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ABSTRACT – *The ability to digest milk during adulthood (lactase persistence) is a genetically determined trait present only in humans. Its origin and diffusion are correlated with the development of pastoralism and the consumption of fresh milk. This work will present the genetic and archaeological data that allow the reconstruction of the co-evolutionary process between dairying culture and lactase persistence, as well as a discussion of the chronology and the way lactase persistence spread in Europe.*

IZVLEČEK – *Sposobnost presnavljanja mleka v odrasli dobi (laktazna persistenca) je genetsko pogojena značilnost, navzoča le pri ljudeh. Njen izvor in razširitev sta povezana z razvojem pastirstva in uživanjem svežega mleka. V članku predstavljamo genetske in arheološke podatke, ki nam omogočajo rekonstrukcijo koevolucijskih procesov med mlečno-gospodarskimi kulturami in laktazno persistenco, poleg tega pa komentiramo kronologijo in način, kako se je laktazna persistenca širila v Evropo.*

KEY WORDS – *lactase persistence; gene-culture coevolution; European Neolithic; genetics; dairying*

Introduction

Mammals have the ability to digest lactose – the main sugar contained in milk – only until weaning is over. After that, there is a significant reduction in the production of lactase, the enzyme that allows the absorption of lactose. In humans, however, at least four genetic mutations have been associated with the production of lactase into adulthood (lactase persistence). The frequency of lactase persistent individuals varies significantly between and within continents, and in some cases even between neighbouring regions. In Europe the distribution of lactase persistent individuals follows a cline showing lower frequencies in the south, and higher frequencies, reaching as much as 98%, in the north.

The study of ancient DNA shows that the lactase persistence associated variant was absent or present in very low frequencies in most regions before and during the Neolithic (*Burger* et al. *2007; Lacan* et al. *2011; Malmström* et al. *2009; Plantinga* et al. *2012*). This result suggests that, before the beginning of animal husbandry, the European population was not able to drink milk during adulthood without suffering from very unpleasant and sometimes deleterious symptoms. After the domestication of cattle, sheep and goats, milk became available as a source of nutrition for adults, and the frequency of the lactase persistence-associated mutation increased rapidly in the population, reaching the present-day rates.

The origin and spread of lactase persistence is a very complex process that, to be understood well, must be considered within its archaeological, genetic and social context (*Gerbault* et al. *2011; Leonardi* et al. *2012*).

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Genetics

The digestion of milk

Lactose is a disaccharide sugar that can be found in different percentages in the milk of almost all mammals apart from the platypus and some marine mammals (*Reich, Arnould 2007*). Lactose cannot be digested in its disaccharide form; to be assimilated, it has to be hydrolysed and separated into two monosaccharide sugars (glucose and galactose). This is performed in the mammal intestine with the enzyme lactase (lactase phlorizin hydrolase or LCT). The production of lactase in the small intestine is usually either already high at birth (*e.g.*, in humans; *Wang* et al. *1994*), or peaks a few days later (*e.g.*, in rodents; *Troelsen 2005*), and remains at more or less the same level until weaning is over, when it decreases significantly.

When this happens, the undigested lactose reaches the colon, where it is fermented by colonic bacteria. The glucose is then fermented involving the production of short chain fatty acids and gases, entailing osmotic effects. The result of this process is the appearance of very unpleasant symptoms such as bloating, chronic flatulence, diarrhoea and abdominal cramps (*Ingram* et al. *2009a*). The severity of symptoms can vary between individuals showing the same levels of lactase production (*Vonk* et al. *2003*), since colonic adaptation can lead to a better capacity to ferment lactose and a reduction in the production of hydrogen by the colonic microbiota (*Szilagyi* et al. *2002*).

In about 35% of adults worldwide, lactase is produced throughout their life, allowing them to drink milk at any age without experiencing any of the above-mentioned ill effects (*Ingram* et al. *2009a*).

The genetics of lactase persistence

Lactase persistence is inherited as a dominant Mendelian trait (*Ferguson, Maxwell 1967; Sahi* et al. *1973; Sahi, Launiala 1977*). A single gene located in chromosome 2, called LTC, codes for lactase. Within the neighbouring MCM6 gene, a region (intron 13) seems to have an enhancer action on the LCT gene (*Fang* et al. *2012; Jensen* et al. *2011; Lewinsky* et al. *2005; Olds* et al. *2011; Olds, Sibley 2003; Troelsen* et al. *2003*). Several different single nucleotide polymorphisms (SNPs) in this region show a strong association with lactase persistence, and their distribution is geographically structured. The first mutation found to be linked to this trait is a cytosine to thymine transition 13 910 nucleotides upstream of the transcription initiation site of the lactase gene (–13 910 C/T) (*Enattah* et al. *2002*). The derived variant at this locus (–13910*T) is associated with lactase persistence throughout Europe (*Anagnostou* et al. *2009; Ingram* et al. *2009a; Itan* et al. *2010; Manco* et al. *2013; Nagy* et al. *2009; Sun* et al. *2007; Torniainen* et al. *2009*), Central Asia (*Heyer* et al. *2011*) and India (*Gallego Romero* et al. *2012*).

However, in Africa –13 910 C/T alone does not explain the observed pattern of lactase persistence distribution, and several other SNPs within the same genetic region appear to be associated with the ability to digest large quantities of raw milk by adults. The same is true of the Middle East and in Tibet (*Al-Abri* et al. *2012; Enattah* et al. *2008; Imtiaz* et al. *2007; Ingram* et al. *2007; Ingram* et al. *2009b; Peng* et al. *2012; Tishkof* et al. *2007*). For this reason, several independent origins for lactase persistence have been proposed (*Enattah* et al. *2008; Ingram* et al. *2007; Peng* et al. *2012; Tishkoff* et al. *2007*).

Lactase persistence in modern worldwide populations

The frequency of lactase persistent individuals varies significantly between geographical regions (*Itan* et al. *2010*). In Eastern Asia and in Native American populations a small percentage of the population is persistent (*Itan* et al. *2010*). In Africa, the distribution is irregular, with frequencies that can reach as much as 92% in pastoralist populations, but can fall as low as 0.02% in non-pastoralist human groups (for a table listing the frequencies in a great number of global populations see http://www.ucl.ac.uk/mace-lab/resources/ glad, partially published in *Itan* et al. *2010*). A similar pattern can be observed in the Arabian Peninsula and in Jordan, with relevant differences between Bedouin and non-Bedouin neighbouring groups (*Al-Abri* et al. *2012; Ingram* et al. *2009a*). In the Indian subcontinent, however, a clinal pattern can be detected, declining from north-west to south-east (*Gallego Romero* et al. *2012; Ingram* et al. *2009a; Itan* et al. *2010*).

Also in Europe, a similar cline with frequencies increasing from south to north can be observed. In the northern part of the continent almost all the sampled individuals are lactase persistent, with frequencies ranging between 96% and 83% in Finland, Denmark, Ireland and the United Kingdom; in the Mediterranean area, the opposite trend can be observed (*Itan* et al. *2010; Manco* et al. *2013*).

Archaeology

Before exploring the origin and spread of lactase persistence in Europe in more detail, it is necessary to consider the cultural and archaeological context related to the beginning of milk consumption in Europe; this will be summarised in the next two sections.

The Mesolithic-Neolithic transition in Europe
The so-called Neolithic revolution marks the transition between a lifestyle based on hunting and gathering to one based on food production through cultivation and animal management and exploitation. The transition from the Palaeolithic-Mesolithic to the Neolithic entailed many different changes, not only related to material culture (*e.g.*, the acquisition of pottery) and knowledge of new skills (*e.g.*, those related to animal and plant domestication) but also to the social structure of the human groups (*e.g.*, sedentism and a different redestribution of wealth).

The first Neolithic cultures seem to have developed around the Fertile Crescent some 12 000 years ago, and then to have spread to neighbouring regions, including Europe, during the following few thousand years (*Flannery 1973*). Two opposite models have been proposed to reconstruct the way in which Neolithic cultures developed and spread in Europe.

The demic diffusion model suggests that the Neolithic culture and lifestyle spread from the Near East into Europe through the migration of farmers/agriculturalists (and possibly domesticates) with no substantial admixture with local hunter-gatherer populations (*Ammerman, Cavalli-Sforza 1984*). On the other hand, ***the cultural diffusion model*** theorises a step-by-step process whereby local Mesolithic groups learnt new skills from neighbouring Neolithic populations, without a replacement of people (*Zvelebil, Zvelebil 1988.574–583*). The more recent studies suggest that a more complex intermediate model involving a succession of migration phases interleaved by local admixture could be a better representation of what actually happened (*Whittle, Cummings 2007*). Genetic data have been used in order to differentiate between the two hypotheses, but the subject is still debated (*Barbujani 2012; Thomas* et al. *2013*).

The pattern of modern non-recombinant diversity in Europe has in some cases been interpreted as supporting the demic diffusion model (*Balaresque* et al. *2010; Barbujani, Bertorelle 2001; Battaglia* et al. *2009; Dupanloup* et al. *2004; Simoni* et al. *2000a; 2000b; Torroni* et al. *2001*) and in others as supporting a major Palaeolithic ancestry for extant lineages (*Pala* et al. *2012; Richards* et al. *2000; Scozzari* et al. *2001; Semino* et al. *2000*).

On the other hand, it must be acknowledged that a rough description of the data can lead to misinterpretation when different hypotheses are not statistically tested through explicit simulations (*Barbujani 2000; Barbujani* et al. *1998; Francois* et al. *2010; Novembre, Stephens 2008; Pinhasi* et al. *2012; Simoni* et al. *2000b*). Simulation studies on this subject have also led to contradictory results (*Barbujani* et al. *1995; Belle* et al. *2006; Chikhi* et al. *1998; Chikhi* et al. *2002; Currat, Excoffier 2005*).

The main problem related to this kind of analysis is that, probably at this stage, even computer simulations are not able to take into account the many different variables that play a role in shaping the genetic patterns of populations (*Pinhasi* et al. *2012*). A very recent article has highlighted some of these difficulties and tends to support a complex model of cultural diffusion affected by range contractions (*Arenas* et al. *2013*).

Ancient DNA can make an important contribution to the solution of this problem (*Pinhasi* et al. *2012*). Several studies have analysed mitochondrial DNA from late hunter-gatherers and/or Early Neolithic samples from different European regions (*Hervella* et al. *2012*): from central Europe (*Bramanti* et al. *2009*), France (even if from a limited number of samples; *Deguilloux* et al. *2011*), Iberia (*Sanchez-Quinto* et al. *2012*) and Scandinavia (*Malmstrom* et al. *2009; Skoglund* et al. *2012*). These studies suggest a local discontinuity with modern European populations. Data from Hungary (*Guba* et al. *2011*) suggest the same pattern, but the chronological attribution of some samples has been questioned (*Banffy* et al. *2012*). In Denmark, on the contrary, continuity with the pre-Neolithic population has been proposed (*Melchior* et al. *2010*).

The role of milk consumption in the Neolithic revolution
Before the Neolithic, milk was available only during the first years of life (*i.e.* breastfeeding); only after the beginning of animal domestication did it become a possible source of nourishment for adults. Lactase persistence, even if already present in some individuals, would have been of no utility until the beginning of the human management of cattle, sheep and

goats. The earliest evidence of milk related animal domestication appear in the Euphrates valley between 10 700 and 10 500 BP, and this is followed by a distribution to Eastern and Central Europe during the following millennia (*Vigne 2011; Zeder 2008*). Domesticated goats and sheep were brought to Europe from the Near East, but for cattle a separate domestication process in Europe would have been possible, although recent simulation studies support a single domestication process in the Middle East (*Bollongino* et al. *2012*).

During the last few decades, there has been a dramatic change in opinion about the importance of milk consumption at the beginning of the Neolithic. The 'Secondary Product Revolution' model has hypothesised that animals were domesticated to exploit so-called primary products, materials made available with the death of the animal (meat, bone, horn, leather *etc.*), and only subsequently was attention directed towards products that can be collected while the animal is alive (wool, milk, labour *etc.*) (*Sherratt 1981*).

However, recent interdisciplinary studies have demonstrated that milk was used from the beginning of animal domestication. Through an analysis of the age and sex ratio in archaeological assemblages of animal bones (*i.e.* kill-off profiles) from the Early Neolithic, it has been possible to show that the exploitation of cattle, sheep and goats was aimed at the production of milk, and not only meat, in both Mediterranean Europe and the Middle East (*Vigne, Helmer 2007; Vigne 2008*).

Moreover, the analysis of organic residues in pottery allows us to recognise whether ceramics were used to ferment milk (*Dudd, Evershed 1998*). Through this method it has been possible to demonstrate that milk exploitation and cheese production started from the beginning of the Neolithic both in the Middle East and in Europe (*Copley* et al. *2005; Craig* et al. *2005; Craig* et al. *2005; Evershed 2008; Salque* et al. *2013*).

The origins of lactase persistence in Europe

The mutation associated with lactase persistence in Europe (–13 910*T) is relatively recent. Estimates based on the method of long-range haplotype conservation suggest its origin between 2188 and 20 650 years ago (*Bersaglieri* et al. *2004*) while an analysis of the variation in closely linked micro-satellites has dated it to a period between 7450 and 12 300 years ago (*Coelho* et al. *2005*). It is interesting to consider that the dates estimated for the origin of one of the African variants (14 010*C) are similar, even if slightly more recent (*Tishkoff* et al. *2007*).

Given the scenario presented, one of the most interesting questions that has been addressed during the last decade is whether the –13 910*T variant was already present in Europe in significant frequencies at the beginning of the Neolithic (*e.g.*, due to random mutation and the effects of genetic drift) or if the spread of the mutation associated with lactase persistence was purely the result of selection acting after the beginning of animal domestication, when milk became available as a nutritional source throughout the entire life of the individuals. The advent and further development of technologies allowing the sequencing of DNA extracted from archaeological specimens has helped answer this question.

The first study to address this issue was performed on a set of samples from Central Europe (Germany, Hungary, Lithuania and Poland) dating from the Mesolithic (one individual) to the Early Neolithic period (eight individuals) (*Burger* et al. *2007*). All of them were homozygotes for the ancestral allele, and therefore unable to digest fresh milk as adults. The authors performed statistical analyses that showed that the frequencies of the derived alleles must have been very low, if not nil, in order to have such a pattern in the sample.

More recently, several studies have been carried out in different regions of Europe clarifying this assertion (*Burger, Thomas 2011; Linderholm 2011*). In France, the mentioned SNP has been typed in 26 skeletons dated to the end of the Neolithic, before the beginning of the Bell-Beaker Culture, and all of these were homozygotes for the C variant (*Lacan* et al. *2011*). In southern Scandinavia only one out of ten Middle Neolithic hunter-gatherers carried the derived allele, and was heterozygote (*Malmström* et al. *2009*).

In contrast, in northern Spain, out of 26 Middle Neolithic individuals, seven (five of them homozygotes) carried the T allele (*Plantinga* et al. *2012*). The authors tend to explain this difference in frequencies, compared to the other European samples, as the effect of genetic drift rather than the result of natural selection.

Additionally, some more recent samples, from the Middle Ages, have been analysed. A single individual from Germany was lactase persistent, being heterozygous (*Burger* et al. *2007*), and out of 23 samples from Hungary only three carried the derived haplotype (*Nagy* et al. *2011*). It has nevertheless to be born in mind that for periods such as the Middle Ages high levels of gene flow and important migrations occurred in Europe, and this must be considered when interpreting such data (*Nagy* et al. *2011; Reich, Arnould 2007*).

Selection on lactase persistence

The above-mentioned data support a massive increase of LP frequency from virtually 0 to close to 100% in Northern Europe in a few thousand years, which is a very short period when considering the evolution of our species. This evidence suggests strong natural selection acting on this locus: the coefficient of selection has been estimated as reaching almost 0.2 in Northern European populations (*Bersaglieri* et al. *2004*). Such a strong indication of selection poses the problem of understanding why drinking fresh milk had such a significant selective advantage.

It is important to consider that the intake of small quantities of fresh milk does not always cause unpleasant symptoms in non-persistent individuals, and that when milk is processed or fermented, such as in yogurt or cheese, the amount of lactose decreases and the consumption of these products does not cause symptoms to non-persistent individuals (*Hammer* et al. *1998*). Moreover, as already discussed, gut flora adaptation can in some cases allow individuals to avoid the symptoms of lactose malabsorption (*Szilagy* et al. *2002*).

The evidence of cheese production during the Early Neolithic mentioned above has a special meaning. It has already been discussed that lactase persistence was very rare or absent during the Neolithic, and this would not allow human groups to drink fresh milk. Processed milk, on the other hand, can be digested by non-persistent individuals without unpleasant symptoms. The production of cheese at the beginning of the Neolithic suggests that at that time human groups may have already recognised the high nutritional benefits available from milk, and, in order to digest it, they processed it. It can be presumed, therefore, that the reason lactase persistence spread and became so common in Europe is not to be found in the simple nutritional benefits of consuming fresh milk.

The observations above raise a question: why is lactase persistence so strongly selected if non-persistent individuals can consume milk by processing it, thereby gaining many of milk's nutritional benefits? Several possible explanations have been proposed, but it is still under debate as whether any is convincing enough to justify levels of positive selection as high as those observed. As previously discussed, high frequencies of lactase persistence tend to correlate with a traditionally pastoralist lifestyle or with high consumption of fresh milk, even if this is not always the case (*Ingram* et al. *2009b*). This evidence could be the result of two quite different scenarios.

The reverse-cause argument (*McCracken 1971*): after its first appearance, a mutation associated to lactase persistence could have grown in frequency within one or several small human groups only because of genetic drift. Milk drinking could then have been adopted since the group would have been able to tolerate it.

Gene culture co-evolution (*McCracken 1971. 497–517, Simoons 1970.695–710*): lactase persistence could have been positively selected in dairying populations, which had access to fresh milk throughout life.

As already noted in the previous section, ancient DNA data support the second hypothesis. During the Neolithic, when dairying practices were already established, lactase persistence appears to be virtually absent, or present in very low frequencies in Europe. It is also important to consider that the random independent origin and then the increase of the frequencies of different lactase persistence-associated alleles due to the random fluctuation (genetic drift) in different regions would be a very complex and unlikely scenario, for which no possible explanation is available at the moment.

The calcium assimilation hypothesis (*Flatz, Rotthauwe 1973*): exposure to sunlight allows human skin to produce vitamin D, which is an element of great importance for the absorption of calcium in the bones. When vitamin D, taken in through a diet rich in fish or produced thanks to exposure to the sun, is not sufficient, bone development can be seriously compromised. In addition to other nutrients, milk contains small amounts of vitamin D and large amounts of calcium. The frequency of lactase persistence in Europe correlates with latitude and sunlight, and this evidence suggests a cause-effect relationship between the two. In Northern Europe, it is possible to observe a transition from a diet rich in fish and marine organisms (rich in vitamin D) during the Mesolithic to one based mainly on cereals (poor in vitamin D) in the Late Neolithic (*Eriksson* et al. *2008; Lidén, Eriksson 2007; Lidén* et al. *2004*). The Meso-Neolithic transition has been shown by many scholars to be associated with a deterioration in health (*Cohen 2008; Eriksson* et al. *2008; Eshed* et al. *2010; Hershkovitz, Gopher 2008; Larsen 1995*). Drinking milk would have helped populations living where sunlight is low to avoid rickets and similar problems related to such a nutritional change.

Adaptation to arid environments (*Cook, al-Torki 1975.135–136*): in a normal situation, raw milk and cheese could provide the same nutritional benefits, but in arid environments milk could be an uncontaminated source of fluid, while lactose intolerance related symptoms (mainly diarrhoea) could lead to dehydration and, eventually, death. Nevertheless, this hypothesis is not easily applicable to Europe, where the climate is temperate.

A statistical test was performed to see whether lactase persistence was more likely to be correlated with dairying practice, calcium assimilation or adaptation to arid environments (*Holden, Mace 1997. 605–628*). The best correlation was obtained between the ability to digest milk and pastoralism. This study suggests, in accordance with the palaeogenetic data, that pastoralism was more probably adopted before lactase persistence arose or became frequent.

The spread of lactase persistence through Europe

The pattern of genetic diversity that can be observed in a population is the result of many different biological and social processes that contribute to shaping it during its history: random mutation, natural selection, genetic drift (and, consequently, demography), social factors influencing mating choices (*e.g.*, social structuring) *etc*.

Computer simulations are very powerful instruments for testing various hypotheses through models with different degrees of complexity. In this way, the most important factors playing a role in shaping the diversity observed can be explored both in a computationally effective way, removing the confounding effect of minor elements, and within a realistic framework integrating all the information that appears to be relevant to the problem. Computer simulations have been applied to investigate the evolution of LP since the late 1980s (*Aoki 1986*). As already mentioned, lactase persistence is not entirely correlated with pastoralism and milk drinking, since some individuals (or human groups) are able to drink milk without being lactase persistent. Aoki tried to test if this could be the result of a process of gene-culture co-evolution and, by using computer simulations, he confirmed that this is the case. Moreover, his study showed that the incomplete correlation could be easily linked to the stochastic nature of the process.

Two recent studies have reached different results when simulating the spread of lactase persistence in Europe. As already discussed, it is still debated whether the beginning of the Neolithic in Europe was linked to the migration of people from the Middle East or to simple cultural transmission of skills and techniques from agriculturalist populations to neighbouring hunter-gatherers. The colonisation and expansion in Europe by farmer populations could have had an important impact on the diffusion of the lactase persistence-associated allele, since some demographic processes could mimic the effects of selection (*Klopfstein* et al. *2006*). The impact of demographic effects and differential selection based on latitude have been taken into account in a recent study simulating the spread of lactase persistence in Europe (*Gerbault* et al. *2009*). The authors tested two different scenarios for the spread of the Neolithic in Europe (the demic and cultural diffusion models). On the basis of the dates for the beginning of the Neolithic in each region, they simulated the evolution of the frequencies of the lactase persistence associated allele through time. Selection was incorporated in three different ways: constant throughout the continent, increasing towards the north (to test the calcium assimilation hypothesis) or higher in central European Early Neolithic (Linearband Ceramic) populations.

The results show that the present-day frequencies of milk digesters in southern Europe could be due to genetic drift linked to the arrival of Neolithic farmers from the Near East, but selection is required to reproduce the modern frequencies observable in the northern part of the continent. The authors then support the demic diffusion model associated with the calcium assimilation hypothesis.

Spatially explicit simulations were also applied to the same subject (*Itan* et al. *2009*). After creating a geographical background as close to Europe as possible, they modelled the evolution of the lactase persistence associated variant in three humans groups: hunter-gatherers (already present in the continent prior to the beginning of the simulations, 9000 years ago), dairying farmers, and non-dairying farmers. Food producers were allowed to reach a higher population density, and they spread from the Middle East towards Europe. Gene flow between groups, long-distance migrations and the cultural diffusion of subsistence practice were also included in the model. Positive selection acted only on dairying farmers. The best simulations were chosen on the basis of the fit with the arrival time of agriculture and modern frequencies of lactase persistence in 12 different locations. The method used to analyse the results allowed the estimation of migration rates, selection coefficients and time and geographical coordinates for the beginning of selection on lactase persistence; the best fit was reached when selection started in a region between the Balkans and Central Europe, from 6256 to 8683 years BP, and differential selection in Northern Europe was not necessary to reach modern frequencies. The times and regions mentioned are in great agreement with the development of the Linearband Ceramic culture (*Pavúk 2005*).

An analysis of the differences between the two mentioned studies can be found in Leonardi *et al.* (*2012*). The simulation model used in Gerbault *et al.* (*2009*) is less complex than that used in Itan *et al.* (*2009*) in several ways. The model from the former that can be better compared with the latter is the so-called LBK scenario, where selection is higher only for the descendants of LBK groups. In this model, the frequencies of lactase persistence in Northern European populations do not reach present-day values, showing that higher levels of selection only in LBK-related populations is not enough to reconstruct in a satisfactory way the modern distribution of lactase persistence in Europe. Since gene flow and long-distance migrations between populations are not explicitly modelled, this result does not contradicts the findings of Itan *et al.* (*2009*) but suggests that selection was not constant through time and space, a hypothesis that has not been rejected by the latter study, where the selection coefficient was constant.

Conclusion

Lactase persistence is an amazing example of gene-culture co-evolution. The modern-day pattern of diversity at this locus in Europe is the result of the interaction of a large number of factors such as physiology, genetics, demography, migrations of people, social structuring, and cultural contact. The study of such a complex subject must start from a very careful analysis of the archaeological, historical and biological contexts and should be performed using methods that allow as far as possible integrations of the different types of information available. During the last decade, the increase of computational power coupled with more effective sequencing techniques has led to the possibility to simulate *in silico* more models, and to reconstruct with better precision the history of our and other species. A better understanding of the origin and spread of lactase persistence in Europe will definitely pass along this path.

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Transition to farming – transition to milk culture: a case study from Mala Triglavca, Slovenia

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ABSTRACT – *In this paper, we discuss the transition to milk culture. While archaeological and biochemical data suggest that dairying was adopted in the Neolithic in Europe, archaeogenetic data show the absence of the allelic variant –13 910*T and very low lactase persistence in Neolithic populations in Europe. The Mala Triglavca case study shows that the Early Neolithic economy in the Caput Adriae region was mixed. It consisted of milk and processed milk, meat animal products, freshwater fish and various plants. The Vlaška group herders managed a broader spectrum of resources than exclusively ovicaprids, and were able to produce a wide range of low-lactose, storable products by fermenting milk.*

IZVLEČEK – *V članku razpravljamo o uporabi mleka in mlečni kulturi v prazgodovini. Medtem ko arheološki in biokemični podatki kažejo na razvoj mlekarstva v neolitiku v Evropi, arheogenetski govorijo o odsotnosti alela –13.910*T in laktozne persistence pri neolitskih populacijah v Evropi. Raziskave v Mali Triglavci kažejo, da je bilo gospodarstvo v zgodnjem neolitiku na območju Caput Adriae mešano, t.j. mlečno in mesno. Temeljilo je na uporabi mleka in mlečnih izdelkov, mesa prežvekovalcev in neprežvekovalcev, sladkovodnih rib in različnih rastlin. Pastirji skupine Vlaška so v svoje gospodarstvo poleg vzreje drobnice vključili tudi druge vire. S pomočjo fermentacije so predelovali mleko v mlečne izdelke.*

KEY WORDS – *European Neolithic; demic diffusion; transition to farming; dairying; lactase persistence; lipids; Vlaška culture*

Introduction

The beginning of dairy culture can be assumed to have occurred in the processes of the transition to farming, and the utilisation of lactic acid bacteria can be traced alongside the domestication of sheep, goat and cattle. In milking and milk processing, the lactococci and lactobacilli were manipulated to initiate the fermentation that converts milk into yogurt, buttermilk, butter and cheese. These have advantages in storing and transporting dairy products and making them available in times of low milk production on one hand, and making milk available as a nutritional source throughout the entire life of the individuals on the other.

Biomolecular analyses of the lipids present in food which become absorbed and trapped in the pores of clay vessels show that milk was being used extensively by the 7th millennium BC in south-eastern Anatolia and around the Sea of Marmara. A millennium later, it was processed at some Early Neolithic sites in Southeast and Central Europe (*Craig* et al. *2005; Evershed* et al. *2008*). Parallel archaeogenetic studies hypothesised that a single mutation (–13 910*T) in the human genome which allow adults to consume fresh milk evolved within a group(s) of Neolithic pioneer stockbreeders among whom lactase persistence was rare, but who initially practised dairying in

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Southeast Europe in the middle of 8th millennium BP and later migrated towards central and northern Europe to an area inhabited by foragers. They reached the northern Adriatic at *c.* 7400 BP (*Gerbault* et al. *2009; 2011; Burger, Thomas 2011; Gerbault 2012*). However, the absence of the lactase gene in Neolithic populations in Europe shows that their lactase persistence was very low and 'may have even been zero' (*Leonardi* et al. *2012.93*). Animal biomarkers observed in pottery in the Northern Adriatic suggest that dairy products were processed and stored at *c.* 6400 BP, and were associated with a mixed subsistence strategy based on meat (ruminant and non-ruminant origin), milk, plant and aquatic animals.

Dairying and lactase persistence

All humans have the lactase gene, but only children produce lactase in sufficient amounts to break down lactose, the main sugar in milk. Fresh milk is a toxin to adults without lactase, and often causes symptoms such as abdominal pain, bloating, flatulence and diarrhoea. Lactase is an enzyme produced in the digestive system of mammalian infants, but is dramatically reduced after the weaning period. The ability to digest lactose found in fresh milk is called lactase persistence. However, the correlation between lactase persistence and fresh milk consumption is not yet fully understood.

The lactase persistence trait is found in approx. 35% of adults in human populations in the world, but varies widely between and within continents. The frequencies of lactase-persistent individuals are generally high in Europe, Central Asia and India but almost zero in Southeast Asia (*Itan* et al. *2010; Gerbault* et al. *2011*). In Europe, lactase persistence is at its highest frequency in the North, with a decreasing cline from the central and western (62–86%) to the southern and eastern regions (15–54%) (*Gerbault* et al. *2011.864*). On the Indian sub-continent the frequency of lactase persistence is higher in the North-West than elsewhere; further East, the lactase persistence frequency is generally low. In Africa and the Middle East, the distribution is patchy, with some pastoral nomadic tribes having high frequencies (92%) of lactase persistence compared with neighbouring groups living in the same region (*Tishkoff* et al. *2007; Ingram* et al. *2009; Gerbault* et al. *2011*).

In a broader context, three main groups are distinguished according to milk and milk product consumption dependence. The first group has never used dairy animals and has not integrated lactose in their diet after weaning (*e.g.*, Aborigines, Eskimos and other American Indians). The second group consists of pastoralists who have never integrated much milk or milk products into their subsistence (*e.g.*, many African populations, Chinese Han, Thai). The third group relates to populations that introduced the practice of drinking milk a long time ago and had a high amount of lactose in their diet (*e.g.*, most Europeans, some African and Middle Eastern populations and North Indians). There are some exceptions, for example, populations that have low lactase persistence, but drink fresh milk (*i.e.* Mongols, Dinka and Nuer in Sudan and the Somali in Ethiopia) (*Liebert 2012.83*).

The global correlation between lactase persistence frequencies and patterns of historically milk drinking populations led to the broadly accepted notion that lactase persistence has been subject to positive selection. This has become known as 'gene – culture coevolution' or the 'culture historical hypothesis', suggesting that the rise in lactase persistence co-evolved alongside the cultural adaptation of milk consumption and its associated nutritional benefits.

A number of single nucleotide polymorphisms that allow lactase to be produced into adulthood have been found in different modern human populations worldwide. They are not located in the lactase gene (LCT), but in the intron of a neighbouring gene, MCM6, on chromosome 2. Several nucleotide changes in this region seem to affect lactase the gene promoter activity associated with lactase persistence (*Gerbault* et al. *2011.864*). They have different geographic distributions within the modern populations. The derived allelic variant –13 910*T of the first nucleotide cytosine to thymine transition C>T–13 910 is associated with lactase persistence in Europe, Central Asia and India (*Enattah* et al. *2002; Ingram* et al. *2007; Itan* et al. *2009*). This allele and associated selection for lactose tolerance seems to originate twice in ancestral populations (bearing haplotypes H) in regions north of the Caucasus and West of the Urals. The first origin is estimated at 12 000 to 5000 BP, and the second more recently at 3000 to 1400 years ago. It was suggested that the frequency gradient in modern populations shows that the allele migrated to the West (*Enattah 2007.619–622*).

Lactase persistence in Africa is linked to three single nucleotide polymorphisms, C–14 010, G–13 915 and G–13 907, close to the lactase gene (*Tishkoff* et al. *2007*). They are linked to different ethnic groups with divergent haplotype backgrounds and geographic regions. However, some questions still remain unanswered. The Hadza people in Tanzania show a high level of lactase persistence despite having nothing to do with herding. The possible explanation is that, although they are now mainly hunter-gatherers, their ancestors might have been pastoralists. European -13 910*T and East African G-13 907 LP alleles are very near to each other and probably share the same ancestral allele that "*might have arisen because of a common domestication event of the cattle, whereas the C-3712 and G-13 915 allele in Arabia most likely arose due to the separate domestication event of camels*" (*Enattah* et al. *2008. 70*). The origin of the African allele G/C-14 010 is estimated between *c.* 6800–2700 BP (*Tishkoff* et al. *2007.36*).

Lactase persistence is one of the leading examples of natural selection in humans and also one of the first clear examples of the polymorphism of a regulatory in the human genome (*Ingram* et al. *2009*). A single gene was involved with different mutations in different parts of the world, but with similar effects. The lactase persistence has been mainly identified in pastoralist populations and, as fresh milk and milk products are the only known naturally occurring sources of lactose, it is therefore unlikely that this trait would be selected without a supply of fresh milk (*Gerbault* et al. *2011.864*). Why this trait was so strongly selected is still widely discussed.

Several scenarios relating to the 'selection hypotheses on lactase persistence' and to 'the advantage of being lactase persistent' have been discussed recently. The first and most widely accepted 'gene – culture coevolution' or 'culture historical' hypothesis proposes that lactase persistence was selected among populations that consumed milk over generations and adopted animal breeding and dairying, thereby increasing the dependence of adults on milk. In opposition, the second, the 'reverse cause hypothesis', suggests that dairying was adapted by populations that were already lactase persistent. A mutation associated with lactase persistence within small human groups could have grown in frequency through genetic drift before milk was introduced into subsistence. The third, the 'calcium assimilation hypothesis', suggests that in high-latitude environments where lower sunlight produces less vitamin D (important for the absorption of calcium in bones) lactose in fresh milk promotes the uptake of calcium present in milk. In contrast to hunter-gatherers who had a vitamin D rich diet abundant in marine food, early agriculturalist might have had problems with vitamin D deficiency, and drinking milk could have been an advantage for lactase-persistent farmers (*i.e.* in the Neolithic). The fourth, the 'arid climate hypothesis', suggests that in regions where water was scarce, milk could be an uncontaminated source of fluid used by pastoralists. While lactase non-persistent individuals were at risk from diarrhoea and the dehydrating effects of drinking fresh milk, the selection may have been strong in lactase-persistent individuals (for a detailed overview, see *Aoki 1986; 2001; Holden, Mace 1997; Bloom, Sherman 2005; Itan* et al. *2010; Gerbault* et al. *2011; Liebert 2012*).

However, archaeological and archaeogenetic data suggest that dairying in Europe was adopted before lactase persistence became frequent. The absence of the allelic variant -13 910*T shows that lactase persistence in Neolithic populations in Europe was very low and 'may have even been zero' (*Leonardi* et al. *2012.93*). On the contrary, the stable isotope analyses of dairy fats in pottery suggest that milking, milk consumption and processing were widely adopted in the Neolithic. Pastoralism was thus adopted before lactase persistence arose or became frequent. We may assume, therefore, that under normal circumstances lactase persistence is not necessarily to be under very strong selection in this population and fits with the hypothesis that dairying and milk consumption emerged before genetic adaptation. Strong selective pressures may have been episodic and occurred only under certain extreme circumstances, such as drought, epidemic or famine.

The transition to milk culture

We may assume that animal domestication brought milk into the diet, and that domestic animals were a more stable seasonal resource, which could became an alternative to hunter-gatherers' system of the seasonal exploitation of a broad spectrum of animal resources. Milk is a good source of calories, specifically an important source of protein and fat, and must have increased the quality of the diet. "*The milk production of a prehistoric cow has been estimated to range between 400 and 600kg per weaning period. Even when the milk necessary for the raising of the calves is subtracted, some 150–250kg remains. This is almost equivalent to the calorie gain from the meat of a whole cow. Hence, over the years, milking may have resulted in a greater energy persistence would have been selected in regions where the disease was frequent. Hence, over the years, milking may have resulted in a greater* *energy yield than the use of cattle for meat*" (*Gerbault* et al. *2011.865–866*). Dairying was especially important for children and adolescents as it prolongs the beneficial effects of milk (proteins, fats, but also calcium supply) long after weaning (*Vigne 2008.200; Panesar 2011*).

Jean-Denis Vigne (2008) suggests that ungulate domestication (*e.g.*, sheep, goat and cattle) in the Near East was part of the diet transition that 'correlates to deep changes in food supply'. It was not because of a better meat supply, but the introduction of milk and milk products that have brought significant modifications to the human diet. Indeed, herd management in the initial Near Eastern Neolithic shows sophisticated herding practices for milk. It implies that large numbers of ovicaprid and bovine female animals were kept; techniques for separately herding young and adults, with particular attention to lambs; and an increase in infant and old-age culling in mortality profiles (*Helmer* et al. *2007; Vigne, Helmer 2007; Vigne* et al. *2011.S266; Çakırlar 2012a; 2012b*).

It is worth noting that modern and ancient cattle mtDNA sequences do not support the currently accepted hypothesis of a single Neolithic origin in the Near East. The processes of livestock domestication and diffusion were certainly more complex than previously suggested, and genetic data provide some evidence in favour of the hypothesis that European cattle had multiple origins. Breeds domesticated in the Near East and introduced to Europe during the Neolithic diffusion probably interbred, at least in some regions, with local wild animals and with African cattle introduced by maritime routes. It is possible that pastoralist societies in Southern and Northern Europe used different breeding techniques, with the latter more concerned with herd protection (*Beja-Pereira* et al. *2006*; see also *Edwards* et al. *2011*).

In addition, stable isotope analyses of dairy fats in pots show evidence of dairy production in southwest Asia as early as 8500 BP. The apparent intensification of dairy processing in northwest Anatolia was recognised as an early centre for milk processing, with cow's milk as the main source of dairy products in this region (*Evershed* et al. *2008; Thissen* et al. *2010*; for comments see *Çakırlar 2012a*). This region had a central position in dispersals of Neolithic subsistence economies into Europe (*Brami, Heyd 2011; Özdoğan 2011*).

On the other hand, Albano Beja-Pereira *et al.* (*2003*) suggest that the strong geographic correlation between cattle milk gene diversity, human lactose tolerance and the distribution of the earliest European cattle pastoralists began in North-Central Europe and led to genetic co-evolution between humans and domestic animals, *i.e.* the ability of adults to consume milk and the ability of dairy cattle to give high milk yields (*Beja-Pereira* et al. *2003*). Allele -13 910*T cline indeed shows frequencies decreasing from North to South. In Scandinavia, where dairying arrived late, almost all the sampled individuals are lactase-persistent, with frequencies ranging between 96% and 89%. In Southern Europe, it ranges between 15% and 54% (*Gerbault* et al. *2011.864*).

The presence of abundant milk fat and specialised vessels used to separate fat-rich milk curds from lactose-containing whey indeed provide direct chemical evidence of milk processing in Northern Europe in the Early Neolithic LBK complex. The pottery assemblage is dated to *c.* 5200 and 4900–4800 calBC (*Salque* et al. *2012*). Oliver Craig *et al.* (*2005*) provided much earlier data for milk processing in the Early Neolithic in Southeast Europe. Degraded ruminant fatty acid in pottery in the Starčevo-Criş (5950–5500 calBC) and Köros culture (5800–5700 calBC) suggest milk products and milk processing, *i.e.* the heating of milk.

It should be noted that lactose is progressively reduced by milk processing. The lactose content of fresh milk ranges between 4.42–5.15 g/g% in cattle, 4.66–4.82 g/g% in goats and 4.57–5.40 g/g% in sheep. It can be reduced to 50–60% by bacterial fermentation. Some processed milk products (such as cheese and butter) have very low lactose content, ranging from 0–3.7 g/g% (*Nagy 2011.267; Liebert 2012.77*).

Milk is extremely perishable and many methods have been developed to preserve it; fermentation was the earliest method. Inoculating fresh milk with the appropriate bacteria can ferment milk at temperatures that favour bacterial growth. As the bacteria grow, they convert milk sugar or lactose to lactic acid. The lowered pH caused by lactic acid preserves the milk by preventing the growth of pathogenic bacteria which do not grow well in acidic conditions. The lactic acid bacteria (*e.g.*, *Lactobacillus acidophilus, Lactobacillus bulgaricus, Lactobacilus caucasius* and *Lactococcus lactis*) thus turn milk into yogurt, kefir, buttermilk and cheese. They make milk available as a nutritional source throughout the entire life of individuals on the one hand, and allow advantages in storing and transporting dairy products and making them available in periods of low milk production on the other.

Lactase persistence and demic diffusion migratory model

Pascale Gerbault *et al.* (*2009; 2011; 2012*) and Yuval Itan *et al.* (*2009; 2010*) intensively studied the evolutionary processes that shaped the European lactase persistence patterns in modern populations. They ran computer simulations to test different selection hypotheses on lactase persistence in relation to demic diffusion and culture diffusion models. Their results are contrasting. Computer simulations showed that high lactase persistence frequencies observed in Northern and Western Europe can be explained by selective pressure, possibly increasing with latitude in a way that is highly compatible with the calcium assimilation hypothesis combined with the effect of demographic expansion (*i.e.* population growth) during the Neolithic transition. The much lower frequencies in Southeast Europe can be explained by genetic drift if this mutation was carried by Near-eastern pioneers. Keeping in mind that the demic diffusion model is based on the decreasing southeast-northwest cline of frequencies for selected Y-chromosome markers, indicating the movement of Neolithic men with Levantine genetic ancestry across Europe, it is important to note that the allelic variant -13 910*T cline travels in the opposite direction. However, computer modelling suggests that the centre of distribution of an allele can be far removed from its location of origin in the direction of population expansion, moving at the front of the demic diffusion. This process is called 'allele surfing' and is thought to have occurred with the spread of farmers in Europe (*Gerbault* et al. *2009.3, 7–8, Fig. 1; 2011*; see also *Gerbault 2012.179–198, Fig. 4*) thus hypothesised that strong selection for lactase persistence runs within the 'niche construction' at the front of the demic diffusion, where local environmental condition and subsistence strategies led to population increase and concentration on milk resources[1]. The initial selection was embedded in Southeast Europe at 8518±66 BP (7592–7528 calBC), and the first lactase persistent farmers and domesticates arrived in Central Europe and the Northern Adriatic a millennium later, at 7416±101 BP (6418–6213 calBC)[2]. The latter ^{14}C date was contextualised in the Edera/Stenašca rock shelter in the Trieste Karst and is linked to the Early Neolithic Vlaška culture (*Pinhasi* et al. *2005.Supporting information, Tab. 1*) (Fig. 1).

Nevertheless, Itan *et al.* (*2009; 2010;* see also *Burger, Thomas 2011; Leonardi* et al. *2012*) suggest

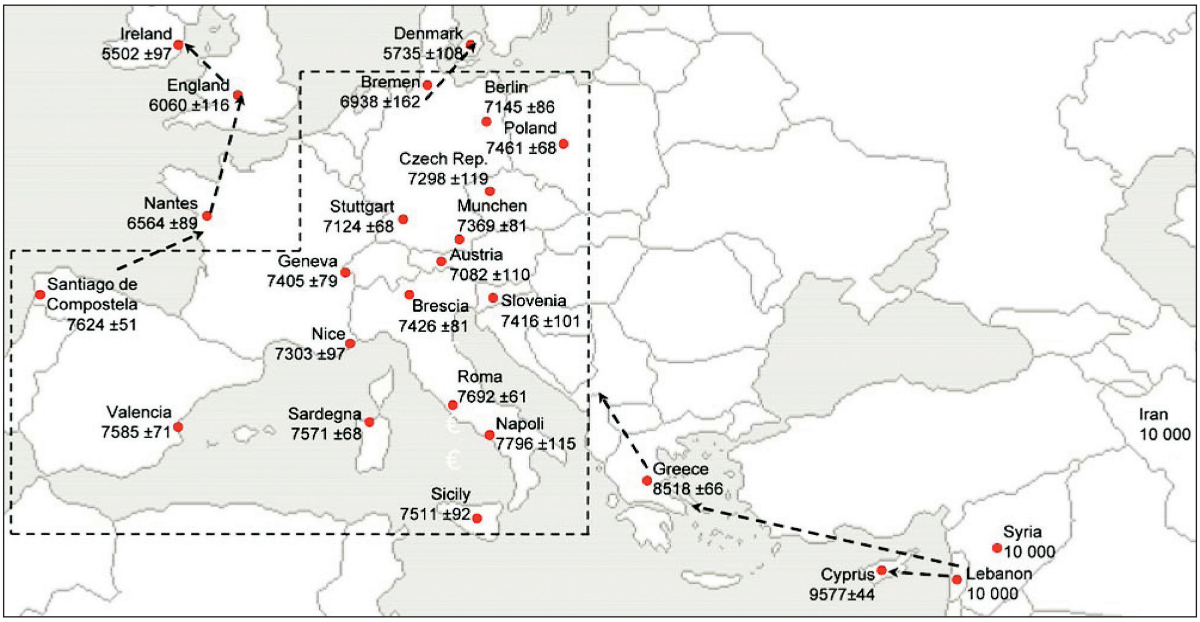

Fig. 1. Map of European and Near-Eastern populations used for the computer simulation test of gene-culture coevolution and calcium assimilation hypotheses of lactase gene selection. It implies that positively selected lactase gene (with frequencies that increase with latitude) was carried over Europe at the front of the Neolithic demic diffusion (from **Gerbault *et al.* 2009.Fig. 1*).***

1 For discussion that farming niche is not necessary an effective strategy for achieving demographic and economic stability see Rowley-Conwy and Layton (*2011*).

2 Calibrated with Oxcal 4.2 programme at 1σ.

that the -13 910*T allele first underwent selection in a relatively short period among dairy farmers in the northern Balkans in the Starčevo and Körös cultures. It was than dispersed by demic diffusion to Central and Western Europe in the area of Linear Pottery culture at 'around 6256–8683 years BP' (*Itan* et al. *2009.7;* see also *Itan* et al. *2010*).

However, both scenarios, the demic diffusion of lactase-persistent farmers across Europe and the evolution of lactace persistence in Central Europe in the Neolithic, seem to be unrealistic. The archaeogenetic analysis of Neolithic skeletons suggests that "*lactase persistence frequency was significantly lower in early Neolithic Europeans than it is today, and may have been zero*" (*Leonardi* et al. *2012.93*; see also *Burger, Thomas 2011*). Indeed, the analysis revealed an absence of the -13 910*T allele in Central Europe, in the Western Mediterranean and the Baltic in Mesolithic and Neolithic populations (*Burger* et al. *2007; Burger, Thomas 2011; Lacan* et al. *2011; Linderholm 2011; Nagy* et al. *2011*). The only exceptions are two post-Neolithic individuals in the Basque Country on the Iberian Peninsula (*Plantinga* et al. *2012*).

Early farming and milking in the Caput Adriae (Northern Adriatic)

The distribution of the first farming communities in the Eastern Adriatic is traditionally associated with the 'Impresso Cardium' (*i.e.* impressed) pottery dispersal. It was also used as an indicator of the spread of farming across the region. Stašo Forenbaher and Preston Miracle (*2005; 2006*) introduced a two-phase model suggesting that impressed ware originated in coastal Northern Greece and spread with immigration from South to North along the Adriatic coast. The process included immigrant farmers that made exploratory visits and set up short-term seasonal camps at caves and open-air sites along the coastal strip of southern Dalmatia (*i.e.* pioneer colonisation), followed by a village settlement that spread slowly towards the Northern Adriatic in areas with fertile soils (*i.e.* consolidation phase).

The northern boundary of 'Impresso Cardium' pottery through the Eastern Adriatic is positioned in southern Istria, as no early farming sites with impressed ware are known from northern Istria and the coastal fringe of the Trieste Bay. Indeed, in most sites across the boundary, the earliest Neolithic is represented by Vlaška pottery (*Barfield 1972*). These pottery assemblages resemble those from the Middle Neolithic Danilo culture in Dalmatia, and it has been hypothesised that the region was not colonised before the Middle Neolithic (*Forenbaher, Miracle 2006; Forenbaher, Kaiser 2006; Biagi, Spataro 2001; Biagi 2003*). The Vlaška and Danilo pottery assemblages have similar characteristics in their shapes, decoration techniques and motifs. However, the main difference between them is the absence of painted pottery in Vlaška assemblages.

Nevertheless, we may assume that the Vlaška group does not represent the initial Neolithic in the region. Materialities in stratigraphicaly super-positioned layers 2a and 3a at the Edera/Stenašca rock shelter show that the first can be recognised as the Vlaška group, but the latter contained plain pottery of local and non-local manufacture, along with the bones of domestic (*i.e.* caprines, cattle and pig) and wild animals, shells of marine molluscs and lithics that includes trapezes and microburins. It was recognised as a Late Castelnovian hunter-gatherer complex and dated to 6700 ± 130 BP (5700–5515 calBC) (*Biagi, Spataro 2001.35*).

The beginning of the Early Neolithic in the Eastern Adriatic appears to be embedded in the time span between 6048–5988 calBC in the North (Vela spilja, Mali Lošinj island), 5985–5843 calBC in the central region (Pokrovnik in Dalmatia), and between 5986–5903 calBC (Spila Nakovana on Pelješac peninsula) and 5989–5767 (Vela spila on Korčula Island) in the South[3]. The available ^{14}C evidences in the Northern Adriatic show that the Istrian peninsula and Karst Plateau above Trieste Bay remained outside this range. It is postulated that the Neolithic was established here at *c.* 5600 calBC and that it was associated with the end of "*Impressed Ware and the appearance of assemblages with only undecorated pottery*" (*i.e.* Vlaška-Danilo pottery) in the Middle Neolithic (*Forenbaher* et al. *2013.599*) (Fig. 2).

Interestingly, Mesolithic sites are known in this area (*Komšo 2006*), but none is securely dated to the pe-

3 The recently published ^{14}C dates are: 7134±37 BP (OxA-18118) for Vela spilja, Mali Lošinj Island; 7000±100 BP (lab code unavailable), for Kargadur 6769±33 BP, 6612±32 (OxA-21092, OxA-21093) and Vižula 6140±70 (HD-11733) on the southern tip of Istria peninsula, and 6999±37 BP (OxA-17194) for Pokrovnik in Dalmatia; 7050±37 (OxA-18120) for Spila Nakovana on Pelješac Peninsula; and 7000±120 (Z-1968) for Vela spila (*Bonsal* et al. *2013.149, Tab. 8.1; Forenbaher* et al. *2013.Tab. 1*). A date from Vela spila, originally published as related to early 'Impresso Cardium' pottery 7300±120 BP, Z-1967), has recently been reattributed to a 'Mesolithic/Neolithic transitional period' (*Forenbaher* et al. *2013.597*). The dates are calibrated at 68.2 probability using the Oxcal 4.2 program.

riod after 6000 calBC. On the other hand, radiocarbon sequences from sites in this region show a temporal gap between the latest Mesolithic and earliest Neolithic occupations that varied in duration and were not synchronous among the sites, although there is an evident continuity of occupation over the wider region. Various hypotheses have already been proposed to account for the temporal discontinuity, but it remains unresolved (for discussions, see *Biagi, Spataro 2001; Biagi 2003; Forenbaher, Miracle 2006.497–504; Mlekuž* et al. *2008; Berger, Guilaine 2009; Bonsall* et al. *2013*).

How the Neolithic Vlaška group herders managed ovicaprids

The question of how the Neolithic Vlaška group herders managed herds has been addressed already. Most authors agree that Vlaška group herders were involved in some form of transhumant or nomadic pastoralism, with seasonal occupation of cave sites (*Miracle, Pugsley 2006; Mlekuž 2005*). However, contradictory scenarios have been proposed based on the interpretation of kill-off curves (see *Rowley-Conwy 2013.163–174*).

It is worth remembering that Sebastian Payne (*1973*) proposed – on the basis of his ethnoarchaeological research among Turkish pastoralists – a middle range theory, which links flock management strategies to kill-off curves. It is based on the assumption than an optimisation of animal products can be obtained by manipulating the sex and age structure of the herd. Ideal dairying and meat models differ in the age when males are culled. In the ideal dairying model, most animals younger than two months are culled in order to reduce competition for milk with people. With an optimal meat strategy, most animals are culled after one to three years, as they achieve their maximum weight.

The interpretation of kill-off curves is complicated by a strong preservation bias against neonates and young animals on the one hand and a high natural mortality of neonates and young animals on the other. But the main problem behind the use of idealised curves is the assumption that people in the past behaved optimally. Ethnographic evidence suggests that within household-based economies, animals are used for a variety of animal products. Specialised and optimised exploitation of animal products emerges from the demands of a market-based economy. Thus, a correspondence to the ideal 'dairying' model

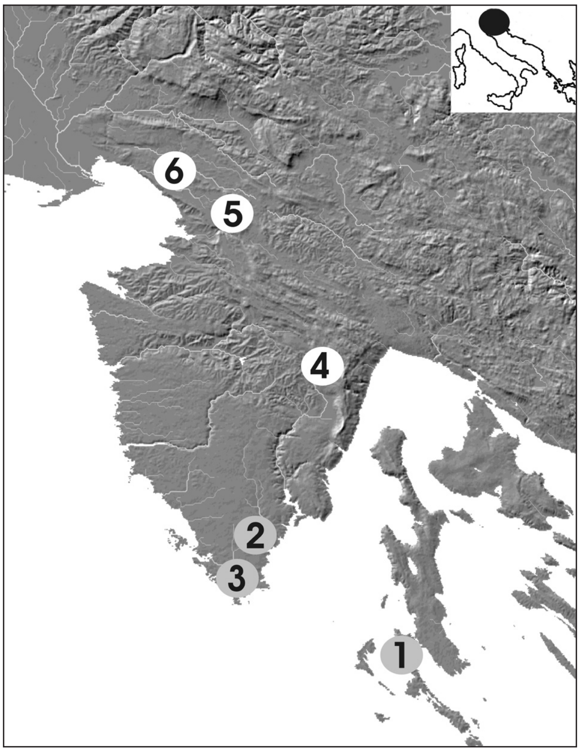

Fig. 2. The Impresso cardium culture (grey dots) and Vlaška culture (white dots) sites distribution in Caput Adria mentioned in text. 1 Vela spilja; 2 Kargadur; 3 Vižula; 4 Pupićina pećina; 5 Mala Triglavca; 6 Edera/Stenašca.

would indicate specialised production geared towards exchange (*Halstead 1996.25; 1998*).

Two new models for detecting animal exploitation for meat and milk have been proposed recently (*Vigne, Helmer 2007; Vigne 2008*). They suggest that caprine and cattle culling profiles in the Near East and the Mediterranean show that the exploitation of cattle, sheep and goats was aimed at milk production and not only meat from the initial Neolithic onwards. While small herds of goats were exploited mainly for milk, larger sheep herds were also for meat production. However, no curve resembles ideal strategies based on either meat or milk.

Vlaška group bone assemblages are comprised predominately of sheep and goat bones (around 60% of sheep and goats and less than 10% of cattle; see *Mlekuž 2005*). Milk yields from small stock are generally much lower than those of cows (goats, which have up to 100% higher yields than sheep, typically produce around 125kg of milk per lactation); however, they have a very high rate of increase (up to ten times compared to cattle). This makes them especially suitable for the accumulation of large herds (see *Ingold 1980; Dahl, Hjort 1976; Mlekuž 2005*).

Kill-off curves from the North Adriatic region (*Miracle, Forenbaher 2005; Miracle, Pugsley 2006. 319–335, Fig. 7.27*) were interpreted as a result of the management of herds aimed at harvesting dairying products. Dimitrij Mlekuž (*2005; 2006*), on the contrary, suggested that kill-off curves demonstrate a relatively simple, non-optimised economy aimed primarily at the domestic consumption of meat, not strategies aimed at maximising dairy products (Fig. 3). However, this does not exclude small-scale dairying of sheep and goats. Since goats are more effective milk producers than sheep (*Dahl, Hjort 1976. 210*), one would assume that goats were milked (*Rowley-Conwy 2000*). Goats are present after the appearance of small stock in Caput Adriae. However, their proportion compared to sheep is relatively low, around 20%, rendering their role in small-scale dairying invisible in the crude resolution of survivorship curves.

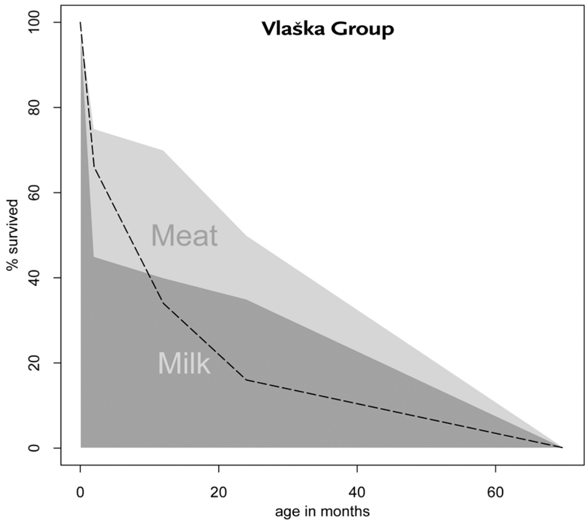

Fig. 3. Combined kill-off curve from Caput Adriae Vlaška assemblages (Grotta dell'Edera/Stenašca, Grotta degli Zingari/Ciganska jama, Grotta del Mitreo/Mitrej and Grotta dei Ciclami/Orehova pejca; see* Mlekuž 2006*). Sample size is 60 dentitions.

Molecular and isotope evidence of dairying and food processing in the Caput Adriae: Mala Triglavca case study

We present the results of the organic residues analyses of pottery deposited in a stratified deposit at the Mala Triglavca rockshelter. The site is located on the Dinaric Karst in south-western Slovenia, 15km from the Northern Adriatic coast (Fig. 2). The site is still being excavated, but the pilot molecular and isotope analyses have already shown well-preserved lipid residues and the presence of dairy products (*Šoberl* et al. *2008*). The AMS ^{14}C dates show a long sequence of human agency from the 8th to the 3rd millennium calBC, combined with post-depositional disturbances of natural and geomorphological processes (*Mlekuž* et al. *2008*) (Fig. 4).

The evidence from the current excavations and associated soil/sediment analyses show that in the central part of the cave a well-defined stratigraphic sequence can be established, despite post-depositional modifications by soil-forming processes. There is, however, evidence of post-depositional disturbances of cave sediments by human agency and geological/geomorphological processes such as rotational slumps, as verified by the presence of distinct shear planes near the cave wall.

The sequences in the central part of the rock shelter consist of a series of thin white powdery layers interleaved with darker layers. This rhythmic depositional sequence can be interpreted as a series of occupation levels. Each occupation started with the preparation of a new floor, sometimes by using large platy stones to cover the previous heap of ash. Irregularities and depressions were filled with stones, so that the floors in the rock shelter were kept horizontal. At the end of occupation, organic debris was cleaned and the collected material heaped and burned; the result is a new heap of ash.

Nevertheless, there are some differences between occupational levels. The quantity of the deposited material varies vastly between levels. Some occupation levels are very simple, while others are quite elaborate, with well-paved surfaces made from large platy stones. In some levels, we have evidence of vertical elements that were part of the occupation floor. Thus, we have found several elaborately built circular stone structures. We have identified 25 occupation episodes so far, embedded in the time span of *c.* 5800 calBC (level 19) and *c.* 3500 calBC (level 1) so far (Tab. 1; Fig. 4).

The Neolithic and Eneolithic pottery assemblage of occupational levels 1 to 23 is comprised mostly of various types of bowls, but beakers, dishes and pots are also present, and most of these have a simple outline (Tab. 1; Fig. 5). According to their shape and decoration, most of the vessels from occupational level 6 onwards can be linked to the Vlaška pottery group as described by Lawrence Barfield (*1972*). The oldest pottery fragments appear as early as 5616–5525 calBC and have the same technological characteristics as the typical Vlaška pottery at the site, *i.e.* with local clays prepared with added crushed calcite (*Žibrat Gašparič 2004*). On the other hand, these oldest pottery fragments were mostly polished and undecorated, *i.e.* they do not exhibit typical Vlaška decorations.

We tested the hypothesis that dairying was an integral part of a mixed subsistence strategy from the initial Neolithic onwards by examining a range of pottery from the site. For the lipid analysis, we sampled 29 vessels from Mala Triglavca from contexts ranging from 5467–5356 to 4338–4261 calBC (Fig. 5; Tabs. 1 and 2). The samples were chosen according to their stratigraphic position, typology and decoration characteristics. The majority of samples (83.3%) are various types of bowls with incised ornaments or appliqués typical of the Vlaška group. The remaining samples were two pots and two deep dishes. The samples are all made of fabrics with added calcite grains as temper and are mostly fine-grained (75%), very fine-grained (20.8%); only one sample had a coarser-grained temper. The surfaces of the vessels were mostly burnished (54.2%) and polished (29.3%); smoothing is less common (16.7%). The surface colour of the vessels is predominantly light brown

Occupation level	Structures	Predominant types of food	$\delta^{13}C_{bulk}$ ±0.2 (‰)	Radiocabon date	Lab code
1				3690±40*	Poz–15343
2					
3					
4					
5					
6		freshwater fish (MaTr470)	–25,7		
7					
8				5530±60	Beta–23604
9		dairy (87MT)***; ruminant adipose fat (MaTr151)	MaTr151: –28,0	6960±170**	Poz–48531
10		dairy (MaTr130, MaTr137); ruminant adipose fat (MaTr112, MaTr115, MaTr116)	MaTr130: –27,8 MaTr137: –27,0 MaTr112: –25,6 MaTr115: –26,4 MaTr116: –24,9	6390±40	Poz–48530
11					
12		ruminant adipose fat (MaTr147)	–26,6	6320±40*	Poz–21395
13		ruminant adipose fat (MaTr159); mixed, plant (MaTr145)	MaTr159: –26,0 MaTr145: –26,2	5660±40**	Poz–48543
14	postholes	dairy (79MT, 161MT)***; mixed (MaTr53); mixed, plant (MaTr107)	MaTr53: –25,4 MaTr107: –26,3	6340±40	Poz–48539
15	circular structure	dairy (MaTr174); ruminant adipose fat (MaTr173, MaTr600)	MaTr174: –26,5 MaTr173: –25,9 MaTr600: –26,0	6940±40**	Poz–48542
16		mixed (159MT)***			
17				6400±40	Poz–48541
18				6410±40	Poz–48538
19	circular structure	dairy (MaTr602); freshwater fish (MaTr599); mixed, plant (MaTr606)	MaTr602: –26,3 MaTr599: –25,4 MaTr606: –23,0	6620±40	Poz–48540
20					
21					
22					
23	posthole, circular structure				
24	posthole				

* Date from Leben's excavations
** Stratigraphic/^{14}C inconsistency
*** Stratigraphic position based in correlation with Leben's excavated levels.

Tab. 1. The composite table presenting the occupational levels at Mala Triglavca, the AMS ^{14}C dates and the lipid residues from pottery.

(41.7%) and brown (20.8%), but dark brown, greyish black, light red and yellow surface colours are also present. The vessels were mostly fired in an incomplete oxidising atmosphere (54.2%), but some samples were also fired in an oxidising and a reducing atmospheres.

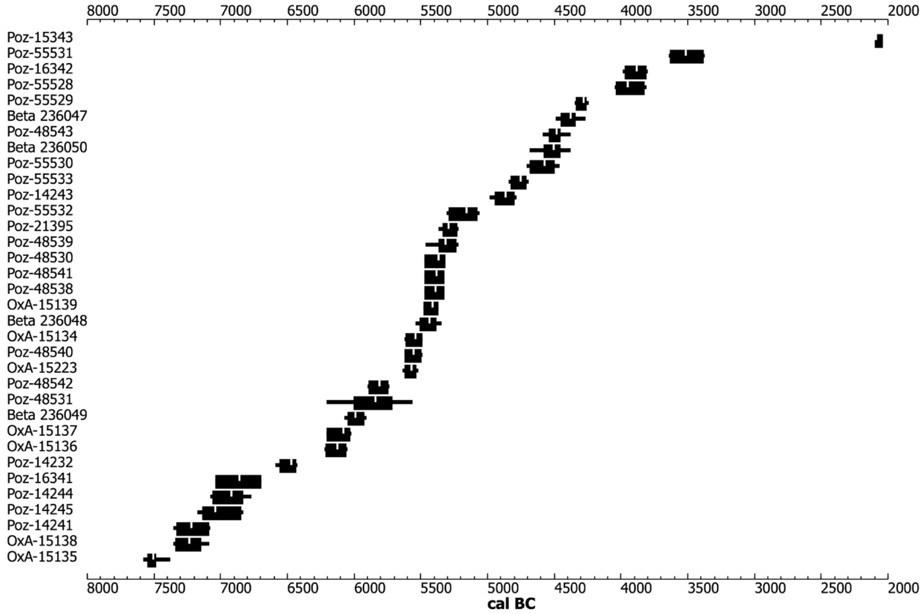

Fig. 4. The Mala Triglavca AMS ¹⁴C sequence.

Various types of decoration were present in 45.8% of the samples, but most of the vessels are undecorated (54.2%). The decoration techniques included incisions, appliqués and rare impressions, or a combination of these techniques. The motifs include: a band of hatched pendant triangles (samples MaTr112, MaTr470; Fig. 5.3), which is the most typical motifs of the Vlaška group (*Barfield 1972.202, Taf. 50.8–11*); a curvilinear garland motif (sample MaTr115; Fig. 5.2) and a plant motif (sample MaTr130; Fig. 5.4). The plant motif is rare in the Caput Adriae region, but appears mostly on typical Vlaška bowls (*Barfield 1972.202, Taf. 50. 15*). Similar decorations are known from the Trieste Karst area, such as on a bowl from layer 5 at Grotta degli Zingari/Ciganska jama (*Gilli, Montagnari Kokelj 1996.79, Fig. 16.72*) and on pottery from Grotta dei Ciclami/Orehova pejca (*Gilli, Montagnari Kokelj 1992(1993).75, Fig. 10.57, 63, Fig. 11.65*), but also from the Danilo culture site of Pokrovnik in Dalmatia (*Müller 1994.Taf. 9.5*). The garland motif is similar to a bowl with a curvilinear, incised decoration from Vlaška jama/Grotta del Pettirosso (*Barfield 1999.Fig. 3.21*), the eponymous site for the characterisation of the Vlaška group, and a similar decoration on a bowl is also known from Neolithic layer 5 of Grotta degli Zingari/Ciganska jama (*Gilli, Montagnari Kokelj 1996.75, Fig. 12.48*), which may have affinities with Linear Pottery culture (*Barfield 1999.30*).

Material and methods

We used all the 29 pottery fragments for chemical study lipid distribution including fatty acids, stable isotope composition (bulk $\delta^{13}C$ or $\delta^{15}N$, and $\delta^{13}C$ of individual fatty acids) and the di- and triacylglycerols (DAGs and TAGs) distribution of organic residues (Tab. 2). The sherds were surface cleaned to

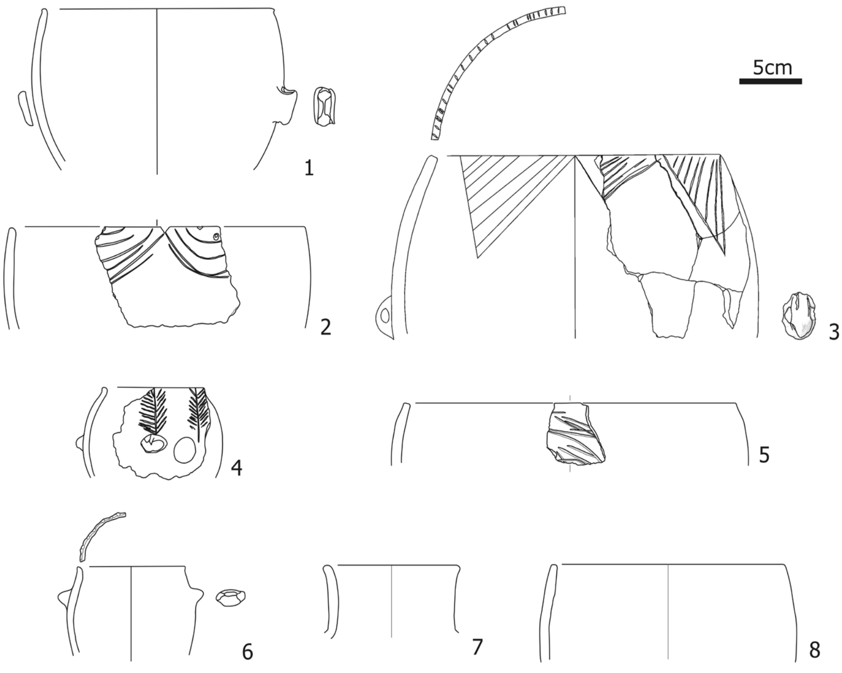

Fig. 5. Selected pottery samples for organic residue analysis from Mala Triglavca.

Lab. sample no.	Occupational level	Description	$\delta^{13}C_{bulk}$ ±0.2 (‰)	$\delta^{15}N_{bulk}$ ±0.3 (‰)	Lipid conc. (µg g^{-1})	$\delta^{13}C_{16:0}$ ±0.3 (‰)	$\delta^{13}C_{18:0}$ ±0.3 (‰)	$\Delta^{13}C$ (‰)	$C_{16:0}/C_{18:0}$	Mono-, di- and triacylgricerols	Fatty acids (FA)	Other lipids	Predominant commodity type
MaTr53	14	bowl	–25.4	4.6	8.62	–33.1	–32.6	0.50	2.6	n/d	$C_{16:0}$, $C_{18:1}$, $C_{18:0}$, $C_{20:0}$	WE	mixed
MaTr100	/	bowl	–26.4	5.4	22.1	–29.6	–30.4	–0.8	1.7	n/d	$C_{12:0}$, $C_{16:0}$, $C_{18:1}$, $C_{18:0}$, $C_{22:0}$	n/d	mixed
MaTr107	14	dish	–26.3	n/d	42.1	–33.4	–34.2	–0.8	1.9	n/d	$C_{12:0}$, $C_{15:obr}$, $C_{16:0}$, $C_{18:1}$, $C_{18:0}$, $C_{22:0}$	ALK, WE	mixed, plant
MaTr109	13	pot	n/d	n/d	6.56	n/d	n/d	n/d	n/d	n/d	n/d	n/d	n/d
MaTr112	10	bowl	–25.6	n/d	51.7	–29.7	–31.4	–1.7	1.7	DAG	$C_{16:0}$, $C_{18:1}$, $C_{18:0}$, $C_{22:0}$	CH, ALK	ruminant adipose fat
MaTr115	10	bowl	–26.4	9.4	60.5	–31.8	–32.9	–1.1	1.8	n/d	$C_{15:0}$, $C_{15:obr}$, $C_{16:0}$, $C_{18:1}$, $C_{18:0}$, $C_{22:0}$	CH, ALK	ruminant adipose fat
MaTr116	10	bowl	–24.9	n/d	38.7	–31.6	–33.4	–1.8	1.7	TAG	$C_{12:0}$, $C_{15:0}$, $C_{16:0}$, $C_{18:1}$, $C_{18:0}$, $C_{22:0}$	n/d	ruminant adipose fat
MaTr125	10	bowl	n/d	n/d	6.41	n/d	n/d	n/d	n/d	n/d	n/d	n/d	n/d
MaTr130	10	bowl	–27.8	5.4	19.1	–29.6	–33.1	–3.5	1.5	DAG, TAG	$C_{16:0}$, $C_{18:0}$	CH	dairy
MaTr137	10	bowl	–27.0	8.9	12.3	–29.5	–33.4	–3.90	2.5	DAG	$C_{16:0}$, $C_{18:1}$, $C_{18:0}$, $C_{20:0}$, $C_{21:0}$	n/d	dairy
MaTr145	13	bowl	–26.2	7.9	50.1	–31.9	–32.3	–0.4	0.4	DAG	$C_{12:0}$, $C_{15:0}$, $C_{16:0}$, $C_{18:1}$, $C_{18:0}$	ALK, OH, WE	mixed, plant
MaTr147	12	bowl	–26.6	7.8	8.02	–30.1	–31.8	–1.70	2.1	n/d	$C_{16:0}$, $C_{17:obr}$, $C_{18:1}$, $C_{18:0}$, $C_{21:0}$	ALK	ruminant adipose fat
MaTr151	9	bowl	–28.0	2.5	14.2	–29.0	–30.8	–1.80	2.7	DAG, TAG	$C_{12:0}$, $C_{16:0}$, $C_{17:obr}$, $C_{18:0}$, $C_{20:0}$, $C_{21:0}$	ALK	ruminant adipose fat
MaTr159	13	bowl	–26.0	8.2	12.6	–28.1	–30.6	–2.50	2.5	n/d	$C_{12:0}$, $C_{16:0}$, $C_{18:0}$, $C_{20:0}$, $C_{21:0}$	ALK, OH, WE	ruminant adipose fat
MaTr160	/	dish	n/d	n/d	3.08	n/d	n/d	n/d	n/d	n/d	n/d	n/d	n/d
MaTr173	15	pot	–25.9	n/d	17.6	–31.3	–32.9	–1.6	1.9	n/d	$C_{16:0}$, $C_{18:1}$, $C_{18:0}$, $C_{22:0}$	n/d	ruminant adipose fat
MaTr174	15	dish	–26.5	6.3	20.2	–30.1	–34.5	–4.40	3.3	DAG	$C_{16:0}$, $C_{17:obr}$, $C_{17:0}$, $C_{18:0}$	n/d	dairy
MaTr470	6	bowl	–25.7	10.3	11.0	–31.4	–29.0	2.40	2.5	DAG	$C_{16:0}$, $C_{18:1}$, $C_{18:0}$	ALK, WE	freshwater fish
MaTr555	3	bowl	n/d	n/d	7.37	n/d	n/d	n/d	n/d	n/d	n/d	n/d	n/d
MaTr599	19	bowl	–25.4	8.4	14.5	–32.1	–30.1	2.00	4.8	n/d	$C_{12:0}$, $C_{14:0}$, $C_{16:0}$, $C_{18:0}$, $C_{20:0}$	ALK, WE	freshwater fish
MaTr600	15	bowl	–26.0	n/d	46.7	–31.2	–32.5	–1.3	1.7	n/d	$C_{16:0}$, $C_{18:1}$, $C_{18:0}$	n/d	ruminant adipose fat
MaTr602	19	bowl	–26.3	9.7	11.5	–30.7	–34.1	–3.40	2.7	MAG, DAG, TAG	$C_{12:0}$, $C_{16:0}$, $C_{18:0}$, $C_{22:0}$	CH, ALK	dairy
MaTr605	19	bowl	n/d	n/d	3.33	n/d	n/d	n/d	n/d	n/d	n/d	n/d	n/d
MaTr606	19	bowl	–23.0	0.1	14.4	–30.9	–30.7	0.20	3.6	n/d	$C_{12:0}$, $C_{16:0}$, $C_{18:0}$, $C_{20:0}$, $C_{21:0}$, $C_{22:0}$	ALK	mixed, plant
79MT[1]	14–15[2]	bowl	n/d	n/d	30.0	–27.7	–31.1	–3.3	n/d	MAG, DAG, TAG	$C_{14:0}$, $C_{15:obr}$, $C_{16:0}$, $C_{17:obr}$, $C_{18:1}$, $C_{18:0}$, $C_{20:0}$	CH, ALK, OH	dairy
87MT[1]	8–10[2]	beaker	n/d	n/d	20.9	–27.3	–31.9	–4.6	1.6	n/d	$C_{16:0}$, $C_{17:obr}$, $C_{18:1}$, $C_{18:0}$, $C_{20:0}$, $C_{22:0}$	CH, ALK	dairy
156MT[1]	15–17[2]	pot	n/d	n/d	10.0	n/d	n/d	n/d	n/d	n/d	n/d	n/d	n/d
159MT[1]	15–17[2]	bowl	n/d	n/d	11.5	–28.8	–28.6	0.2	n/d	MAG, DAG, TAG	$C_{14:1}$, $C_{15:obr}$, $C_{16:0}$, $C_{17:obr}$, $C_{18:1}$, $C_{18:0}$, $C_{22:0}$	CH	mixed
161MT[1]	14–15[2]	bowl	n/d	n/d	42.4	–28.1	–33.2	–5.1	n/d	MAG, DAG	$C_{14:0}$, $C_{15:obr}$, $C_{16:0}$, $C_{17:obr}$, $C_{18:1}$, $C_{18:0}$, $C_{20:0}$	n/d	dairy

[1] Samples re-analysed, see *Šoberl* et al. *2008.257, Tab. 1*; [2] Stratigraphic position based in correlation with Leben's excavated levels.

Tab. 2. A summary of lipid residues detected in pottery vessels in Mala Triglavca. Key: MAG – moniacylglycerols; DAG – diacylglycerols; TAG – triacylglycerols; ALK – **n-*****alkanes; OH –*** **n-*****alcohols; WE – wax esters; CH –cholesterol; n/d – not detected.***

remove any exogenous lipids. The sub-samples were then ground to a fine powder. In addition, fat samples of modern cattle, sheep and cow that have been fed exclusively on C3 forage grasses on the Karst plateau were analysed in order to test the origin of the fat in the archaeological ceramics (Tab. 3).

First, powder samples were analysed by elemental analysis isotope ratio mass spectrometry (IRMS) using Europa Scientific IRMS with an ANCA-SL preparation module for solid and liquid samples (PDZ Europa Ltd, Crewe, UK) as previously reported (*Ogrinc* et al. *2012*). Each sample was acidified using 1 N HCl to remove carbonate minerals and dried. Stable isotope results are expressed as $\delta^{13}C$ or $\delta^{15}N$ values in per mil (‰) relative to the VPDB and AIR international standard, respectively. The precision of measurements was ±0.2‰ for $\delta^{13}C$ and 0.3‰ for $\delta^{15}N$.

The powdered material (2g sample) is then extracted by ultrasonication with an organic solvent (*e.g.*, chloroform/methanol, 2:1 v/v) and evaporated to dryness under a gentle stream of nitrogen to obtain the total lipid extract (TLE). One portion of extract was trimethylsilylated directly and analysed by high-temperature gas chromatography (HT GC) and where necessary combined gas chromatography/mass spectrometry (GC-MS) analyses were performed to identify the structure of components (*Evershed* et al. *1990*). Further aliquots of the TLE were methylated using BF3/methanol to obtain fatty acid methyl esters (FAMEs) (14%, w/v; 100µl; Sigma Aldrich, Gillingham, UK; at 70°C for 1h). The methyl ester derivatives were extracted with hexane and the solvent removed under nitrogen. FAMEs were re-dissolved in hexane for analysis by GC and GC-combustion-isotope ratio MS (GC-C-IRMS) using standard protocols (*Evershed* et al. *1994; Mottram* et al. *1999; Greg, Slater 2010; Ogrinc* et al. *2012*). GC-C-IRMS analyses were performed using an Isoprime GV system (Micromass, Manchester, UK). Modern samples were extracted by the same procedure. For GC-C-IRMS, the precision on repeated measurements was 0.3‰.

Sample	$\delta^{13}C_{16:0}$ ±0.3 (‰)	$\delta^{13}C_{18:0}$ ± 0.3 (‰)	$\Delta^{13}C$ (‰)	Location / citation
Sheep milk	−30,2	−36,2	−6,0	Divača Karst, local
Goat milk	−27,2	−32,6	−5,4	Divača Karst, local
Cow milk	−29,6	−37,5	−7,9	Divača Karst, local
Sheep curd	−27,2	−32,1	−4,9	Divača Karst, local
Sheep cheese	−27,6	−32,3	−4,7	Divača Karst, local
Sheep milk	−33,2	−39,0	−5,8	*Spangenberg* et al. *2006.7–8, Fig. 4*
Sheep milk	−33,2	−39,9	−6,7	*Spangenberg* et al. *2006.7–8, Fig. 4*
Sheep milk	−33,0	−40,0	−7,0	*Spangenberg* et al. *2006.7–8, Fig. 4*
Sheep milk	−33,9	−41,0	−7,1	*Spangenberg* et al. *2006.7–8, Fig. 4*
Cow milk	−29,6	−34,6	−5,0	*Richter* et al. *2012a.911, Tab. 3*
Goat milk	−27,2	−34,0	−6,8	*Spangenberg* et al. *2006.7–8, Fig. 4*
Goat milk	−28,0	−35,0	−7,0	*Spangenberg* et al. *2006.7–8, Fig. 4*
Sheep cheese	−30,8	−35,8	−5,0	*Spangenberg* et al. *2006.7–8, Fig. 4*
Sheep cheese	−29,8	−35,5	−5,7	*Spangenberg* et al. *2006.7–8, Fig. 4*
Goat cheese	−26,5	−30,5	−4,0	*Spangenberg* et al. *2006.7–8, Fig. 4*

Tab. 3. Means for stable carbon isotope composition of $C_{16:0}$ and $C_{18:0}$ in different dietary components of modern reference animal fats.

The third TLE aliquot was used to identify the di- and triacylglycerol (DAG, TAG) content, following the procedure described by Sigrid Mirabaud *et al.* (*2007*). TAG analyses were performed by hybrid quadruple time of flight mass spectrometer (Q-TOF Premier) provided with an orthogonal Z-spray ESI interface (ESI-MS; Waters Micromass, Manchester, UK) (*Ogrinc* et al. *2012*).

The bulk C and N isotope composition

The determination of the isotopic composition of carbon (C) and nitrogen (N) was possible in 19 samples. The average and standard deviation from potsherd samples are −26.1±1.1‰ and +6.8±2.9‰ for $\delta^{13}C$ and $\delta^{15}N$, respectively (Tab. 2). These data fall in the range expected for degraded animal and plant tissues whose subsistence was based mainly on C3 plants. The $\delta^{15}N$ values show greater variations compared to the $\delta^{13}C$ values.

We could discriminate three groups of samples on the basis of their $\delta^{15}N$ and $\Delta^{13}C$ values (*i.e.* $\delta^{13}C_{18:0}$ – $\delta^{13}C_{16:0}$). The first group has the highest $\Delta^{13}C$ values of >2.0‰ and were found in two samples (MaTr470 and MaTr599). Freshwater fish is the most likely component of residuals with the highest $\delta^{15}N$ value of +10.3‰ in sample MaTr470, while the lower value of +8.4‰ could indicate the presence of molluscs and crustaceans in sample MaTr599. The second group with $\delta^{15}N$ values between +0.1 and +5.4‰ and $\Delta^{13}C$ values of around 0‰ shows that these pots were probably used to process herbivore products and/or plant material (MaTr53, MaTr100, MaTr151, MaTr606). The $\Delta^{13}C$ values of the third group of samples indicate the presence of ruminant adipose and dairy fats (MaTr107, MaTr112, MaTr115, MaTr116, MaTr130, MaTr137, MatR145, MaTr147, MaTr159, MaTr173, MaTr174, MaTr600, MaTr602, 79MT, 87MT, 159MT, 161MT); and the $\delta^{15}N$ values ranged from +5.4 to +9.7‰. It should be noted that the $\delta^{15}N$ values of protein from terrestrial herbivores from temperate environments in Europe should not exceed 7.0‰ (*Richards* et al. *2003*). However, the protein derived from domestic animals can be higher (*Privat* et al. *2002; Polet, Katzenberg 2003; Richards* et al. *2003; Ogrinc, Budja 2005*). As most of the $\delta^{15}N$ values of our samples are higher than +7.0‰, we hypothesise that the protein derived mainly from domestic animals.

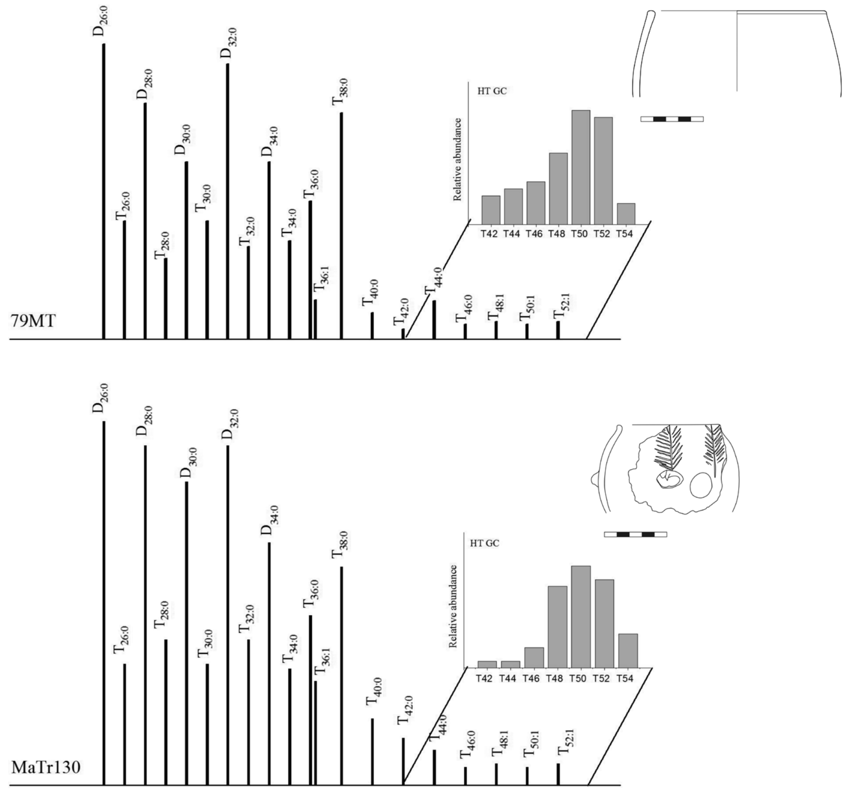

Fig. 6. HT GC and ESI Q-TOF MS mass distribution of the TAG fraction from the pottery samples 79MT and MaTr130 from Mala Triglavca.

The evidence of processing of dairy and other animal and/or plant products in pottery vessels was further investigated by lipid analysis. Lipid preservation was very good, with more than 80% of potsherds yielding an appreciable lipid concentration (Tab. 2).

Processing of dairy and other animal products

DAG and TAGs are indicative lipids of degraded animal fats and could help to differentiate between fats of ruminant and non-ruminant animals and ruminant dairy fats (*Kimpe* et al. *2002; Mirabaud* et al. *2007; Regert 2011*). The TAG analysis of modern fats exhibits two main distributions of TAGs: a narrow one that corresponds to non-ruminant adipose fats, and a broad one ranging from T_{40}/T_{42} to T_{54} that are characteristic of ruminant or dairy fats (*Dudd* et al. *1999; Mukherjee* et al. *2007*). The distribution with low quantities of T_{42}, T_{44} and T_{46} are attributed to ruminant adipose fats. It should be mentioned, however, that TAGs are likely to be preferentially degraded. Degradation pathways are not fully understood and might differ depending on the use and burial environment. Therefore, TAG distribution has to be considered as preliminary information to assess the origin of fats.

The identification of TAGs in our samples was first performed with HT GC-MS. MAGs, DAGs and TAGs were detected in 12 samples, together with relatively high amounts of $C_{16:0}$ and $C_{18:0}$ fatty acids. A relatively broad TAG distribution in the range from T_{44} to T_{54}, maximising at T_{50} or T_{54}, was observed in five samples (159MT, 79MT, MaTr130, MaTr174, MaTr602) indicating the presence of ruminant adipose or dairy fats. Two samples (MaTr115, MaTr174) presented a narrower distribution, from T_{50} to T_{54}, indicating the presence of ruminant adipose fats.

The identification of original products was further examined by ESI Q-TOF MS and ESI-MS/MS methods to obtain more information about the structure of TAGs. This method enables the TAGs identification down to T_{28} and could be used to detect dairy fats (*Garnier* et al. *2007; Mirabaud* et al. *2007; Regert 2011*) since the HT GC could not detect TAGs under T_{40}. The distribution of TAGs obtained by ESI Q-TOF MS was possible only for three samples (MaTr115, MaTr130, 79MT). The TAGs distribution in MaTr115 was closer to that observed by HT GC: T_{42} – T_{52} instead of T_{50} – T_{54} (T_{54} was not detected by ESI Q-TOF MS probably due to its poor ionisation yield).

In the other two samples, 79MT and MaTr130, a large TAG distribution from T_{28} to T_{52} was observed, which indicates the presence of dairy fat products (Fig. 6). The comparison of these TAG and DAG distributions with data on goat versus cow milk favours goat milk (*Mirabaud* et al. *2007*). A more precise differentiation between cow and goat milk could be obtained from fatty acid distribution in $T_{44:0}$ using ESI-MS/ MS fragmentation, but this was not possible due to the low quantity and poor ionisation yield of $T_{44:0}$ in our sample; thus a more precise discrimination of the specific origin of dairy fat could not be performed.

The stable carbon isotope composition of individual fatty acids is a complementary tool in determining the origin of residues in ancient pottery vessels. In Figure 7, we present the $\delta^{13}C$ values of modern reference animal fats of both Neolithic domesticates and the animals that are actually bred in the region, as well as the values from the Mala Triglavca pottery samples. The $\delta^{13}C_{16:0}$ and $\delta^{13}C_{18:0}$ values in different reference animal fats ranged from –37.5 to –27.2‰ (Tab. 2). The modern reference animals (cow, sheep and goat) were fed exclusively on C3 local forage grasses. The theoretical mixing curves were determined from the modern reference animal fats, as in Simon E. Woodbury *et al.* (*1995*), to illustrate the $\delta^{13}C$ values which would result from mixing sheep and porcine fats in the vessels. Each dot in Figure 7 indicates the effect of mixing a specific percentage of each of the respective commodities and their influence on the $\delta^{13}C_{16:0}$ and $\delta^{13}C_{18:0}$ values. It should be further mentioned that modern dairy ruminant fats (milk, butter and cheese; see Tab. 3) have higher $\delta^{13}C_{16:0}$ and $\delta^{13}C_{18:0}$ values compared to adipose fats, which can be explained by the distinct metabolic pathway of milk fatty acids. The $C_{16:0}$ fatty acid is the major fatty acid produced from fermenting dietary sugars, while the $C_{18:0}$ fatty acid derives mainly from dietary plant fatty acids. These different sources explain why the values are up to 7.9‰ lower $\delta^{13}C_{18:0}$ compared to $\delta^{13}C_{16:0}$. In addition, the $\delta^{13}C_{16:0}$ and $\delta^{13}C_{18:0}$ values in sheep cheese and curd are enriched in ^{13}C relative to the raw milk samples. This enrichment is probably the consequence of the bacterial degradation of long-chain fatty acids during cheese or curd production and storage. These data are in good agreement with the published data on reference modern animal fats (*Spangenberg* et al. *2006; Richter* et al. *2012a; 2012b*).

Since the data points plot between the reference animal fat fields presented in Figure 7, extensive mixing of animal products could be identified. The $\delta^{13}C_{16:0}$ and $\delta^{13}C_{18:0}$ values from four samples (MaTr130, MaTr137, MaTr602, 161MT) plot within the area of the mixture between adipose and dairy fats, while another seven samples (MaTr145, MaTr147, MaTr-159, MaTr173, MaTr600, 79MT, 87MT) plot within the reference ruminant adipose fat. Further four samples (MaTr100, MaTr112, MaTr151, 159MT) plot in the area between porcine and ruminant adipose fat, and the remaining seven samples (MaTr53, MaTr107, MaTr115, MaTr116, MaTr470, MaTr599, MaTr606) do not plot along any of the theoretical mixing curves, thus suggesting an admixture of fats of different origins and different degrees of degradation. Only one sherd plots in the area of dairy fat (MaTr174).

A more precise differentiation between non-ruminant adipose, ruminant adipose and ruminant dairy fats can be obtained in the diagram, where $\Delta^{13}C$ values ($\delta^{13}C_{18:0}$–$\delta^{13}C_{16:0}$) are plotted against the $\delta^{13}C_{16:0}$ values (Fig. 8). $\Delta^{13}C$ values of lower than –3.3‰ are used as a criterion for determining dairy foods (*Evershed* et al. *2002; 2008; Copley* et al. *2003; 2005; Mukherjee* et al. *2007; Dunne* et al. *2012*). Four ves-

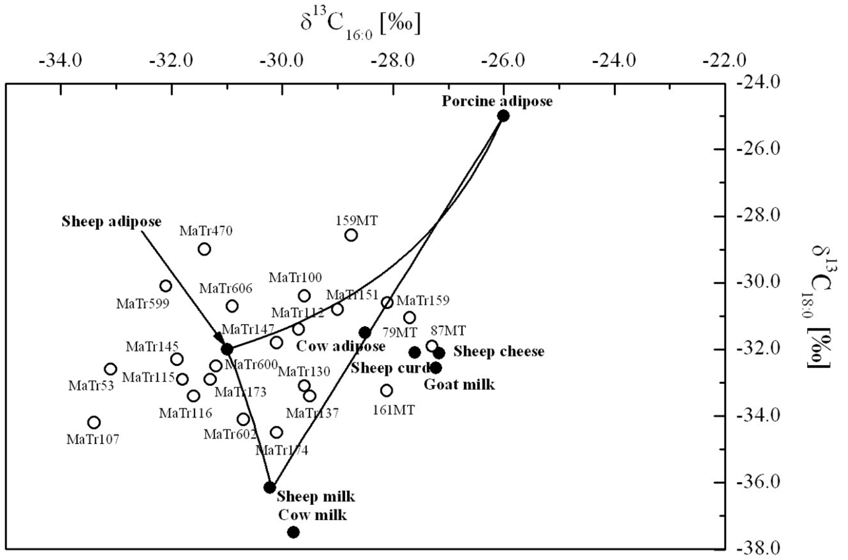

Fig. 7. Plot of the $\delta^{13}C$ of $C_{18:0}$ and $C_{16:0}$ fatty acids of modern reference fats and the lipid extracts of potsherds from Mala Triglavca (see Tabs. 2 and 3). Open circles represent the archaeological fats. The theoretical mixing curve was determined as in Woodbury **et al.** ***(1995) to illustrate $\delta^{13}C$ values resulting from the mixing of these fats.***

sels from Mala Triglavca (MaTr174, MaTr137, 161MT, 87MT) are plotted in this region, while another three (MaTr130, MaTr602, 79MT) are plotted on the border of two ranges, thus suggesting mixing of different types of fats during pottery use. In total, 30% of the pottery samples contained lipids characteristic of dairy fats, indicating that the processing of dairy products in vessels was quite extensive during the Neolithic period at Mala Triglavca.

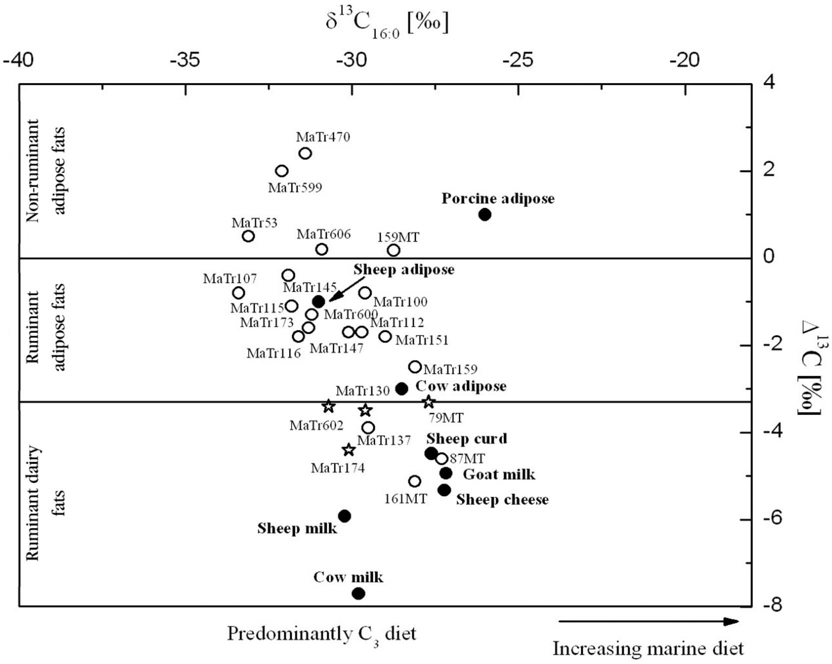

Fig. 8. Plot showing the difference in the δ13C values of $C_{18:0}$ and $C_{16:0}$ fatty acids (Δ13C) versus δ13C16:0 recovered from pottery extracts from Mala Triglavca and modern reference fats (see Tabs. 2 and 3). The ☆ represent those with typical degraded dairy TAG distribution.

As presented in Figure 8, 43% of pottery samples plot in the range for ruminant adipose fats. The $C_{16:0}/C_{18:0}$ ratios of fatty acids for these samples range between 1.3 and 2.0 (Tab. 2), which is typical for ruminant adipose fat (*Copley* et al. *2005*). The $\delta^{15}N$ values suggest that people at Mala Triglavca used diverse domesticated animal products (from cattle, sheep and goats) in their diet. A further 17% of the samples (MaTr53, MaTr145, MaTr606, 159MT) fall close to the limit value between non-ruminant and ruminant meat ($\Delta^{13}C$ = 0‰). However, the later samples may not be assigned exclusively to meat mixtures, but also to a mixture of plant and animal fats. Two of the samples (MaTr470, MaTr599) plot in the area of non-ruminant fats, and their high $\delta^{15}N$ values of +8.4 and 10.3‰ (Tab. 2) suggest the presence of fresh-water organisms such as molluscs and fish fats. No evidence of porcine fat was found in the pottery when observing the $\delta^{13}C$ values of $C_{16:0}$ and $C_{18:0}$ fatty acids.

Processing of plant and beeswax products

The evidence of plant lipids in pottery vessels can be detected by a homologous series of long chain *n*-alkanes C_{16}–C_{33} (odd-over-even carbon number predominance), *n*-alcohols, β-sitosterols and palmitic and stearic wax esters (C_{40}–C_{52}) (*Bianchi 1995*). Some or all of these compounds were also detected in 14 pottery samples, although always in low amounts. Six samples (MaTr53, MaTr107, MaTr145, MaTr470, MaTr599, MaTr606), were associated with non-ruminant or mixed adipose fats, five samples (MaTr112, MaTr115, MaTr145, MaTr151, MaTr159) were associated with ruminant adipose fats and three samples (79MT, 87MT, MaTr602) with dairy fats, suggesting that the pots were used for mixed food processing and storage. Sample MaTr606 was used mainly for preparing or storing plant foods, which can be proven by the highest abundance of $C_{16:0}$, high $C_{16:0}/C_{18:0}$ ratio of 3.6 and the lowest $\delta^{15}N$ value of +0.1‰. Overall, 48% of the pottery vessels contained plant lipid components, indicating the importance of plants in the Mala Triglavca population diet.

The presence of wax esters, characteristic of beeswax, may indicate the addition of honey to other food or the application of beeswax to pottery vessels to improve their impermeability (*Regert* et al. *2001; Evershed* et al. *2003; Copley* et al. *2005*). Six pottery samples contained beeswax-derived lipids; two of them also yielded evidence of fresh-water fish (MaTr470, MaTr599) and a further four samples contained animal fats and beeswax (MaTr107, MaTr145, MaTr53, MaTr159). Although the quantity is relatively low (21% of all of the samples), it indicates that this particular commodity was utilised in the Mala Triglavca vessels associated with cooking/processing food, or applied as a coating, which made them waterproof and more resistant.

Different use of vessels

The results obtained from lipid analyses indicate markedly different uses of the Mala Triglavca pottery. It was found that 30% of sampled pottery contain lipids characteristic of dairy fats (MaTr174, MaTr137, 161MT, 87MT, MaTr130, MaTr602, 79MT), indicating that the processing of dairy products in pottery vessels was quite extensive. The TAG distributions in samples MaTr130 and 79MT showed the residues of dairy products that probably derived from goat milk. We have found evidence that five vessels were used to process only animal fats either of ruminant origin (MaTr116, MaTr173, MaTr600) or a mixture of ruminant and non-ruminant origin (MaTr53, MaTr100). However, none of the total lipid extracts contained porcine adipose fat. The appearance of both animal and plant biomarkers observed in 14 pottery samples (see Tab. 2) suggests mixed food processing and storage. Only one of them (MaTr606) was mainly used in preparing or storing plant foods. Moreover, our results show that some vessels were also used to process aquatic organisms such as molluscs and fish (MaTr470, MaTr599). The presence of beeswax in some of the vessels suggests the storage and use of honey or, more probably, the use of beeswax for waterproofing.

The lipid analysis of Neolithic vessels from Mala Triglavca showed a variety of different foods prepared and consumed at the site (Tab. 2). If we look closely at the most common vessels type at the site, *i.e.* the Vlaška bowl, we can observe that lipids of ruminant adipose and dairy fats are the most common residue, but freshwater fish, plants and a mixture of different fats were also detected in the bowls. Therefore, we may conclude that these bowls had no specific function, but were rather treated as universal vessels for preparing and consuming a variety of different foods. Typical Vlaška bowls also contained lipids derived from beeswax, which can indicate the technique of applying beeswax to waterproof vessels, but can also suggest the use of honey in food preparation. Other types of vessel showed the use of ruminant adipose and dairy fats in dishes (MaTr107, MaTr174) and ruminant fats in one pot from Mala Triglavca (MaTr173).

The remains of dairy lipids were detected in 29% of the samples, most of them Vlaška bowls (MaTr130, MaTr137, MaTr602, 79MT, 161MT), but also in a beaker (87MT; *Mlekuž* et al. *2008.247*) and a dish (MaTr174), well embedded in the time span 5467–5227 calBC. Sample MaTr130 with an incised plant motif and sample 161MT with incised pendant triangles (Fig. 5.3–4) (*Mlekuž* et al. *2008. Fig. 6; Šoberl* et al. *2008.Tab. 1*) are two of the most prominent Vlaška vessels with preserved dairy fats from the site.

Conclusions

The Mala Triglavca case study shows that the Early Neolithic economy in Caput Adriae was mixed. It consisted of both milk and processed milk (low-lactose food), meat (ruminants and non-ruminants) animal products, and fresh-water fish and various plants. The Vlaška group herders managed a broader spectrum of resources than ovicaprids alone, and by fermenting milk they were able to produce a wide range of low-lactose, storable products.

Archaeological and biochemical data suggest that dairying was adopted in the Early Neolithic in Europe. Archaeogenetic data show, on the contrary, the absence of the allelic variant -13 910*T in Neolithic populations in Europe, and that their lactase persistence was very low and may have even been zero. Thus pastoralism appeared before lactase persistence arose or became frequent. We may assume, therefore, that under normal circumstances lactase persistence is not necessarily under very strong selection in these populations and fits with the hypothesis that dairying, milk consumption and fermented milk consumption emerged before the genetic adaptation.

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The beginnings of dairying as practised by pastoralists in ‘green’ Saharan Africa in the 5th millennium BC

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ABSTRACT – *Previous research has identified the antiquity and chronology of dairying practices as beginning in the Near East and its subsequent spread across Europe. In the Libyan Sahara, archaeological evidence, confirmed by the remarkable rock art depicting cattle herding, together with faunal evidence, also suggests an early inception of dairying practices in North Africa and the formation of an independent ‘secondary products’ economy by mobile pastoral groups. In this paper, we elaborate on the first unequivocal chemical evidence, based on the* $\delta^{13}C$ *and* $\Delta^{13}C$ *values of the major fatty acids of milk fat, for the adoption of dairying practices by prehistoric Saharan African people in the fifth millennium BC.*

IZVLEČEK – *Predhodne raziskave so pokazale, da je najstarejši začetek uporabe mleka vezan na območje Bližnjega Vzhoda, od koder se je potem širila v Evropo. Arheološki podatki iz libijske Sahare, podprti z izjemnimi upodobitvami pastirjev z govedom v skalah in z živalskimi ostanki na najdiščih, kažejo na zgodnjo uporabo mleka v Severni Afriki in na neodvisno gospodarstvo ‘sekundarnih produktov’, ki so ga oblikovale mobilne pastirske skupine. V članku predstavljamo prve nedvoumne kemijske dokaze, ki temeljijo na vrednostih* $\delta^{13}C$ *in* $\Delta^{13}C$ *glavnih mlečno-maščobnih kislin, o usvojitvi mlečno-gospodarskih praks prazgodovinskih ljudi v saharski Afriki v petem tisočletju pr. n. št.*

KEY WORDS – *dairying; North Africa; Sahara; Tadrart Acacus; pottery; hunter-gathers; herders; cattle; rock art; stable carbon isotopes; fatty acids*

Introduction

In African prehistory, it is widely accepted that the existence of pastoralism (using domesticated cattle, sheep and goats) as an established and widespread way of life emerged long before plant domestication (*Marshall, Hildebrand 2002*). This is in contrast to the process of ‘Neolithisation’ beginning in the Near East, characterised by the transition from a mobile hunter-gatherer lifestyle to an increasingly settled, agricultural way of life. With the domestication of plants and animals such as cattle, sheep, goats and pigs, and the adoption of these new subsistence practices in the Near East, this sedentary, farming way of life spread outwards across Europe and into the British Isles.

In Saharan Africa, extremely favourable climatic and environmental conditions prevailed during the Holocene African Humid Period which began around 10000 years ago (*e.g., de Menocal* et al. *2000; Gasse 2000; Cremaschi* et al. *2010*). The strengthening of northern hemisphere summer insolation due to earth orbital changes resulted in a shifting of the African monsoon hundreds of kilometres to the north, leading to an intensive recharge of large water bo-

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dies such as Lake Mega-Chad and Lake Mega-Fazzan. Rock art and faunal remains confirm the presence of abundant savannah and lake margin fauna such as elephant, hippopotamus, giraffe and crocodile at this time, inhabiting a mosaic of savannah and woodland vegetation (*Brooks* et al. *2005; Mercuri 2008; Cremaschi, Zerboni 2009; Cremaschi* et al. *2010; Drake* et al. *2011*).

Fig. 1. Rock art image of domesticated cattle, between 5000 and 8000 years old, from Tagg'n Tort, in the Tadrart Acacus Mountains, Libyan Sahara. (Photo by Filippo Gallino; The Archaeological Mission in the Sahara, Sapienza University of Rome).

During these prevailing favourable climatic conditions in the Early Holocene, prehistoric peoples in the Libyan Sahara lived as primarily sedentary and pottery-producing hunters, fishers and gatherers, exploiting different environments and resources. Towards the end of the Early Holocene period, we see the advent of food production (throughout the Sahara) with the adoption of bovids and ovicaprids (*Cremaschi, di Lernia 1999; Garcea 2004; Brooks* et al. *2005; Cremaschi, Zerboni 2009; di Lernia 2013*).

The development of African subsistence strategies would likely have been heavily shaped by the drying conditions beginning in the Middle Holocene, which led to the unstable, marginal environments that Saharan hunter-gatherers inhabited. As conditions deteriorated and aridification took hold (*Brooks* et al. *2005; Cremaschi, Zerboni 2009; Cremaschi* et al. *2010*), the previously semi-sedentary prehistoric groups became nomadic cattle herders (*di Lernia 2002*) moving seasonally in response to climatic conditions. Then, predictable access to resources would surely have been their major concern, rather than the intensification of yield more applicable to early farmers in the Levant (*Marshall, Hildebrand 2002*).

Secondary products and the dairying revolution

Some thirty years ago, Andrew Sherratt (*1983*) argued that, several millennia after the beginning of the development of animal husbandry in the Near East, another innovation in animal exploitation occurred, that of the intensive use of secondary products, such as milk, blood, wool and traction, which can be repeatedly extracted from an animal throughout its lifetime. It is now generally agreed that the exploitation of secondary products probably began earlier, likely during the first spread of farming (*Sherratt 2006*), although it is increasingly becoming clear that the adoption and development of dairying as part of a subsistence strategy may have been a piecemeal process, developing in varying ways depending on local environmental conditions and different cultural groups (*Evershed* et al. *2008*). Direct evidence for the practice of dairying, beginning in the 7th millennium BC in northwestern Anatolia (*Evershed* et al. *2008*), appearing in the 6th millennium BC in eastern Europe (*Craig* et al. *2005*) and reaching Britain in the 4th millennium BC (*Copley* et al. *2003; Dudd, Evershed 1998*) has been established through the compound-specific stable carbon isotope analysis of animal fat residues preserved in archaeological pottery. Significantly, this research on the antiquity of dairying practices has largely been confined to Europe, the Near East and Eurasia, with no attempt yet being made to identify the inception of dairying practices in the African continent. In the Libyan Sahara, however, the rock art and faunal evidence (*e.g., Mori 1965; Cremaschi, di Lernia 1998; di Lernia, Zampetti 2008*) suggests that the inception of dairying practices in north Africa and an early and independent 'secondary products' economy (*Sherratt 1983*) seems plausible given what we now know of the first appearance of milking in the Near East (*Evershed* et al. *2008*).

Rock art and cattle

Compelling evidence (not seen in European contexts) of prehistoric cattle herding in northern Africa comes from the remarkable rock paintings and engravings of the Sahara (Fig. 1), possibly one of the world's highest concentrations of prehistoric art, and long known for their rich and vivid portrayal of astonishing scenes from everyday life. The extensive rock art, probably originating from *c.* 10 000 years ago, demonstrates that cattle clearly played a significant part in the lives and ideology of ancient human groups living in this region during the Holocene. The most widespread representations, with hundreds of decorated sites having been identified throughout the Sahara, are of domestic cattle and it is thought this 'style' (with many internal regional variants), generally associated with Pastoral Neolithic groups, may have persisted for a very long period, from around 7000–4000 uncal BP (*e.g., di Lernia, Gallinaro 2010; Gallinaro* et al. *2008; Le Quellec 1998; Lutz, Lutz 1995*). This pictorial record contains countless scenes with representations of cattle, some emphasising the female's full udders and, in a few cases, depictions of the actual milking of a cow, such as at Wadi Teshuinat II (*Gallinaro* et al. *2008*) in the Acacus or Wadi Tiksatin in the Messak (*Lutz, Lutz 1995*). However, reliable dates for this rock art can rarely be ascertained (*di Lernia, Gallinaro 2010*) and thus, although highly suggestive of the existence of dairying practices by prehistoric herders in the region, cannot provide an accurate chronology of its uptake.

Faunal remains from securely dated Saharan contexts also indicate that domesticated animals (cattle, sheep or goats) were present in the area from the end of the 8th millennium BP (*di Lernia 2013*), becoming much more common in the 5th millennium BC (*Gautier 2002; Gifford-Gonzalez, Hanotte 2011*). In European contexts, the reconstruction of the age profile of domesticated animals (which reflects herding strategies) excavated from archaeological sites enables the identification of kill-off patterns (*Payne 1973; Vigne, Helmer 2007*). Unfortunately, in the Libyan Sahara, these remains are very poorly preserved and highly fragmented, precluding such herd reconstructions; thus even indirect evidence of dairying is missing (*Gautier 2002*).

The archaeological evidence comprising the rock art, faunal remains and ceramic assemblages suggests that we might hypothesise that these prehistoric herders were exploiting their cattle for their secondary products. Thus, a biomolecular approach, where lipid residues are extracted from Saharan ceramics (Fig. 2), has the potential to ascertain the chronology and location of the inception of dairying practices beginning in northern Africa.

Biomolecular archaeology and lipids

The field of biomolecular archaeology can be defined as the study of biological molecules surviving from antiquity which yield information relating to past human activity (*Evershed 1993; 2008*). Over the last decades, analytical methodologies have been developed to investigate and identify 'archaeological biomarkers' in biomolecules such as ancient DNA, protein, carbohydrates, pigments and lipids. Lipids, the organic solvent soluble components of living organisms, *i.e.* the fats, waxes and resins of the natural world, are the most frequently recovered compounds from archaeological contexts (*Evershed 1993; 2008*). They are also resistant to decay and are likely to endure at their site of deposition because of their inherent hydrophobicity, making them excellent candidates for use as biomarkers in archaeological research (*Evershed 1993; 2008*).

Pottery has become one of the most extensively studied materials for organic residue analysis (*Mukherjee* et al. *2005*) as ceramics, once made, are virtually indestructible and therefore among the most common artefacts recovered from archaeological sites from the Neolithic period onwards (*Tite 2008*). These residues survive in three ways; rarely, actual contents are preserved in situ (*e.g., Charrie-Duhaut* et al. *2007*) or, more commonly, as surface residues (*Evershed 2008*). The most common form is that of absorbed residues preserved within the vessel wall, which have been found to survive in >80% of dome-

Fig. 2. Middle Pastoral restored vessels from the Murzuq dunefield (*c. *6000–5000 uncal BP).

stic cooking pottery assemblages worldwide (*Evershed 2008*).

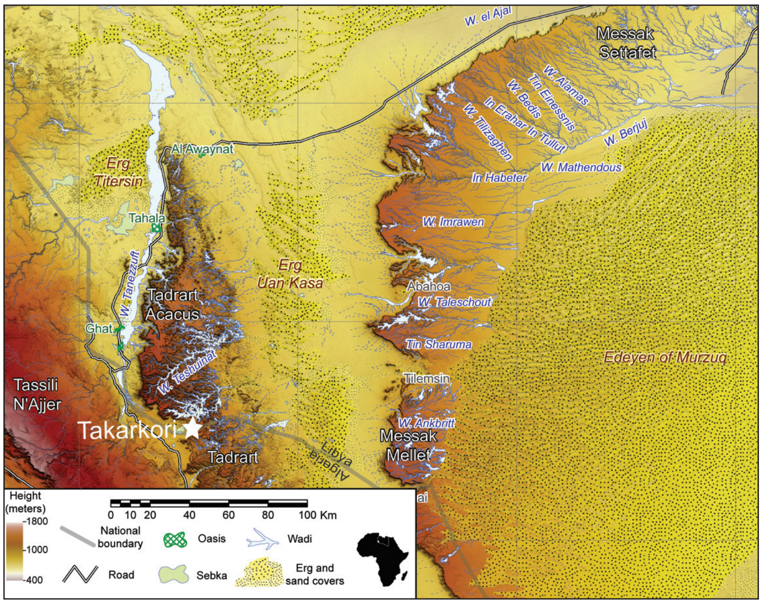

Fig. 3. The Takarkori rockshelter shown in the region of the Messak plateau and surroundings (modified, from* di Lernia *et al.* 2013*).

The analysis of lipid components of visible or absorbed organic residues found in archaeological pottery has to date allowed the identification of a considerable range of substances such as terrestrial animal fats (*Evershed* et al. *1997a; Mottram* et al. *1999*), marine animal fats (*Copley* et al. *2004; Craig* et al. *2007*), plant waxes (*Evershed* et al, *1991*), beeswax (*Evershed* et al. *1997b*), birch bark tar (*Charters* et al. *1993a; Urem-Kotsou* et al. *2002*) and palm kernel oil (*Copley* et al. *2001*). However, preserved animal fats are by far the most commonly observed constituents of lipid residues recovered from archaeological ceramics. A range of chemical criteria, including saturated fatty acid compositions, double bond positions, triacylglycerol distributions and $\delta^{13}C$ have been used to assign the origin of ancient animal fats to domesticated animals such as cattle, pigs and sheep and goats (*Copley* et al. *2003; Dudd, Evershed 1998; Mottram* et al. *1999*). These techniques have allowed the fats from ruminant and non-ruminant animals to be distinguished, but it was the establishment of a stable carbon isotope approach which allowed the identification of ruminant adipose and dairy fats resting on differences in the $\delta^{13}C$ values of the principal fatty acids (C_{16} and C_{18}) that are present in all animal fats, and this technique has therefore been of considerable value in answering many archaeological questions regarding ancient economies. This method is based on the fact that the differential routing of dietary carbon and fatty acids during the synthesis of adipose and dairy fats in ruminant animals results in different $\delta^{13}C$ values for the two saturated fatty acids produced (*Dudd, Evershed 1998*).

Site and samples

The Takarkori site is a large rock shelter some 80m long and approx. 10 to 15m deep, lying 100m above a dry river valley. It is located in the Tadrart Acacus massif, which is situated in the Central Sahara, in the south-western corner of Libya, close to the Algerian border (Fig 3.) (*Biagetti, di Lernia 2007; Biagetti* et al. *2004; Biagetti, di Lernia 2013*).

The Tadrart Acacus is a sandstone mountain range traversed by several wadis that run from west to east. Several rock shelters serving as human occupations since the late Pleistocene are located along the wadis (*Barich 1987; Cremaschi, di Lernia 1999*).

This region (see Fig. 3) has been licensed to the 'Italian-Libyan Archaeological Mission in the Acacus and Messak' under the control of the University of Rome La Sapienza and the Department of Antiquities, Tripoli. Research began here in 1955, originally focused on rock art, but later expanding into excavations of single stratified rock shelters such as Ti-n-Torha, Uan Muhuggiag, Uan Tabu and Uan Telecat (*Mori 1965; Barich 1987; Cremaschi, di Lernia 1998*). In the 1990s, a landscape approach was adopted, using systematic extensive surveys, which has gathered a large dataset relating to landscape exploitation, settlement patterns, rock art, genetics and burial customs within Holocene cultural trajectories, all of which have led to crucial insights into the prehistory of this part of the Sahara. Additional excavations also took place at stratified shelters in the Acacus, such as Uan Afuda, Uan Tabu and Takarkori (*Cremaschi, di Lernia 1998; di Lernia 1999; Garcea 2001; Biagetti, di Lernia 2013*).

This long period of extensive research in the region has provided an understanding of the development of human subsistence strategies within the region and led to the development of a model of cultural trajectories (*e.g., Cremaschi, di Lernia 1999*). The two cultural horizons within the Early Holocene based on extractive economies are named Early and Late Acacus. Early Acacus hunter-gatherers specialised in hunting Barbary sheep from multi-activity base camps within the Acacus and small site hunting stations near lakes in the lowlands (*Barich 1987; di Lernia 1996; Cremaschi, di Lernia 1998; Garcea 2001*). The Late Acacus was marked by a more sedentary lifestyle, with a broader subsistence base largely founded on plant resources, and the introduction of grinding equipment and ceramic technology (*Barich 1987; di Lernia 1999; Garcea 2001; Biagetti, di Lernia 2007*). Some animal management (corralling and delayed use) of Barbary sheep also appears to take place at this time (*di Lernia 2001*).

The subsequent 'Pastoral' or Neolithic horizon consists of four phases, Early, Middle, Late and Final Pastoral (*di Lernia 1999; di Lernia, Merighi 2006*). These stages cover the Holocene and denote the adoption of cattle and sheep/goats, together with intensive exploitation of wild cereals (*Mercuri 2008*). In the Early Pastoral period, sedentism (in the mountains) remained high, with the settlement pattern in the Middle Pastoral being characterised by the seasonal exploitation of different environments, with the herding of cattle through a transhumant lifestyle through summer semi-residential sites in the lowlands to winter sites in the mountains (*Cremaschi, di Lernia 1999; di Lernia 2002*). In the Late and Final Pastoral period (5th–4th millennium BP), increasingly arid conditions denote a move to long-distance specialised nomadism with sheep and goats (*di Lernia 1999; di Lernia, Merighi 2006*).

The Takakori rock shelter was chosen for excavation because of the remarkable preservation of its archaeological deposit (about 1.6m in depth) over a large area. Fieldwork identified evidence of a long and protracted human occupation covering the Late Acacus (Mesolithic) period, together with Early, Middle and Late Pastoral (Neolithic) remains. Radiocarbon dating fixes the layers between 8800 to 4200 years uncal BP, demonstrating more than 4000 years of human occupation (*Biagetti, di Lernia 2007; 2013*).

Sherd number	Lab Code	Period	Lipid concentration (ug/g)	$\delta^{13}C_{16.0}$	$\delta^{13}C_{18.0}$	$\Delta^{13}C$	Classification
21	TAK21A	Middle Pastoral	5830.6	−14.7	−20.5	−5.8	Dairy Fat
26	TAK1	Middle Pastoral	760.7	−14.2	−15.0	−0.9	Ruminant adipose
45	TAK45	Middle Pastoral	639.8	−21.9	−24.1	−2.1	Ruminant adipose
120	TAK120	Middle Pastoral	5592.7	−15.2	−18.7	−3.5	Dairy Fat
124	TAK124	Middle Pastoral	1615.5	−18.1	−20.1	−2.0	Ruminant adipose
197	TAK197	Middle Pastoral	151.5	−20.9	−21.1	−0.2	Non-ruminant adipose
420	TAK420	Middle Pastoral	1119.3	−18.3	−21.5	−3.2	Dairy Fat
443	TAK443	Middle Pastoral	17217.6	−16.9	−23.7	−6.8	Dairy Fat
576	TAK6	Middle Pastoral	800.2	−22.0	−21.7	0.3	Non-ruminant adipose
748	TAK9	Middle Pastoral	5650.5	−13.7	−19.0	−5.2	Dairy Fat
824	TAK11	Late Pastoral	4994.2	−20.5	−24.9	−4.4	Dairy Fat
873	TAK873	Middle Pastoral	71.8	−18.5	−17.7	0.8	Non-ruminant adipose
896	TAK896	Middle Pastoral	218.0	−23.6	−25.0	−1.5	Ruminant adipose
987	TAK987	Middle Pastoral	4442.6	−13.6	−19.3	−5.7	Dairy Fat
997	TAK15	Middle Pastoral	1117.4	−13.3	−17.4	−4.1	Dairy Fat
1009	TAK1009	Middle Pastoral	1555.7	−11.0	−11.0	0.0	Non-ruminant adipose
1012	TAK1012	Middle Pastoral	3591.2	−14.9	−16.5	−1.7	Ruminant adipose
1572	TAK1572	Middle Pastoral	3148.5	−23.7	−28.2	−4.5	Dairy Fat
1693	TAK21	Late Acacus	20.1	−23.1	−19.8	3.3	Non-ruminant adipose
1797	TAK24	Early Pastoral	1674.6	−21.9	−21.0	0.9	Non-ruminant adipose
1846	TAK25	Middle Pastoral	819.2	−15.6	−19.7	−4.1	Dairy Fat
1863	TAK26	Middle Pastoral	175.0	−22.3	−26.2	−4.0	Dairy Fat
1903	TAK27	Early Pastoral	308.5	−22.8	−21.7	1.1	Non-ruminant adipose
2028	TAK2028	Middle Pastoral	1931.0	−24.5	−28.9	−4.4	Dairy Fat
2251	TAK28	Middle Pastoral	96.9	−21.5	−24.0	−2.5	Ruminant adipose
2523	TAK29	Late Pastoral	445.6	−18.5	−19.7	−1.2	Ruminant adipose
2588	TAK30	Late Acacus	823.3	−13.9	−13.8	0.1	Non-ruminant adipose
2817	TAK32	Late Acacus	6882.8	−19.3	−17.5	1.8	Non-ruminant adipose
2857	TAK35	Middle Pastoral	238.3	−20.1	−22.9	−2.8	Ruminant adipose

Tab. 1. Subset of sherds selected for isotopic analyses showing period, lipid concentrations and fatty acid $\delta^{13}C$ and $\Delta^{13}C$ values.

This site presented a remarkable opportunity to utilise the archaeological biomarker approach to identify which foodstuffs were processed in the ceramic assemblages from each cultural horizon and thus ascertain the subsistence strategies practised by the prehistoric peoples living at the site together with their changes through time.

Material and methods

A total of 81 potsherds covering a wide range of decoration techniques and motives commonly found on Saharan ceramics (*Biagetti* et al. *2004; Caneva 1987*) were sampled from the Takarkori rock shelter, of which 56 were excavated from the Middle Pastoral period (*c.* 5200–3800 BC), and the remainder originating from the Late Acacus (n = 8), and Early (n = 14) and Late Pastoral (n = 3) periods (Tab. 1). The samples were analysed by GC and GC–MS in order to identify and quantify the extracted compounds. Only those residues unambiguously assigned as degraded animal fats, *i.e.* those with exceptionally high $C_{16:0}$ and $C_{18:0}$ values, were selected for gas chromatography-combustion-isotope ratio mass spectrometry (GC–C–IRMS) analysis to determine the $\delta^{13}C$ values for the individual $C_{16:0}$ and $C_{18:0}$ carboxylic acids, with the aim of classifying the fats. Of the 29 samples selected for GC–C–IRMS analysis, 18 displayed clear evidence of pure animal fat origin, with the remaining 11 comprising lipid profiles suggestive of the mixing of animal and plant fats.

Lipid analysis and interpretations were performed by means of established protocols described in detail in earlier publications (*e.g., Evershed* et al. *2008*). Briefly, ~2g of potsherd were sampled and surfaces cleaned with a modelling drill to remove any exogenous lipids. The sherds were then ground to a powder, an internal standard added and solvent extracted by ultrasonication (chloroform/methanol 2:1 ν/ν, 2x10ml). The solvent was evaporated under a gentle stream of nitrogen to obtain the total lipid extract (TLE). Aliquots of the TLE were trimethylsilylated (*N,O*-bis(trimethylsilyl) trifluoroacetamide 80μl, 70°C, 60min; Sigma-Aldrich Company Ltd, Gillingham, UK), and submitted to analysis by GC and GC–MS. Further aliquots of the TLE were treated with $NaOH/H_2O$ (9:1 ω/ν) in methanol (5% ν/ν, 70°C, 1h). Following neutralisation, lipids were extracted into chloroform and the excess solvent evaporated under a gentle stream of nitrogen. Fatty acid methyl esters (FAMEs) were prepared by reaction with BF_3-methanol (14% ω/ν, 70°C, 1h; Sigma-Aldrich Company Ltd, Gillingham, UK). The FAMEs were extracted with chloroform, and the solvent removed under nitrogen. The FAMEs were re-dissolved into hexane for analysis by GC and GC–C–IRMS. FAMEs of freeze-dried reference fats (typically using 5mg of TLEs) were prepared exactly as above.

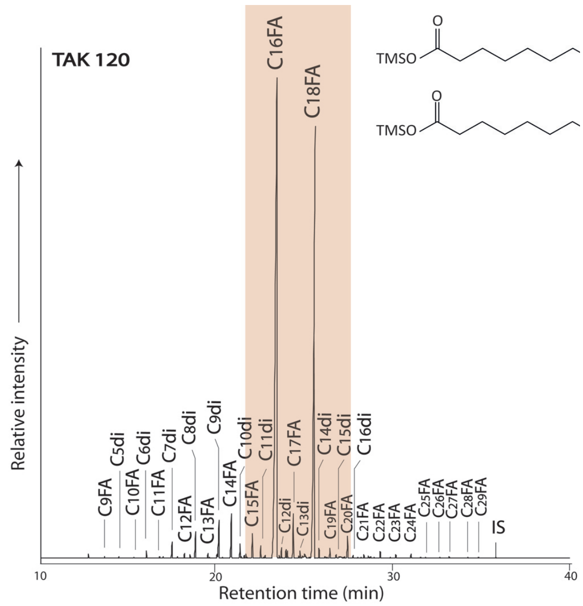

Fig. 4. Partial gas chromatogram displaying the typical trimethylsilylated lipid extract from potsherd TAK120 excavated from Middle Pastoral levels in the Takarkori rock shelter. C_x indicates a fatty acid, where x is the carbon chain length, and $C_x$diFA, α,ω-dicarboxylic acids, IS, Internal Standard, C_{34} n-tetratriacontane. The distribution is characteristic of a degraded animal fat origin.

Results and discussion

GC analysis of the total lipid extracts (TLEs) showed that many of the 81 potsherds demonstrated extraordinary preservation of lipids, containing concentrations of up to 6mg/g (mean 1.2mg/g), with one particular sherd (TAK 443) displaying a concentration of 17mg/g. It is noteworthy that lipids were observed in every sherd, in contrast to European archaeological sites, where generally <40% of sherds contain extractable lipids with mean concentrations of *c.* 0.1mg/g (*Charters* et al. *1993b; Dudd, Evershed 1998*). This remarkable preservation is likely to be related to the arid conditions prevailing in the region.

Lipid biomarker analyses by GC–MS showed residues fall into 3 broad categories. The most common distribution (Fig. 4) was dominated by high abundances of the $C_{16:0}$ and $C_{18:0}$ fatty acids, which derive from degraded animal fats. Also abundant were branched chain fatty acids, C_{13} to C_{18}, components of bacterial origin diagnostic of ruminant animal fats (*Christie 1981*). The two other types of residues identified in these ceramics reflect the processing of plants and mixtures of plant and animal products in the vessels and will not be discussed further in this paper.

With regard to the 81 potsherds, only those residues unambiguously assigned as degraded animal fats (Tab. 1), *i.e.* those dominated by $C_{16:0}$ and $C_{18:0}$ (*e.g.*, Fig. 3), were selected for GC-C-IRMS analysis to determine the $\delta^{13}C$ values for the individual $C_{16:0}$ and $C_{18:0}$ carboxylic acids, with the aim of establishing whether they originate from a ruminant or non-ruminant dairy or adipose fats origin. It has been demonstrated that differences occur in the $\delta^{13}C$ values of these major *n*-alkanoic acids, palmitic ($C_{16:0}$) and stearic ($C_{18:0}$), due to the differential routing of dietary carbon and fatty acids during the synthesis of adipose and dairy fats in ruminant animals, thus allowing ruminant milk fatty acids to be distinguished from carcass fats by calculating $\Delta^{13}C$ values ($\delta^{13}C_{18:0}-\delta^{13}C_{16:0}$) and plotting them against the $\delta^{13}C$ value of the $C_{16:0}$ fatty acid. Previous research has shown that by plotting $\Delta^{13}C$ values, variations in C_3 versus C_4 plant consumption are removed, thereby emphasising the biosynthetic and metabolic characteristics of the fat source (*Dudd, Evershed 1998; Copley* et al. *2003*). This is now confirmed by the stable carbon isotope analyses of a new reference collection of modern ruminant animal fats from Africa collected to encompass the range of carbon isoscapes (*West* et al. *2010*) likely to have been encountered by early Saharan pastoralists (*Dunne* et al. *2012*).

Of the 29 animal fats residues selected for GC-C-IRMS analyses, 22 originate from Middle Pastoral levels, 3 from the Late Acacus, 2 from the Early Pastoral and the remaining 2 from the Late Pastoral period (Tab. 1). The comparison of the $\Delta^{13}C$ values of the residues from the archaeological pottery from the Middle Pastoral period (*c.* 5200–3800 BC) with those of modern reference animal fats collected from Libya and Kenya (*Dunne* et al. *2012*) show that 50% of these plot within, or on the edge of, the isotopic ranges for dairy fats, with a further 33% falling within the range for ruminant adipose fats and the remainder corresponding to non-ruminant carcass fats (Figs. 5 and 6). Significantly, the residues originating from the Late Acacus phase, where archaeological levels do not yield faunal remains from domesticated animals, and Early Pastoral periods, where they are rare and badly preserved, do not contain dairy fats, and plot in the non-ruminant fat range, probably derived from wild fauna found locally. The unambiguous conclusion is that the appearance of dairying fats in pottery correlates with the more abundant presence of cattle bones in the cave deposits during the Middle Pastoral period, suggesting a full pastoral economy, as the cattle were intensively exploited for

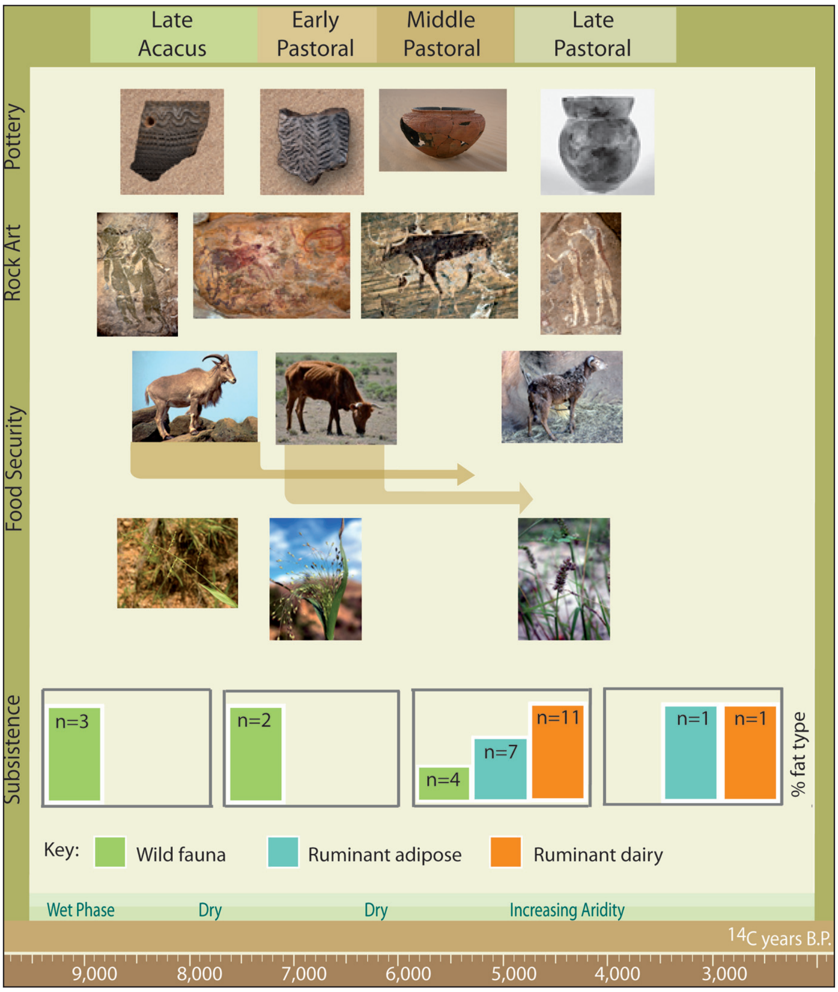

Fig. 5. Showing the cultural sequence in the Tadrart Acacus region, pottery, rock art and food security. Histograms demonstrate the prevalence of dairy fat, ruminant and wild fauna adipose fats within ceramics excavated from the Takarkori rock shelter (modified, after* Dunne et al. 2012*).

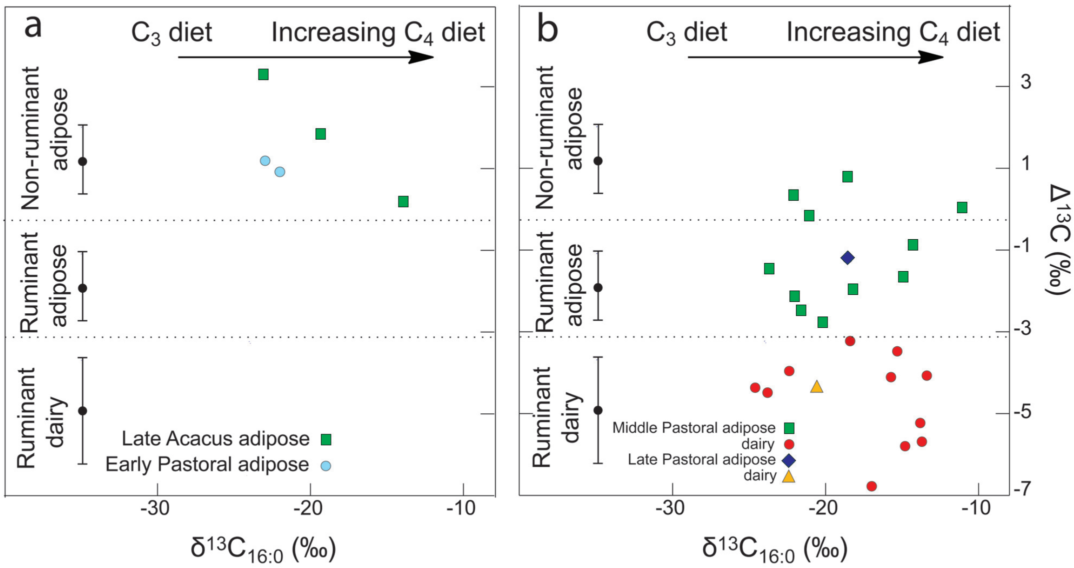

Fig. 6. Plot of the $\Delta^{13}C$ values for the archaeological fat residues (Late Acacus/Early Pastoral and Middle/Late Pastoral). Significantly, the residues originating from the Late Acacus and Early Pastoral periods (Plot a) do not contain dairy fats, and plot in the non-ruminant range, probably deriving from wild fauna. Plot b clearly demonstrates that extensive processing of dairy products in pottery vessels from this region begins in the Middle Pastoral period* c. *5200–3800 BC. The ranges shown here represent the mean ± 1 s.d. of the $\Delta^{13}C$ values for a global database comprising modern reference animal fats and fats from Africa, UK (animals raised on a pure C_3 diet) (*Dudd, Evershed 1998*), Kazakhstan (*Outram *et al.* 2009*), Switzerland (*Spangenberg *et al.* 2006*) and the Near East (*Gregg *et al.* 2009*), published elsewhere.

their secondary products. Of the two samples originating from the Late Pastoral period, one has a dairy fat source and the other a ruminant adipose fat origin.

Of particular note is the wide range of $\delta^{13}C$ values exhibited by the fatty acids, plotting across the range –25‰ to –10‰, perhaps suggesting that the animals giving rise to these fats had subsisted on an extensive range of different forages either comprised entirely of C_3 plants, varying combinations of C_3 and C_4 plants to a diet comprising wholly C_4 plants. This wide range of $\delta^{13}C$ values for these African potsherds is unprecedented, and points to differing pastoral modes of subsistence, such as vertical transhumance, by these prehistoric Saharan groups, as suggested by their settlement pattern based on summer sites in the lowland sand seas and winter sites (such as Takarkori) in the mountains (*di Lernia 2002*), probably in response to seasonal weather patterns. This pattern is confirmed by the recent isotope studies on human and faunal remains from Takakori rock shelter (*di Lernia, Tafuri 2013*) as well on cattle remains from Middle Pastoral ceremonial sites in the Messak plateau and surroundings (*di Lernia* et al. *2013*).

It is noteworthy that the remarkable preservation of organic material excavated from Takarkori rock shelter in the Libyan Sahara is also mirrored at the molecular level, with organic residues being identified in 80 out of the 81 potsherds analysed, sometimes in extremely high concentrations. The interpretation of 80 diagnostic absorbed organic residues from the ceramics demonstrates that these vessels were used frequently or intensively to contain or process commodities of animal and plant origin. In the Middle Pastoral Period (*c.* 5200–3800 BC) the animal products appeared to derive predominantly from dairy products (50%), although carcass fats (33%) were also extensively processed. Significantly, the residues originating from the Late Acacus and Early Pastoral periods (n = 5), where archaeological levels either do not contain faunal remains from domesticated animals (Late Acacus) or are quite rare (Early Pastoral), plot in the non-ruminant fat range, probably deriving from wild fauna found locally. The appearance of dairying fats in pottery correlates with the more abundant presence of cattle bones in cave deposits during the Middle Pastoral period and confirms the indirect evidence of dairying provided by the remarkable rock art of the region.

Conclusion

In summary, our findings corroborate the evidence of dairying practices by prehistoric Saharan herders as seen in the rock art of the region. The first appearance of domesticated fauna in the Tadrart Acacus archaeological record, radiocarbon dated from around 7400 uncal bp (*di Lernia 2013*), seems not to be paralleled at Takarkori by a developed exploitation of secondary products. Significantly, the chemical evidence for extensive processing of dairy products in pottery vessels in the Libyan Sahara dates to the Middle Pastoral period (*c.* 5200–3800 BC), confirming that milk and its secondary products played a significant part in the diet of these prehistoric pastoral people. The finding of dairy fat residues in pottery is consistent with milk from the domesticated animals being processed, thereby explaining why, in spite of lactose intolerance, milk products could be consumed by these people. It is noteworthy that stable carbon isotope analyses demonstrate that the animal sources of the fats processed in the ceramic vessels excavated from the Takarkori rock shelter subsisted on an extensive range of different forages comprised either completely of C_3 plants, varying combinations of C_3 and C_4 plants or a diet comprising wholly C_4 plants. This wide range of $\delta^{13}C$ values for these African potsherds is unprecedented and points to differing pastoral modes of subsistence and mobility (likely vertical transhumance) by these prehistoric Saharan groups, as suggested by archaeological evidence confirming their settlement pattern based on summer sites in the lowland sand seas and winter sites (such as Takarkori) in the mountains (*di Lernia 2002*). This would probably have been in response to seasonal weather patterns, although it is also possible that these animals may have originated from non-local regions, as shown in the nearby area of the Messak plateau and Edeyen of Murzuq (*di Lernia* et al. *2013*).

These results also confirm that domesticated cattle used as part of a dairying economy were present in north Africa during the 5th millennium BC, thus supporting the idea of an earlier ingression into the central Sahara (*Gifford-Gonzalez, Hanotte 2011; Marshall, Hildebrand 2002; di Lernia 2002*), possibly suggesting a local process of pastoral development, also based on the exploitation of secondary products. This is also consistent with the finding of the –13 910*T allele, associated with the LP trait in Europeans, across some Central African groups, such as the Fulbe of northern Cameroon (*Mulcare* et al. *2004*), supporting arguments for some movement of people, with their cattle, from the Near East into eastern Africa in the early-middle Holocene.

These new data provide a tantalising, yet emphatic, glimpse of the emergence of the dairy complex as a component of pastoralism in Africa. The stage is now set for a wider, continental scale, investigation using lipid biomarkers in pottery.

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Pots and food: uses of pottery from Resnikov prekop

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ABSTRACT – *In this article, we discuss the role of pottery in food-related practices at the Resnikov prekop site on Ljubljansko barje (Ljubljana Marshes). We integrate chemical analyses of organic food residues with typological, technological and functional analyses of pottery. The vessels from Resnikov prekop reveal a broad range of sizes, forms and fabrics, as demonstrated by our analyses. The lipid residue analysis demonstrate that vessels from Resnikov prekop were mostly used for storing and serving different foods derived from terrestrial animals, mostly ruminants.*

IZVLEČEK – *V prispevku razpravljamo o vlogi lončenine pri praksah, povezanih s pripravo in uživanjem hrane na najdišču Resnikov prekop na Ljubljanskem barju. Integriramo kemične analize organskih ostankov v lončenini s tipološkimi, tehnološkimi in funkcionalnimi analizami lončenine. Posode iz Resnikovega prekopa kažejo veliko variabilnost glede na oblike, velikosti in tehnološke značilnosti, medtem ko analize lipidov kažejo, da so posode uporabljali za shranjevanje in serviranje različnih jedi, pripravljenih iz kopenskih živali, predvsem prežvekovalcev.*

KEY WORDS – *pottery; lipid analyses; pile-dwellings; Ljubljansko barje; Neolithic*

Introduction

Pottery is the most abundant type of material from Neolithic sites. Whereas pottery research used to be concerned primarily with questions focusing on typology and chronology, pottery constitutes an important source of information on various aspects of Neolithic daily life. Pots were made for use in diverse human activities, from transport and storage to the preparation, cooking and consumption of food. The *chaîne opératoire* of pottery manufacture intersects with other operational sequences, usually food preparation, storage and consumption. Relations between these operational sequences are not straightforward. The same pots can be used for different functions, even if they were made for a specific purpose. Thus in order to understand the role of pottery in daily food-related practices at the Resnikov prekop site on Ljubljansko barje (Ljubljana Marshes) we juxtapose chemical analyses of organic food residues in pottery with typological, technological and functional analyses.

Resnikov prekop

Resnikov prekop is located in the eastern part of the Ljubljansko barje area on a floodplain of the Iščica River (Fig. 1). Several test trenches have been excavated at Resnikov prekop since the 1950s (*Jesse 1954; Bregant 1964; Korošec 1964; Velušček 2006*). The largest area of 160m^2 was excavated by Josip Korošec in 1962. He encountered the remains of vertical wooden piles, wooden objects, platy stones, pieces of daub, pottery and stone tools. Artefacts were deposited directly on the lake marl, in a layer of organic detritus and silt. The general density of piles

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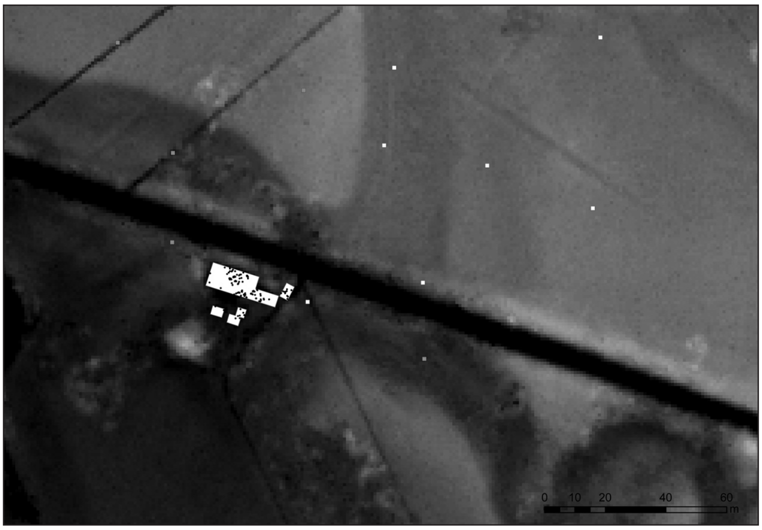

Fig. 1. Plan of Resnikov prekop test trenches.

is very low, only one pile per 2m^2, concentrated in several parallel rows, suggesting the outlines of several rectangular buildings with dimensions of approx. 5 x 3m (*Bregant 1964*; see also *Budja 1994/1995*).

The Lidar image clearly shows that the test trenches at Resnikov prekop are located in the middle of an abandoned palaeochannel (Fig. 1). This explains the recent analyses at the site which demonstrated that the stratigraphic sequence of the site was destroyed by intensive river erosion (*Andrič 2006*). The channel cut into the lake marl dates to 6396–6230 calBC, and the artefacts were deposited on this surface. Two radiocarbon dates from the channel infill date the silting up of the palaeochannel to 392–203 calBC (*Andrič 2006*).

Radiocarbon dates

Prior to this research, only two radiocarbon dates were available for Resnikov prekop, both being taken from wood piles recovered during Korošec's excavations in 1962 and Velušček's excavation in 2004. The wood piles were dated to 4605–4500 calBC and 4900–4535 calBC, making Resnikov prekop one of the oldest Slovenian Neolithic sites.

These two dates are now complemented by ten new AMS radiocarbon dates obtained from organic residue on the surface of the pottery (Tab. 1). The dates range over almost 1500 years in the period between 5726–4242 calBC. At least three new dates correspond well with the existing dates (*i.e.* Poz-55549, Poz-55548 and Poz-48529). However, several dates of food residue yielded much older dates than the dates of wood structures, dating the pots from Resnikov prekop to a period between 5726–4730 BC. If those dates are accurate, then they are the oldest dates of pottery in central Slovenia so far, preceding the earliest known dates by some 1000 years.

A similar pattern with some dates of pottery being much older than dates of wooden structures and bones was found at the nearby Maharski prekop site (*Mlekuž* et al. *2012*). The analyses of food residue on pottery from Maharski prekop and Resnikov prekop have not produced any markers of freshwater resources (which is surprising in itself, given that both Resnikov prekop and Maharski prekop are located on a marshy floodplain). Thus the freshwater reservoir effect, producing anomalous older dates, cannot be taken into account.

The new radiocarbon dates might indicate – as we have suggested already for Maharski prekop (*Mlekuž* et al. *2012*) – that activities at Resnikov prekop occurred much earlier than is indicated by the dates of wooden structures This might point to either several discrete periods of occupation or a long-term settlement. The idea of the long-term use of the site is further supported by the variability in the composition of the pottery assemblage and pottery technology (see below and *Žibrat Gašparič 2013.149–153*). These very old dates could have important implications for understanding and dating the process of neolithisation in continental Slovenia. The oldest date from Resnikov prekop is contemporaneous with the only radiocarbon date from the Breg near Škofljica site, located a few hundred metres to the east, on the edge of the Ljubljansko barje, where fragments of pottery were retrieved from a Late Mesolithic context (*Mlekuž 2002*).

However, another possible explanation for these older dates is the hard water effect (*Philippsen* et al. *2010*). The hard water effect arises when the dated material incorporated bicarbonate during its life that derived in part from old, inert sources, which causes ages to be over-assessed. Since the watershed of the Iščica floodplain lies in predominately carbonate geology, the hard water effect could be a source of apparently older dates. The hard water effect is still a poorly understood source of error in radiocarbon dates; it is usually reckoned that the maximum possible error is equivalent to the half-life of ^{14}C.

Lab No.	Material	^{14}C Conventional age BP	Stand. dev.	Calibrated age calBC (1σ)	Calibrated age calBC (2σ)	$\delta^{13}C_{bulk}$ ±0.2 (‰)	$\delta^{15}N_{bulk}$ ±0.3 (‰)	Reference
Poz–48527	food crust	6310	40	5322–5225	5369–5214	–34.6	5.5	
Poz–48528	food crust	6290	40	5309–5225	5368–5207	–34.3		
Poz–55545	food crust	6340	40	5371–5229	5465–5219	–35.4	5.2	
Poz–55547	food crust	6780	35	5711–5646	5726–5631	–29.3	7.3	
Poz–55548	food crust	5625	35	4498–4373	4528–4365	–25.0	1.4	
Poz–55542	food crust	6020	60	5000–4840	5195–4780			
Poz–55543	food crust	6220	40	5295–5075	5305–5060			
Poz–55793	food crust	5955	35	4900–4785	4935–4730			
Poz–55549	food crust	5445	35	4345–4260	4350–4250			
Poz–48529	food crust	5630	40	4515–4375	4535–4370			
Z–354	wood	5850	150	4900–4535	5055–4365			*Srdoć* et al. *1987.354*
Hd–24038	wood	5718	23	4605–4500	4610–4495			*Čufar, Korenčič 2006.124*

Tab. 1. Radiocarbon dates from Resnikov prekop.

Recently, it has become apparent that many radiocarbon dates of food residue from North Europe are up to several hundred years older than expected given their context (*Fischer 2002; Fischer, Heinemeier 2003*). The wide range of potentially anomalous old dates on pottery from Resnikov prekop could be a result of mixing plant freshwater and terrestrial foodstuffs during cooking. However, as we have no evidence of the use of freshwater foodstuffs, the path for the incorporation of older carbon in the food residue might be more complex, such as through the grazing of animals on wetland plants. It might be significant that stable isotope analyses of bulk samples of food crust that yielded dates older than expected display very negative $\delta^{13}C$ values (less than –30‰; Tab. 1). Therefore, without further research, we cannot exclude the possibility that dates older than expected are not the result of the hard water effect.

Pottery typology and functional categories

In its life cycle, every pot goes through three distinct stages: manufacture, use and discard. Manufacture consists of the fashioning of a pot for some intended function from raw materials obtained from the environment; this is followed by the utilisation of the pot for either food storage, preparation or consumption, in some instances followed by its use for some other purposes. When it is no longer useful – usually due to fragmentation – it is discarded and the fragments are then incorporated into archaeological deposits, becoming part of the archaeological record. If we are interested in the role of pottery in social life, its production and use in food processing and consumption operation sequences, then the main unit of analysis is the individual pot or vessel, not a sherd; vessels need to be reconstructed from sherds.

The potter makes technical choices related to performance in manufacture and use in accordance with the vessel's intended functions, controls the shape and size of vessels, paste characteristics, firing conditions and surface treatments to create vessels to perform their intended roles (*Skibo 1992.27–56; DeBoer 1984; Tite 2008; van As 1984*). Vessel shape, size and capacity are likely to relate very closely to the different potential functions of the pot (*Rice 1987.207*).

Technical choices made by potters are marked by equifinality: the same vessel shapes and fabrics can be chosen for different intended uses. Interpretation is made even more difficult by the fact that the same vessels may have been used for different purposes, or may have been reused when considered no longer appropriate for their intended function (*Rice 1987. 207–208*). And while the choice of shape and fabric could suggest their intended function, only an analysis of preserved lipids in pots can show what was actually boiled, cooked, boiled, stored or processed in them.

Prudence Rice (*1987.224–226*) identified four loosely defined performance characteristics related to vessel shape: capacity, stability, accessibility and transportability. These attributes are not defined mathematically, but are nevertheless useful in describing the properties of vessels in relation to their intended use. On the other hand, Marion Smith (*1988*) found three properties of vessels to be particularly informative when correlating form to function. The first is the relative openness of the vessels, which is the ratio of the circumference of the rim to the total external surface area; the second is the diameter of the vessel rim and the capacity of the vessel. These properties determine the possible uses of pots; for example, rim size is usually related to the frequency with which the contents of a vessel are changed. Long-term storage vessels usually have smaller openings, while vessels that require access to the contents during use will have an opening big enough for hand access. Vessels used for transporting liquids have a small opening, while serving vessels usually have rim forms that do not curve inward.

Other technological choices are also closely related to the intended use of the pot. Thus the choice of a particular temper, paste characteristics and firing conditions might have an impact on how the vessel performs during manufacture and use (*Braun 1983; DeBoer 1984; Skibo 1992.27–56*). Technological properties such as thermal shock resistance and heating effectiveness might thus be closely related to the intended function of vessels.

The pottery assemblage from Resnikov prekop was scattered over three trenches (*Korošec 1964; Harej 1975; Velušček 2006*); we were able to reconstruct the shape of 128 individual vessels from the pottery fragments.

Pottery technology

For the present study, 120 pottery samples from Resnikov prekop were analysed with a hand lens to identify inclusions, their size and frequency, and the presence of voids. The samples were chosen according to typological groups and could be attributed to three technological groups (description after *Horvat 1999*): the first group of vessels, made from non-calcareous clay and only quartz inclusions (25.8%); the second group with quartz and calcite/limestone inclusions is the most common (49.2%); and the third comprised mostly calcite/limestone inclusions (25%). The majority of vessels have inclusions in the size range of medium sand (0.25 to 0.50mm) and very fine sand (less than 0.25mm). Vessels with coarser sand inclusions (0.50 to 2.00mm) are much less common (less than 10%) and are mostly made with quartz and calcite/limestone inclusions belonging to the second technological group. The vessel surfaces of pottery from Resnikov prekop were smoothed or burnished; some vessels were decorated with a red and, rarely, black slip. The vessels were fired in an incomplete oxidising atmosphere and only rarely in an oxidising and reducing atmosphere.

For the petrographic analysis of pottery from Resnikov prekop, 25 samples were chosen and prepared as standard thin sections. These samples can be attributed to eight different fabric groups according to the characteristics of clays and inclusions, as well as temper added by the potters (for a description of the fabrics see *Žibrat Gašparič 2013.149–153*). The fabrics show the characteristics of at least four different natural non-calcareous clay pastes: very fine-grained with sponge spicules, very fine-grained with frequent opaque minerals, a fine to coarse paste with many natural limestone inclusions and only few mica grains, and a paste with naturally occurring concentrations of chert, sandstone and limestone grains in the silt fraction. The potters prepared these pastes into different recipes; for example, with no temper added or with chert, sandstone, limestone and calcite tempers added to mostly the same natural clay paste. Therefore, the potters made vessels with no temper, using different types of paste; on the other hand, they added various natural inclusions as temper to similar pastes. This shows the variety of technical solutions of these potters when preparing the clay body; nevertheless, the forming, decorating and firing techniques of Resnikov prekop pottery were quite similar for most of the vessels made at the site.

Pottery typology

The typological analysis of Resnikov prekop pottery excavated in the years 1957, 1962 and 2002 (*Korošec 1964; Harej 1975; Tomaž, Velušček 2005; Velušček 2006*) showed the use of a variety of types at the site. The vessels could be assigned to eight basic types according to their shapes and the proportions of different vessels' sections, *i.e.* pots, jugs, dishes, bowls, pedestal dishes, cups, beakers and lids.

In the classification of dishes and bowls, functional criteria (*e.g.*, open/closed, deep/shallow) and the criteria of the outline of the vessel were used. Dishes (Fig. 2) are classified into closed shallow dishes, with a biconical outline with a semi-ellipsoid shape and a simple mouth (S01, S02), and dishes with an ellipsoid shape, a rim and a prominent contact point with the wall (S03). The open dishes include shallow types with a simple semi-ellipsoid outline (S04) and deep dishes with a composed, slightly biconical outline, with a spherical-cylindrical shape (S05) with a simple mouth and fluid contact with the wall. Among the open deep dishes, a special group is represented by an obliquely shaped rim and typical contact be-

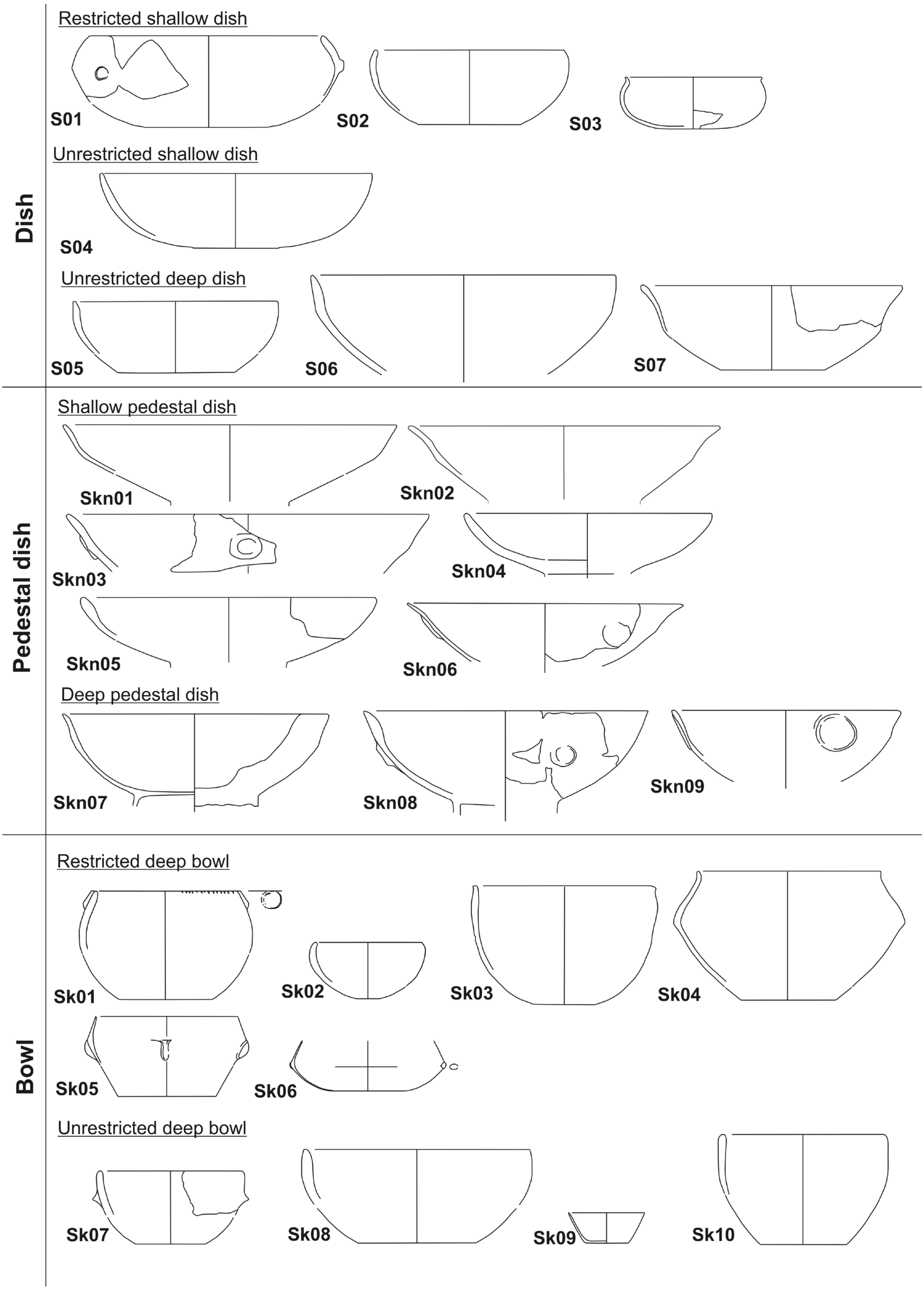

Fig. 2. Typological classification of vessels from Resnikov prekop: dishes, pedestal dishes and bowls. Scale 1:4.

tween the rim and the spherical (S06) or ellipsoid (S07) lower part of the vessel.

The typological classification of vessels with a foot or pedestal is more complicated in the Resnikov prekop pottery assemblage. It is difficult to determine if the vessels had a pedestal, especially when only the upper parts of vessel walls were preserved (see *Tomaž, Veluščček 2005.91*). In our classification of pedestal vessels, we considered only fragments with a preserved lower part of the vessel body (Fig. 2). Regarding the proportion – between height and maximum rim circumference – we observed that open shallow types with a conical (Skn01, Skn02), semi-ellipsoid (Skn04, Skn05, Skn06) or cut hyperboloid cone (Skn03) shape in the lower part of the vessels predominate among pedestal dishes. Most of these vessels have a prominent contact point between the rim and the wall. The only exceptions are variants Skn04 and Skn05, with an inconspicuous contact between rim and wall. Deep open pedestal dishes represent the second and less common group, with a spherical lower part (Skn07, Skn08, Skn09) and with less prominent contact between the rim and the wall of the vessel. Only variant Skn04 has a simple rim, but the majority of pedestal dishes have diverse shapes of rims.

The typologically defined bowls (Fig. 2) all have deep shapes. The deep closed bowls have a simple outline with a spherical (Sk01, Sk03) or spherical ellipsoid shape (Sk02), but closed deep bowls with a biconical outline and a spherical half-ellipsoid (Sk04), double cone (Sk05) or half-ellipsoid spherical shape (Sk 06) are also present. The open deep bowls with a simple outline and spherical (Sk07) or conical shapes (Sk09) are less common. The biconical shape is less prominent in bowls with a complex outline, which have a spherical cylindrical (Sk08) or a semi-ellipsoid cylindrical shape (Sk10). Most of the bowls have a simple mouth and a fluid, almost inconspicuous contact with the wall. Only two type variants have a prominently shaped rim, *e.g.* bowl Sk03 with a stunted rim and bowl Sk04 with a vertical rim.

Pots (Fig. 3) are classified into two groups according to their outline and the shape of the contact between the upper and lower part of the vessel. The first group is comprised of pots without necks and with a simple cone (L01), ellipsoid (L02) or biconical shape (L03, L04). The mouth of the pot is either simple, with a fluid contact with the wall (L01, L02, L04a) or with a shaped rim with a prominent contact with the wall (L03, L04b). The second group is comprised of pots with different necks and a complex outline and sharp (L06–L12) or rounded contact with the wall (L13–L16); the pots have various mouth or rim shapes and the contact with the wall can be fluid or prominent. The necks of the pots can be slightly arched (L06), prominently arched (L07, L08, L13), cone shaped (L10, L11), cylinder cone shaped (L12) or hyperboloid cone shaped (L15, L16), but a hyperboloid collar (L09, L14) is also present in some vessels.

Jugs (Fig. 3) are rare among the Resnikov prekop pottery assemblage. Their shapes are very similar to pots, but they have different capacities and differently attached handles. The position of the upper part of the handle is just below the vessels' aperture, and the lower part is close to the maximum circumference of the vessel. The jugs have a complicated outline, with a sharp contact with the lower part of the vessel; they have slightly arched (V02) or prominently arched necks (V03) or a collar (V01). The mouth is simple, with fluid contact with the walls.

The rarest types of vessels at Resnikov prekop are cups and beakers (Fig. 3). Only two cups and beakers could be typologically reconstructed from the whole assemblage. They can be classified into shallow and deep dishes according to their function, capacity and shape. They have complicated outlines and sharp contact points between the upper part and lower spherical (Sd01) or semi-ellipsoid (Sd02) parts of the vessel. The neck is heavily arched (Sd01) or conical (Sd02); the shape of the mouth is simple. The ideal size of beakers is achieved if they can fit into a hand. Their height is usually higher than the circumference of the aperture. The beakers (Fig. 3) have simple mouths and the walls have simple outlines with an ellipsoid shape (K02) or biconical outline, with a conical hyperboloid shape (K01).

In general, the Resnikov prekop pottery was richly decorated. Different basic techniques were used for the decorations. The most common techniques are incisions (incised, grooved and fluted decoration) and impressions made with a fingernail (*Korošec 1964.T. 6.3, T. 10.9, T. 18.1*), with a fingernail or finger (*Korošec 1964.T. 12.2, T. 10.5–7; Harej 1975.T. 6.7*) or with an awl or similar tool with a modified point. Appliqués are also present, mostly in the form of shallow plastic button-shaped bulges. In two vessels, the decoration is made with a modelling technique, *i.e.* with a cordon (*Korošec 1964.T. 14.1, T. 10.1–4*). Usually, a combination of these techniques was used to decorate the vessels from Resnikov pre-

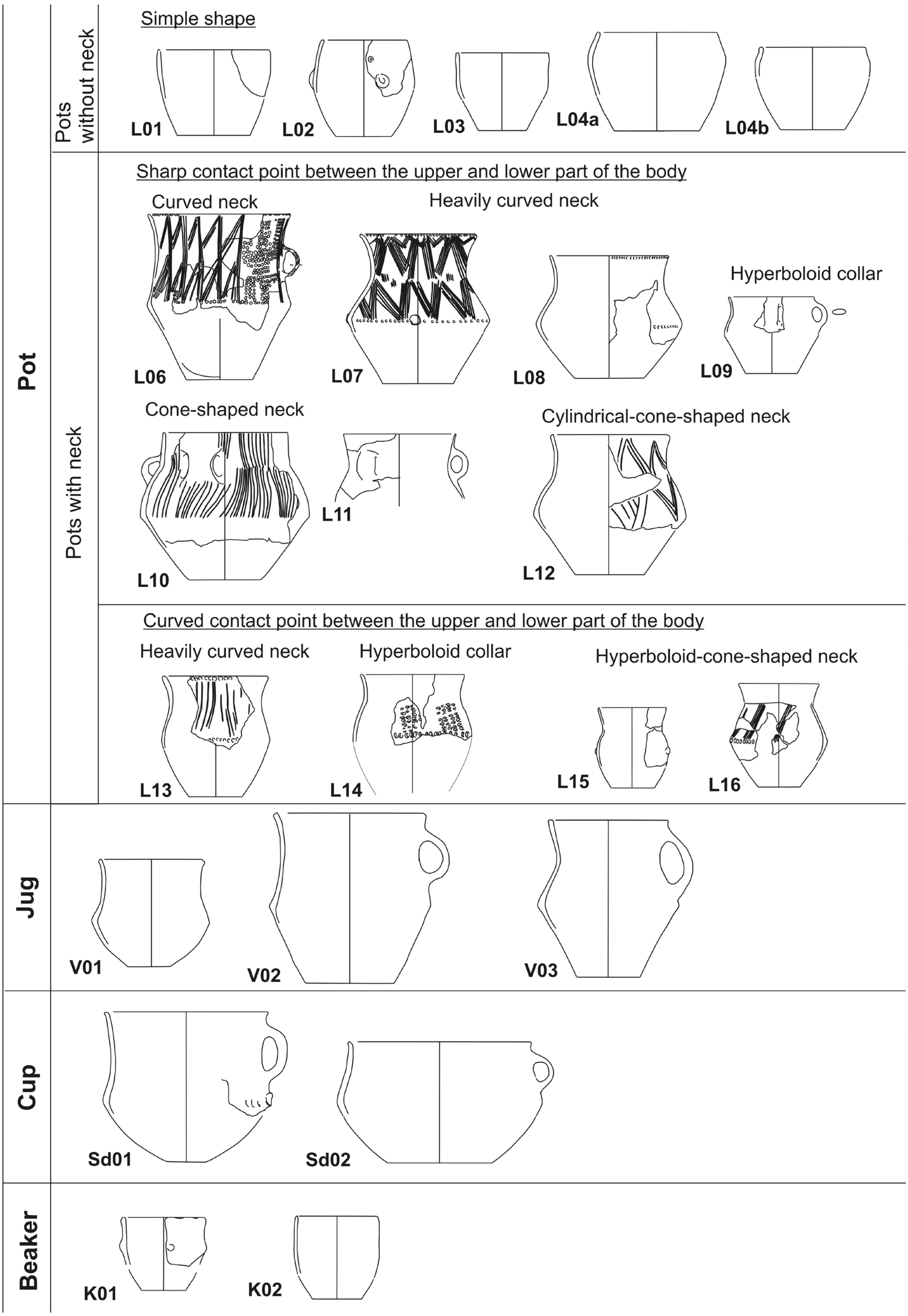

Fig. 3. Typological classification of vessels from Resnikov prekop: pots, jugs, cups and beakers. Pots are in scale 1:8; jugs, cups and beakers are in scale 1:4.

kop, such as a combination of impressions and appliqués, or of incisions, impressions and appliqués.

The ornamentation can be simple or complex, with straight motifs, short incisions, plastic appliqués or simple impressions. Some vessels have more complex motifs, such as a band with a number of parallel lines that form zigzags (see Fig. 3.L06, L12; *Korošec 1964.T. 16.4; Harej 1975.T. 1.3, T. 1.6, T.2.3*). Some bands with parallel lines are formed into vertical or inclined motifs (see Fig. 3.L16; *Harej 1975.T. 1.7, T. 6.7*) or a combination of the two bands (see Fig. 3.L10; *Harej 1975.T. 1.1, T. 7.12*). One pot (Fig. 4) from Resnikov prekop stands out from the assemblage with its rich decoration of complex zigzag bands and two seated anthropomorphic figures on each side of the handle. During our revised analysis of Resnikov prekop pottery from the 2002 excavation, we were able to reconstruct a vessel that was previously published as single fragments (*Velušček 2006.T. 8.5, T. 10.1–14, T. 13.6, T. 16.9, T. 17.9*) or with an incorrect reconstruction (*Tomaž, Velušček 2005.96, Fig. 33*).

Functional categories of vessels

The reconstruction of 56 vessels was sufficiently complete for the capacity, openness and rim diameter to be estimated. Openness was defined as the ratio between the orifice area and the exterior surface area. The vessels were then arranged along three axes: capacity, openness and rim diameter. The most informative proved to be the relation between the vessel's openness and its capacity (Fig. 5).

Vessel capacities range from 0.05 litres to 9 litres, with a median of 1.7 litres. Thus vessel volume is generally low: the first quartile is at 1 litre, while the third quartile is at 3.5 litres, meaning that three quarters of the vessels have a capacity of less than 3.5 litres, and half of the vessels have a volume between 1–3.5 litres.

Openness – defined as the ratio between the orifice area and the exterior surface of the pot – varies between 0.1 (very closed) to 0.7 (very open). The median is around 0.27, while the first and third quartiles are at 1.9 and 0.4. When plotted on a graph (Fig. 5), the relation between openness and volume is L-shaped, *i.e.* vessels with low volumes (less than 3 litres) display high variability in their openness, and vessels with a more restricted opening have volumes over 3 litres.

High variability in openness among low-capacity vessels indicates different intended uses for smaller pots. Very open vessels can be interpreted as vessels for serving or even displaying food, while closed vessels could have been used for the consumption and storage of liquids and cooking. Vessels with a high volume and closed rim shape were probably intended for cooking or storing (liquid) foodstuffs.

Based on these criteria, we divided the corpus of vessels into five functional groups (Figs. 2, 3, 5).

❶ The first group consists of small vessels with volumes below 0.5 litres and moderate openness, between 0.3 in 0.5. Their moderate accessibility and very small rim diameter suggest that they were used for the individual consumption of liquids, possibly fitting in one hand. Typologically, they are defined as bowls (Sk) or cups (Sd).

❷ The second group consists of vessels with very high to extreme openness. The vessel capacities range between 0.5 and 2.5 litres. Rim diameters are very high and the vessels are mostly shallow, indicating very high accessibility and stability. These vessels

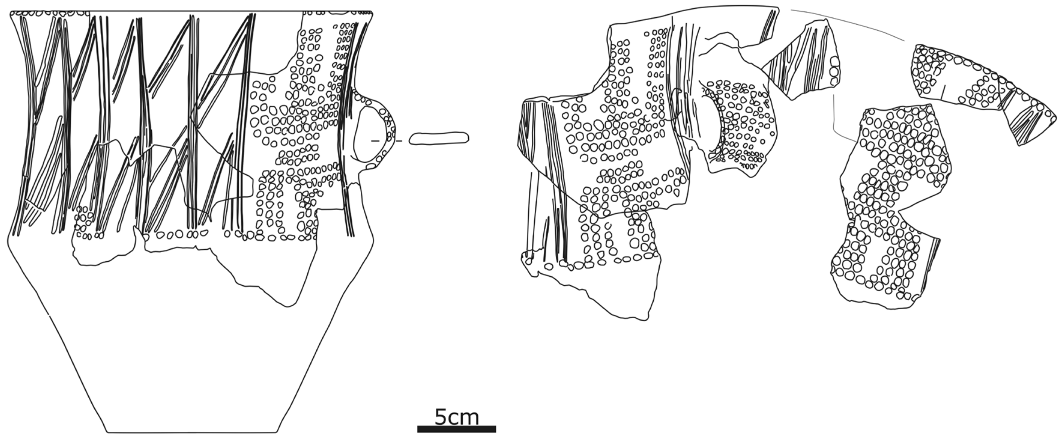

Fig. 4. Large decorated pot (sample No. RP82) of type L06 from Resnikov prekop.

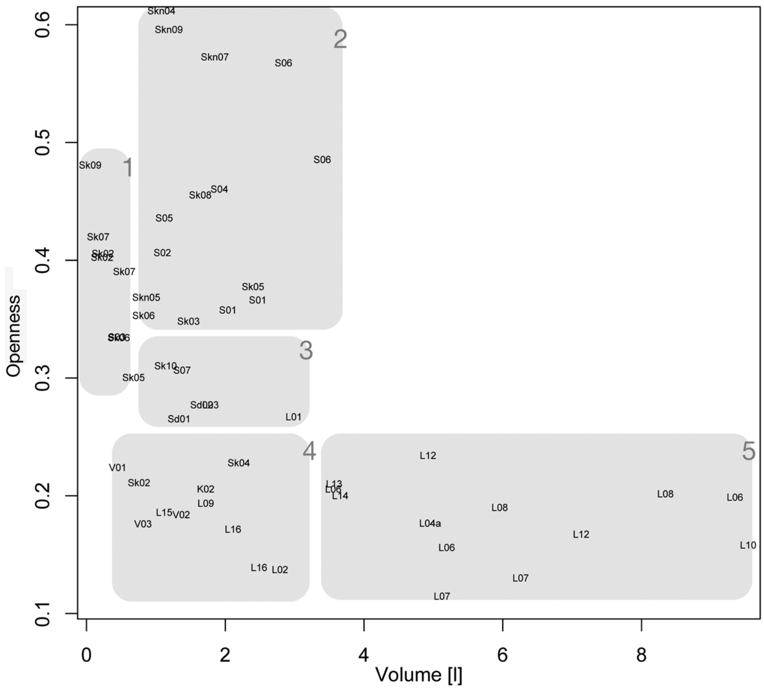

Fig. 5. Vessels from Resnikov prekop arranged according to capacity, openness and typological classification. Vessel use groups are indicated.

might have been used for individual (in the case of low-capacity vessels), communal consumption or even the display of food (in the case of pedestal vessels). Typologically, these vessels are described as dishes (S) and pedestal dishes (Skn).

❸ The third group consists of vessels with moderate openness and capacities in the range between 0.5 and 2.5 litres. These vessels are usually described as bowls (Sk), cups and beakers (Sd). Their intermediate accessibility suggests that they could have had a variety of possible functions.

❹ The fourth vessel group consists of smaller vessels, with volumes less than 2.5 litres. These vessels are generally closed, with openness less than 0.27. The vessels in this group are described as pots (L), jugs (V), and bowls (K). Their smaller volumes, small rim diameter and closed and inaccessible forms indicate that they might have been used to store liquid foodstuffs intended for a small group of people.

❺ The fifth group consists of vessels with volumes over 2.5 litres. The vessels in this group are closed, deep and inaccessible. Their large capacity and accessibility suggest that they can be used either for cooking larger meals and/or temporary storage. Typologically, all these vessels are classified as pots (L).

Food residues

Material and methods

For the organic residue analyses, we sampled 38 pottery samples from Resnikov prekop (Tab. 2); 12 samples were chosen from the 1957 assemblage (*Harej 1975*), 16 samples from the 1962 pottery assemblage (*Korošec 1964*) and 10 from the 2002 excavation (*Veluščček 2006*). The samples included diverse vessel forms, such as 14 pots (types L02, L04b, L06, L07, L08, L12, L14, L15), 6 pedestal dishes (types Skn03, Skn 04, Skn06, Skn08, Skn09), 5 dishes (types S01, S05), 5 bowls (Sk02, Sk 05, Sk06), 3 beakers (types K01, K02), 2 jugs (types V01, V03), one cup of type Sd01 and one ladle or spoon (Figs. 2, 3). The pots, dishes and pedestal dishes share many technological characteristics and are typically made with inclusions of quartz and calcite/limestone, which are in the medium sand fraction. Bowls are similarly made, but nevertheless exhibit a greater presence of vessels made only with quartz inclusions and much more fine-grained fabrics with fine sand inclusions.

In the chemical study, we analysed the distribution of lipid biomarkers and stable isotope composition (bulk $\delta^{13}C$ and $\delta^{15}N$ values, and $\delta^{13}C$ of individual fatty acids) of organic residues from pottery. Firstly, we cleaned the surfaces of the samples to remove any exogenous lipids and then ground the sub-samples to a fine powder.

The bulk isotope composition of carbon and nitrogen was determined by elemental analysis isotope ratio mass spectrometry (IRMS) using Europa Scientific IRMS with an ANCA-SL preparation module for solid and liquid samples (PDZ Europa Ltd, Crewe, UK). Each sample was acidified using 1 N HCl to remove carbonate minerals, and dried. Stable isotope results are expressed as $\delta^{13}C$ or $\delta^{15}N$ values in per mil (‰) relative to the VPDB and AIR international standard, respectively. The precision of measurements was ±0.2‰ for $\delta^{13}C$ and 0.3‰ for $\delta^{15}N$.

To obtain the total lipid extract (TLE), 2g of the samples were extracted by ultrasonication with an organic solvent (*e.g.*, chloroform/methanol, 2:1 v/v) and then evaporated to dryness under a gentle stream of nitrogen. One portion of the extract was trimethyl-

Lab. sample no.	Vessel type (see Figs. 2–3)	Description	Lab.No.	^{14}C Conventional age BP	Stand. dev.	$\delta^{13}C_{bulk}$ ±0.2 (‰)	$\delta^{15}N_{bulk}$ ±0.3 (‰)	Lipid concentration ($\mu g\ g^{-1}$)	$\delta^{13}C_{16:0}$ ±0.3 (‰)	$\delta^{13}C_{18:0}$ ±0.3 (‰)	$\Delta^{13}C$ (‰)	$C_{16:0}/C_{18:0}$
RP1	V03	jug				−28.9	−1.6	36.5	−26.4	−28.4	−2.0	0.7
RP2	L07	pot				n/d	n/d	9.7	n/d	n/d	n/d	n/d
RP3	L02	pot	Poz–48527	6310	40	−34.6	5.5	113	−31.7	−31.6	0.1	1.6
RP4	K01	beaker				−32.2	−3.4	25.8	−27.6	−28.3	−0.7	1.8
RP6	Sk02	bowl				−28.7	1.9	46.1	−29.6	−30.9	−1.3	1.0
RP7	Sk06	bowl				−29,6	0,1	97,2	−28.3	−31.3	−3.0	1.2
RP10	Sk02	bowl				−31.0	−0.3	29.1	−32.9	−31.4	1.5	4.0
RP14	L14	pot				−25.8	−1.0	42.7	−25.8	−27.5	−1.7	1.9
RP15	L15	pot				n/d	n/d	3.2	n/d	n/d	n/d	n/d
RP16	Sk05	bowl				n/d	n/d	7.8	n/d	n/d	n/d	n/d
RP22		beaker				−26.7	−6.0	34.2	−29.2	−28.6	0.6	0.2
RP23		pot				n/d	n/d	3.1	n/d	n/d	n/d	n/d
RP27	Skn08	pedestal dish				n/d	n/d	7.3	n/d	n/d	n/d	n/d
RP28	K02	beaker				−27.9	3.7	31.0	−28.9	−31.2	−2.3	0.7
RP29	S01	dish				−27.0	5.7	27.5	−27.7	−29.8	−2.1	0.4
RP30	L08	pot				−29.7	0.8	27.3	−26.0	−28.2	−2.2	1.0
RP31	Skn06	pedestal dish				−29.8	1.1	44.0	−29.0	−29.2	−0.2	1.8
RP36	Sd01	cup				−26.1	−1.1	26.0	−28.2	−28.0	0.2	1.8
RP38	L12	pot				−27.5	3.4	17.2	−27.2	−28.4	−1.2	1.4
RP39	Skn09	pedestal dish				−30.0	2.9	21.2	−27.8	−27.4	0.4	0.1
RP42	S01	dish				n/d	n/d	4.6	n/d	n/d	n/d	n/d
RP43	L08	pot				−27.0	−0.9	42.9	−32.1	−31.9	0.2	1.2
RP44		dish				n/d	n/d	7.6	n/d	n/d	n/d	n/d
RP46		pot	Poz–48528	6290	40	−34.3	n/d	225	n/d	n/d	n/d	n/d
RP47	V01	jug	Poz–55545	6340	40	−35.4	5.2	146	−29.4	−31.5	−2.1	1.4
RP48		pot	Poz–55547	6780	35	n/d	n/d	60.8	−30.4	−30.4	0.0	1.9
RP50	Skn06	pedestal dish				n/d	n/d	6.2	n/d	n/d	n/d	n/d
RP71		ladle/spoon	Poz–55548	5625	35	−25.0	1.4	15.9	−30.1	−27.3	2.8	0.8
RP75		vessel	Poz–48529	5630	40	n/d	n/d	28.2	n/d	n/d	n/d	n/d
RP80		bowl				n/d	2.1	21.4	−27.8	−28.6	−0.8	1.5
RP82	L06	pot				−28.9	2.8	33.6	−28.5	−30.5	−2.0	0.9
RP93		pot				−26.6	3.6	13.7	−26.7	−27.6	−0.9	1.6
RP96	L04b	pot				n/d	n/d	3.4	n/d	n/d	n/d	n/d
RP98	Skn03	pedestal dish				−26.2	4.7	36.2	−27.1	−29.1	−2.0	0.5
RP104		pot				−29.2	3.8	47.4	−29.3	−31.8	−2.5	1.3
RP111		dish				−27.3	3.2	22.7	−29.5	−30.4	−0.9	0.6
RP112	Skn04	pedestal dish				n/d	n/d	6.1	n/d	n/d	n/d	n/d
RP118	S05	dish				n/d	n/d	??	n/d	n/d	n/d	n/d

Tab 2. A summary of lipid residues detected in pottery vessels from Resnikov prekop. Key: MAG – moniacylglycerols; DAG – diacylglycerols; TAG – triacylglycerols; ALK – **n*****-alkanes; OH –*** **n*****-alcohols; CH – cholesterol; n/d – not detected.***

silylated directly and analysed by high temperature-gas chromatography (HT GC), and combined GC-mass spectrometry (GC-MS) analyses were performed to identify the structure of components where necessary (*Evershed* et al. *1990*).

Further aliquots of the TLE were then methylated using BF3/methanol to obtain fatty acid methyl esters (FAME) (14%, w/v; 100μl; Sigma Aldrich, Gillingham, UK; at 70°C for 1h). The methyl ester derivatives were extracted with hexane, and the solvent removed under nitrogen. FAMEs were re-dissolved in hexane for analysis by GC and GC-C-IRMS, using standard protocols (*Evershed* et al. *1994; Mottram* et al. *1999; Gregg, Slater 2010; Ogrinc* et al. *2012*). The GC-C-IRMS analyses were performed using an Iso-

	Mono-, di- and tria-cylglycerols	Fatty acids (FA)	Other lipids	Predominant commodity type	Reference
	n/d	$C_{11:0}$, $C_{12:0}$, $C_{13:0}$, $C_{14:0}$, $C_{14:1}$, $C_{15:0}$, $C_{15:1}$, $C_{16:0}$, $C_{16:1}$, $C_{18:0}$, $C_{18:1}$, $C_{19:0}$, $C_{20:0}$, $C_{21:0}$, $C_{24:0}$	ALK, OH	ruminant adipose fat	*Harej 1975.T. 1.5*
	n/d	n/d	n/d	n/d	*Harej 1975.T. 2.1*
	n/d	$C_{11:0}$, $C_{12:0}$, $C_{13:0}$, $C_{14:0}$, $C_{14:1}$, $C_{15:0}$, cis-$C_{15:1}$, $C_{16:0}$, $C_{17:0}$, cis-$C_{17:0}$, $C_{18:0}$, $C_{18:1}$, $C_{20:0}$, $C_{22:0}$	CH	mixed	*Harej 1975.T. 2.6*
	n/d	$C_{11:0}$, $C_{12:0}$, $C_{13:0}$, $C_{14:0}$, $C_{15:0}$, $C_{16:0}$, $C_{17:0}$, $C_{18:0}$, $C_{20:0}$, $C_{21:0}$	ALK, OH	mixed, plant	*Harej 1975.T. 2.7*
	n/d	$C_{11:0}$, $C_{12:0}$, $C_{13:0}$, $C_{14:0}$, $C_{15:0}$, $C_{16:0}$, $C_{17:0}$, $C_{18:0}$, $C_{20:0}$, $C_{21:0}$	n/d	ruminant adipose fat	*Harej 1975.T. 3.4*
	DAG	$C_{11:0}$, $C_{12:0}$, $C_{13:0}$, $C_{14:0}$, $C_{15:0}$, $C_{16:0}$, $C_{17:0}$, $C_{18:0}$, $C_{19:0}$, $C_{20:0}$, $C_{21:0}$, $C_{22:0}$, $C_{23:0}$, $C_{24:0}$, C25:0, $C_{26:0}$	ALK, OH	dairy?	*Harej 1975.T. 3.7*
	n/d	$C_{11:0}$, $C_{12:0}$, $C_{13:0}$, $C_{14:0}$, $C_{15:0}$, $C_{16:0}$, $C_{17:0}$, $C_{18:0}$, $C_{20:0}$, $C_{21:0}$	n/d	non-ruminant	*Harej 1975.T. 4.5*
	n/d	$C_{11:0}$, $C_{12:0}$, $C_{13:0}$, $C_{14:0}$, $C_{15:0}$, $C_{16:0}$, $C_{17:0}$, $C_{18:0}$, $C_{20:0}$, $C_{21:0}$	n/d	ruminant adipose fat	*Harej 1975.T. 6.7*
	n/d	n/d	n/d	n/d	*Harej 1975.T. 6.8*
	n/d	n/d	n/d	n/d	*Harej 1975.T. 7.1*
	DAG, TAG	$C_{11:0}$, $C_{12:0}$, $C_{13:0}$, $C_{14:0}$, $C_{15:0}$, $C_{16:0}$, $C_{17:0}$, $C_{18:0}$, $C_{20:0}$, $C_{21:0}$	ALK	mixed, plant	excavated in 1957; not published
	n/d	n/d	n/d	n/d	excavated in 1957; not published
	n/d	n/d	n/d	n/d	*Korošec 1964.T. 17.1*
	n/d	$C_{11:0}$, $C_{12:0}$, $C_{13:0}$, $C_{14:0}$, $C_{15:0}$, $C_{16:0}$, $C_{17:0}$, $C_{18:0}$, $C_{20:0}$, $C_{21:0}$	ALK	ruminant adipose fat	*Korošec 1964.T. 17.3*
	MAG, DAG	$C_{11:0}$, $C_{12:0}$, $C_{13:0}$, $C_{14:0}$, $C_{15:0}$, $C_{16:0}$, $C_{17:0}$, $C_{18:0}$, $C_{20:0}$, $C_{21:0}$	ALK	ruminant adipose fat	*Korošec 1964.T. 17.7*
	n/d	$C_{11:0}$, $C_{12:0}$, $C_{13:0}$, $C_{14:0}$, $C_{15:0}$, $C_{16:0}$, $C_{17:0}$, $C_{18:0}$, $C_{20:0}$, $C_{21:0}$	ALK	ruminant adipose fat	*Korošec 1964.T. 18.1*
	MAG, DAG	$C_{11:0}$, $C_{12:0}$, $C_{13:0}$, $C_{14:0}$, $C_{15:0}$, $C_{16:0}$, $C_{17:0}$, $C_{18:0}$, $C_{20:0}$, $C_{21:0}$	ALK, OH	mixed, plant	*Korošec 1964.T. 18.3*
	n/d	$C_{11:0}$, $C_{12:0}$, $C_{13:0}$, $C_{14:0}$, $C_{15:0}$, $C1_{16:0}$, $C_{17:0}$, $C_{18:0}$, $C_{20:0}$, $C_{21:0}$	ALK, OH	mixed, plant	*Korošec 1964.T. 4.3*
	n/d	$C_{11:0}$, $C_{12:0}$, $C_{13:0}$, $C_{14:0}$, $C_{15:0}$, $C_{16:0}$, $C_{17:0}$, $C_{18:0}$, $C_{20:0}$, $C_{21:0}$	ALK, OH	ruminant adipose fat	*Korošec 1964.T. 6.1*
	n/d	$C_{11:0}$, $C_{12:0}$, $C_{13:0}$, $C_{14:0}$, $C_{15:0}$, $C_{16:0}$, $C_{17:0}$, $C_{18:0}$, $C_{20:0}$, $C_{21:0}$	ALK	mixed, plant	*Korošec 1964.T. 7.1*
	n/d	n/d	n/d	n/d	*Korošec 1964.T. 9.8*
	n/d	$C_{11:0}$, $C_{12:0}$, $C_{13:0}$, $C_{14:0}$, $C_{15:0}$, $C_{16:0}$, $C_{17:0}$, $C_{18:0}$, $C_{20:0}$, $C_{21:0}$	ALK	mixed	*Korošec 1964.T. 10.2*
	n/d	n/d	n/d	n/d	*Korošec 1964.T. 10.7*
	n/d	$C_{16:0}$, cis-$C_{17:0}$, $C_{18:0}$, $C_{18:1}$, $C_{19:0}$, $C_{22:0}$	n/d	n/d	*Korošec 1964.T. 12.2*
	n/d	$C_{14:0}$, $C_{14:1}$, $C_{16:0}$, $C_{17:0}$, cis-$C_{17:0}$, $C_{18:0}$, $C_{18:1}$, $C2_{22:0}$	CH	ruminant adipose fat	*Korošec 1964.T. 13.4*
	n/d	$C_{16:0}$, $C_{18:0}$, $C_{18:1}$, $C_{22:0}$	n/d	mixed	*Korošec 1964.T. 14.4*
	n/d	n/d	n/d	n/d	*Korošec 1964.T. 15.4*
	DAG, TAG	$C_{12:0}$, $C_{16:0}$, $C_{18:0}$, $C_{18:1}$, $C_{20:0}$	ALK, OH, CH	non-ruminant	excavated in 1957; not published
	n/d	n/d	n/d	n/d	excavated in 1957; not published
	n/d	$C_{11:0}$, $C_{12:0}$, $C_{13:0}$, $C_{14:0}$, $C_{15:0}$, $C_{16:0}$, $C_{17:0}$, $C_{18:0}$, $C_{20:0}$, $C_{21:0}$	ALK, OH	mixed, plant	*Velušček 2006.T. 1.1*
	n/d	$C_{11:0}$, $C_{12:0}$, $C_{13:0}$, $C_{14:0}$, $C_{15:0}$, $C_{16:0}$, $C_{17:0}$, $C_{18:0}$, $C_{20:0}$, $C_{21:0}$	nd	ruminant adipose fat	*Tomaž, Velušček 2005.Fig. 33*
	n/d	$C_{11:0}$, $C_{12:0}$, $C_{13:0}$, $C_{14:0}$, $C_{15:0}$, $C_{16:0}$, $C_{17:0}$, $C_{18:0}$, $C_{20:0}$, $C_{21:0}$	ALK	mixed, plant	*Velušček 2006.T. 1.4*
	n/d	n/d	n/d	n/d	*Velušček 2006.T. 16.5*
	DAG	$C_{11:0}$, $C_{12:0}$, $C_{13:0}$, $C_{14:0}$, $C_{15:0}$, $C_{16:0}$, $C_{17:0}$, $C_{18:0}$, $C_{20:0}$, $C_{21:0}$	ALK	ruminant adipose fat	*Velušček 2006.T. 19.4*
	n/d	$C_{11:0}$, $C_{12:0}$, $C_{13:0}$, $C_{14:0}$, $C_{15:0}$, $C_{16:0}$, $C_{17:0}$, $C_{18:0}$, $C_{20:0}$, $C_{21:0}$	ALK	ruminant adipose fat	excavated in 1957; not published
	n/d	$C_{11:0}$, $C_{12:0}$, $C_{13:0}$, $C_{14:0}$, $C_{15:0}$, $C_{16:0}$, $C_{17:0}$, $C_{18:0}$, $C_{20:0}$, $C_{21:0}$	n/d	mixed	*Velušček 2006.T. 14.18*
	n/d	n/d	n/d	n/d	*Velušček 2006.T. 14.17*
	n/d	n/d	n/d	n/d	*Velušček 2006.T. 15.4*

prime GV system (Micromass, Manchester, UK); the precision of repeated measurements was 0.3‰.

Results and discussion

General overviews (Tab. 2) of the lipids preserved in the vessels could be obtained from bulk $\delta^{13}C$ and $\delta^{15}N$ values. The $\delta^{13}C$ values are < –25.0‰, and the $\delta^{15}N$ values range from –6.0 to +7.3‰. These data indicates that these vessels were used to process terrestrial herbivore products and/or plant material. Terrestrial C3 plants have $\delta^{13}C$ values between –30 and –23‰, while $\delta^{15}N$ values range from –7 to +6‰ (*Ostrom, Fry 1993*).

It was found that 68% of the pottery samples contained extractable lipid residues. The lipid distribution is dominated by fatty acids, specifically $C_{16:0}$ and $C_{18:0}$. Other components include *n*-alkanes (principally C_{27}–C_{33}), *n*-alcohols (C_{24}–C_{34}) and mono-, di- and tri-acylglycerols (MAGs, DAGs, TAGs) (Tab. 2). Unfortunately, MAGs, DAGs and TAGs were present only as traces, making further identification impossible (in samples RP7, RP22, RP29, RP31, RP71, RP98). Therefore, in order to elucidate the origin of residues in pottery vessels, the $\delta^{13}C$ values of the principal fatty acids $C_{16:0}$ and $C_{18:0}$ were determined.

First, fat extracts from the samples were classified into principal commodity groups by plotting $\delta^{13}C_{16:0}$ versus $\delta^{13}C_{18:0}$ (Fig. 6). The three principal sources of animal fats were generated from the $\delta^{13}C$ values of modern domestic animal fats. Theoretical mixing curves were calculated to show the effect of vessel re-use and the processing of mixtures of commodities (*Copley* et al. *2005*). It should be mentioned that these modern animals (cow, sheep and goat) were from the same geographical area as Resnikov prekop and fed exclusively on C3 forage grasses (see *Budja* et al. *2013.Tab. 3*).

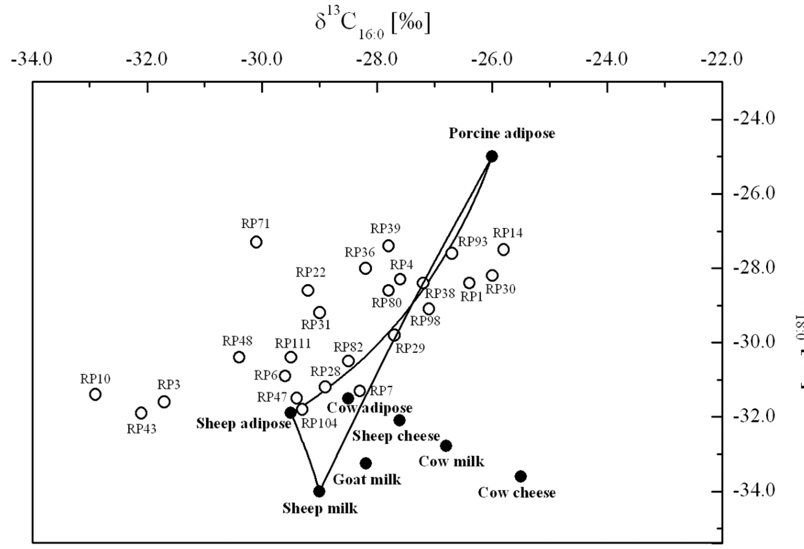

Fig. 6. Plot of the $\delta^{13}C$ of $C_{18:0}$ and $C_{16:0}$ fatty acids of modern reference fats and the lipid extracts of pottery samples from Resnikov prekop. Open circles represent the archaeological fats. The theoretical mixing curve is plotted to illustrate $\delta^{13}C$ values resulting from the mixing of modern fats (see* Budja *et al. 2013*.Tab. 3*).

The lipid extracts that plot between the reference animal fat field indicate the presence of a mixture of these specific fats as a consequence of vessel re-use (Fig. 6). As can be seen, there is evidence of the processing of ruminant animal products derived mainly from adipose fat (RP6, RP7, RP28, RP47, RP104), while none of the extracts plot within or in the vicinity of the reference porcine adipose fat or in the area of dairy fat. However, some samples plot in the area between porcine and ruminant adipose fat (RP1, RP4, RP14, RP29, RP30, RP38, RP-80, RP82, RP93, RP98), suggesting that these vessels were used to process mixed ruminant and non-ruminant adipose fats. The data that do not plot along any of the theoretical mixing curves (RP3, RP10, RP22, RP31, RP36, RP39, RP43, RP48, RP71, RP111) indicate an admixture of fats of different origin and different degrees of degradation.

Furthermore, the plot where $\Delta^{13}C$ values ($\delta^{13}C_{18:0}$–$\delta^{13}C_{16:0}$) are plotted against the $\delta^{13}C_{16:0}$ values define the origin of the fats more explicitly (Fig. 7) by eliminating variability in diet and sources of local environmental variations (*Copley* et al. *2005*). Up to 15 samples (60%) contained predominantly ruminant adipose fat, indicating that ruminant meat produce was an important commodity at Resnikov pre-

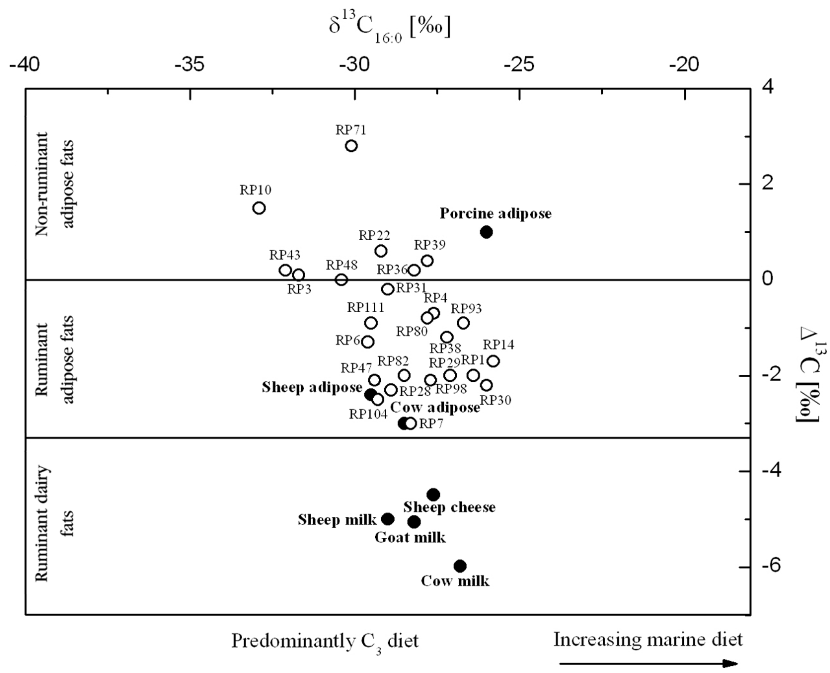

Fig. 7. Plot showing the difference in the $\delta^{13}C$ values of $C_{18:0}$ and $C_{16:0}$ fatty acids ($\Delta^{13}C$) versus $\delta^{13}C_{16:0}$ recovered from pottery extracts from Resnikov prekop and modern reference fats (see* Budja *et al.* 2013.Tab. 3*).

kop. One of the samples (RP7) plotted on the border of two ranges of ruminant and dairy fats suggests the possible mixing of these two types of fat during pottery use. However, none of the pottery samples plot below the $\Delta^{13}C$ = –3.3‰ line, which was used as a criterion to determine dairy foods (*Evershed* et al. *2002; 2008; Copley* et al. *2003; 2005*).

A further 7 samples or 28% (RP3, RP22, RP31, RP36, RP39, RP43 and RP 47) fall close to the $\Delta^{13}C$ = 0‰ line and are therefore indicative of the processing of mixed ruminant and non-ruminant animal products and/or processing of mixed plant and animal fats. Two of the samples plot in the area of non-ruminant adipose fat (RP10, RP 71). Low $\delta^{15}N$ values of –0.3 and +1.4, respectively, suggest the presence of plant fats in these two samples, and the high $C_{16:0}/C_{18:0}$ ratio of 4.0 (Tab. 2) determined in sample RP10 indicates the presence of degraded vegetable oil (*Copley* et al. *2005*). Fish fat was not detected in any of the pottery samples from Resnikov prekop.

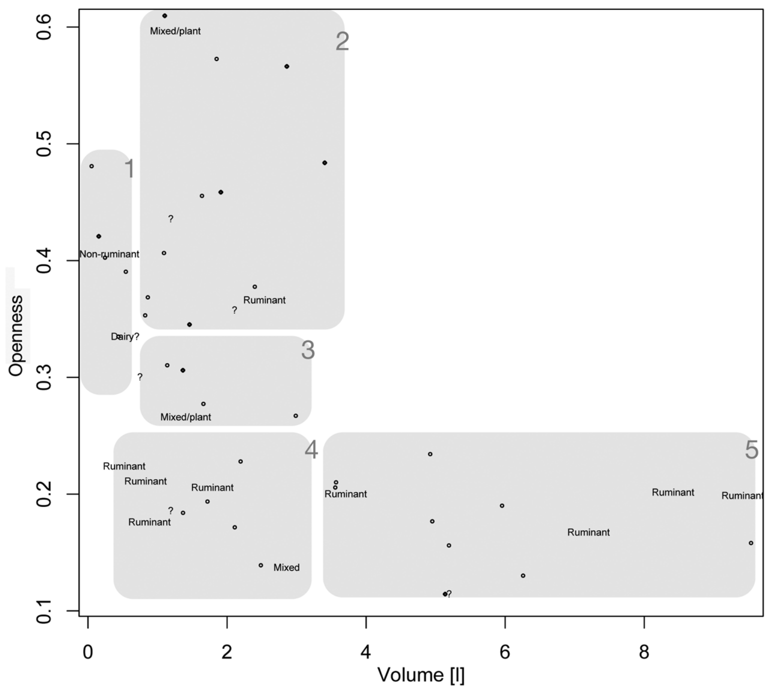

Fig. 8. Vessels from Resnikov prekop arranged according to capacity, openness and predominant organic residue identified using lipid analysis. Vessel use groups are indicated.

The processing of plant products was also detected by a homologous series of long chain *n*-alkanes and *n*-alcohols in almost 68% of the pottery samples. These compounds were associated with adipose fats (RP1, RP7, RP27, RP28, RP29, RP30, RP38, RP104, RP111), a mixture of ruminant and non-ruminant fats (RP4, RP22, RP31, RP36, RP39, RP43, RP80) and one with non-ruminant fat (RP71). The appearance of both animal and plant biomarkers suggests that these vessels were associated with the cooking/processing of a variety of different foods.

Pottery use at Resnikov prekop

The vessels from Resnikov prekop reveal a broad range of sizes, forms and fabrics, as demonstrated by our analyses. We could detect no correlation between functional types and fabric groups, suggesting that variability could not be explained by technical choices, but different traditions or individual idiosyncrasies. The vessels are generally very small, with a maximum volume of 9 litres, and capacities peak between 0.5 and 3.5 litres. This suggests that most of the assemblage consists of vessels for preparation and storage for small groups of people and individual consumption. The lipid residue analysis demonstrates that the vessels from Resnikov prekop were mostly used to process and serve different foods derived from terrestrial animals, mostly ruminants such as sheep, cattle or goat (Fig. 8).

Vessels that can be interpreted as cooking pots are generally lacking. Pots with very low accessibility (groups 4 and 5) are generally well made and richly decorated, have very thin walls and are made from a large variety of different fabrics. Only terrestrial animal (mostly ruminant) fats were detected in these two groups. Ruminant fat was also detected in jugs with very low capacities (Fig. 8). Rather than cooking pots, they can probably be interpreted as being for the long-term storage of foods containing ruminant fats. Richly decorated pots in this group might point to the social importance of such foodstuffs (*e.g.*, sample RP82; Fig. 4).

Plant fats were very rarely detected in pots, where terrestrial animal fats predominate in the samples. Traces of terrestrial plant foods, mostly mixed with animal fats, were found mostly in more open vessels (groups 3, 2 and 1) described as pedestal dishes, bowls, cups and beakers (Fig. 8). The only evidence of possibly dairy fats was found in group 1, with small volumes and moderate openness, intended for individual uses.

The exclusively terrestrial diet suggested by the lipid analysis is in stark contrast with the environment of Resnikov prekop. Since the site is located in a marshy floodplain and was interpreted as a pile-dwelling, we would expect many more freshwater resources to be used in food preparation and storage. Fish remains are present on some pile-dwellings (*Govedič 2004*) as well as elements of fishing toolkits (harpoons, hooks, net weights; *Greif 1997*); however, the scale and importance of fishing and the role of freshwater foodstuffs in the diet of people who lived at these sites remains unknown.

The pottery assemblage from Resnikov prekop is unusual, especially compared to the nearby site of Maharski prekop (see *Mlekuž* et al. *2012*). The Resnikov prekop assemblage clearly lacks vessels that can be interpreted as food processing vessels; instead, it seems that most of the larger pots were used for storage and consumption, perhaps even for displaying food.

Food articulates identity in many ways. Food can be described as "*a highly condensed social fact*" (*Appadurai 1986.494*). Food storage and consumption at Resnikov prekop seem to have played an important role in the expression of collective identity. The use of relatively large, richly decorated pots in the daily routine of food consumption expressed and created relations of equality or solidarity within group(s). On the other hand, the importance of individual consumption reflected in the wide variety of small serving vessels suggests that food consumption played a role in the creation of individual identity, indicating rank, distance or segmentation (*Appadurai 1986*).

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A new look at old material: ceramic petrography and Neo/Eneolithic pottery traditions in the eastern Ljubljansko barje, Slovenia

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ABSTRACT – *In this article, a new look at old material, pottery, is presented, as the technology and operational sequences of pottery from the Neolithic and Eneolithic in Slovenia is mostly understudied. Here, the focus is on 5th and 4th millennia BC artefacts from the eastern part of Ljubljansko barje and sites, such as Resnikov prekop, Maharski prekop and Breg near Škofljica. The pottery was studied with a hand lens and petrographically, using an optical polarising microscope. The results were then compared to analyses of locally gathered clays and sediments. Pottery traditions at Resnikov prekop and Breg were different from those at Maharski prekop, although the vessels from all three sites were produced locally and mostly made from local material, but with different recipes or fabrics. The selection of raw material, the shaping and decorating of pots, their firing and use were probably more related to different traditions and individual choices of potters at these sites than to purely technological choices.*

IZVLEČEK – *V članku predstavljam nov pogled na star material, lončenino, saj se tehnologiji in operacijskim sekvencam pri izdelavi lončenine iz obdobja neolitika in eneolitika v Sloveniji posveča le majhna pozornost. Pričujoča analiza je osredotočena na artefakte 5. in 4. tisočletja BC. Iz vzhodnega dela Ljubljanskega barja, ki so bili izkopani na najdiščih Resnikov prekop, Maharski prekop in Breg pri Škofljici. Lončenino smo preiskali na makroskopskem nivoju in s petrografsko metodo opazovanja pod optičnim polarizacijskim mikroskopom. Rezultate smo primerjali z analizami lokalnih glin in sedimentov. Lončarske tradicije se na najdiščih Resnikov prekop in Breg razlikujejo od tradicij na Maharskem prekopu po svojih lončarskih masah in receptih, kljub temu da so bile posode izdelane iz lokalnih materialov. Izbor naravnih materialov, oblikovanje in okraševanje posod, žganje in uporaba so verjetno povezani z različnimi tradicijami in individualnimi odločitvami lončarjev na teh najdiščih in ne prestavljajo izključno le tehnološke rešitve.*

KEY WORDS – *Ljubljansko barje; Neolithic/Eneolithic; pottery technology; petrography;* chaîne opératoire

Introduction

The Ljubljansko barje is a very intriguing place. This floodplain located to the south of the Slovenian capital, Ljubljana, has been a focus for archaeologists for more than a hundred years. In the Neolithic and Eneolithic, many settlements were erected on the floodplain, mostly in the tradition of so-called pile-dwellings, and these sites were present in this area at least from the 6th millennium calBC to the Early Bronze Age. Besides this long occupational sequence and similar building techniques, considerable differences may be observed in the material culture, especially in the different pottery traditions (*e.g., Bregant 1964; Korošec 1964; Korošec, Korošec 1969; Bregant 1974a; 1974b; 1975; Harej 1975; 1978; 1981–82; 1987; VeluščEk 2004; 2006; 2009 etc.*). Ljubljansko barje is also a subject of continuous debate over the existence or non-existence of a Holocene lake and the interpretation of Neolithic-Eneoli-

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thic pile-dwellings (*e.g., Melik 1946; Velušček 2004; 2007; Verbič 2011 contra Budja 1995; Mlekuž* et al. *2006; Budja, Mlekuž 2008; 2010*). Despite all the controversy surrounding these finds, the area has always been part of extensive studies covering many fields of research since the first excavations; from palynology to dendrochronology, from archaeozoology to material culture studies (*e.g., Šercelj 1966; 1974; 1975; Strmole 1974; Osterc 1975; Stritar 1975; Golyeva 2006; Turk 2006; 2009; Bernardini 2009 etc.*). With the vast scope of research it is surprising that the most common artefacts at these sites, namely pottery, are the most understudied material in terms of technology. Besides basic descriptions of colour, inclusions and general appearance, typological studies have been prevalent, and only some samples from Maharski prekop and Resnikov prekop have been studied with petrography and X-ray diffraction (*Osterc 1975*).

In this article, a new look into old material, ceramics, is presented. The observations and results are based on studies of pottery samples from three Neolithic/Eneolithic sites in Ljubljansko barje: Resnikov prekop, Maharski prekop and Breg near Škofljica. The samples were studied by hand specimen analysis and grouped according to their sand-sized inclusions. Later samples for were chosen for petrographical analysis, prepared as thin sections. The pottery was then ordered into various fabrics that can also be interpreted as the recipes of potters at these sites. In the last stage, these results were compared to analyses of locally gathered clays and sediments. The ceramic vessels are presented as part of an operational sequence or *chaîne opératoire* in pottery preparation in the Neolithic and Eneolithic period of the eastern Ljubljansko barje region, and their role in the complexity of people's lives is also investigated.

Archaeological sites and samples

Resnikov prekop

Resnikov prekop is one of the oldest Neolithic sites in central Slovenia and was discovered during excavations for a new canal near Ig on the Ljubljansko barje in 1953 (Fig. 1). In 1957, Staško Jesse excavated two trenches, one on each side of the canal; the results of his excavation were published later, in the 1970s (*Harej 1975*). The most extensive excavations were carried out in 1962 by Josip Korošec (*Bregant 1964; Korošec 1964*). A small number of vertical and horizontal wooden piles was discovered, as well as fragments of branches, stone slabs and plaster fragments. A great amount of pottery, 8 stone axes and some silex tools were also found (*Korošec 1964.34*). In 2002, the Institute of Archaeology in Ljubljana excavated trenches at Resnikov prekop, south of Korošec's excavation area, where mostly pottery was found (*Velušček 2006*). The excavation confirmed the observations from the 1960s that the cultural layer at the site had been swept away and the finds represent artefacts from different periods mixed together (*Budja 1994/1995.167; Velušček 2006.57*). Only heavier artefacts, such as pottery, stones, larger bones and vertical piles probably remained in their original positions at the site.

The piles, although only a few of them have been excavated, show rows that ran in a southwest-northeast direction typical of Ljubljansko barje. In comparison with other so-called pile-dwelling sites on the Ljubljansko barje, Resnikov prekop has fewer piles and the buildings were poorly maintained. This led to the conclusion that the site was occupied for only a short period, perhaps less than a decade (*Velušček 2006.57*). According to the radiocarbon dates of vertical piles, the existence and duration of the Resnikov prekop site was placed firmly in the 46th century calBC (*Čufar, Korenčič 2006.124, Tab. 2*). Nevertheless, new radiocarbon dates from charred organic residues on pottery show that the occupation at Resnikov prekop had a longer time span, lasting from around 5300 to 4400 calBC (see *Mlekuž* et al. *2013*).

Maharski prekop

This site was also discovered in 1953, at a location Na Mahu near the Maharski prekop canal (Fig. 1). Systematic excavations began in 1970 by Tatjana Bregant and the Department of Archaeology at the University in Ljubljana and continued for several seasons until 1977 (*Bregant 1974a; 1974b; 1975; with unpublished material from seasons 1976 and 1977*). The excavated area was more than 1100m^2 and the finds were documented in 4 x 4m grid squares (*Bregant 1975.9–10*). The results of these excavations and recent geomorphological assessments using LiDAR show that Maharski prekop is located on a floodplain with several paleochannels and an active river channel near the site (*Mlekuž* et al. *2006; Budja, Mlekuž 2008*). The site had a distribution of more than 2400 wooden piles, clay floors and grindstones, which were interpreted as the remains of 9 houses, approx. 4 x 10m in size (*Mlekuž* et al. *2006*). New radiocarbon dates show that the occupation at Maharski prekop had roughly two phases: one dated between 4400 and 4000 calBC and the other between 3800 and 3550 calBC (*Mlekuž* et al. *2012.Fig. 2*).

Breg near Škofljica

This site was discovered during a topographic survey and is located on a small isolated hill called Breg near the small town of Škofljica in the south-eastern part of Ljubljansko barje (Fig. 1). In the years 1983 to 1984 two small trenches, 2 x 2m, were excavated by Franc Osole and his team; the oldest layers were dated to the castelnovien or younger Mesolithic period (*Frelih 1986.35–36*). The excavations yielded more than 2500 different stone tools, such as scrapers, blades, burins, cores and other types of flake (*Frelih 1986.27*). These layers were also radiocarbon dated, but the published dates are confusing, since different dates are given for the same samples (see *Budja 1993.175*). The second excavation was led by Mihael Budja in the 1990s, and again two small trenches, 2 x 2m, were excavated (trench II in1996 and trench I in 1997). Pottery fragments were excavated in the oldest layer, together with typical Mesolithic geometrical tools (*Tomaž 1999.58–73; Budja, Mlekuž 2008*).

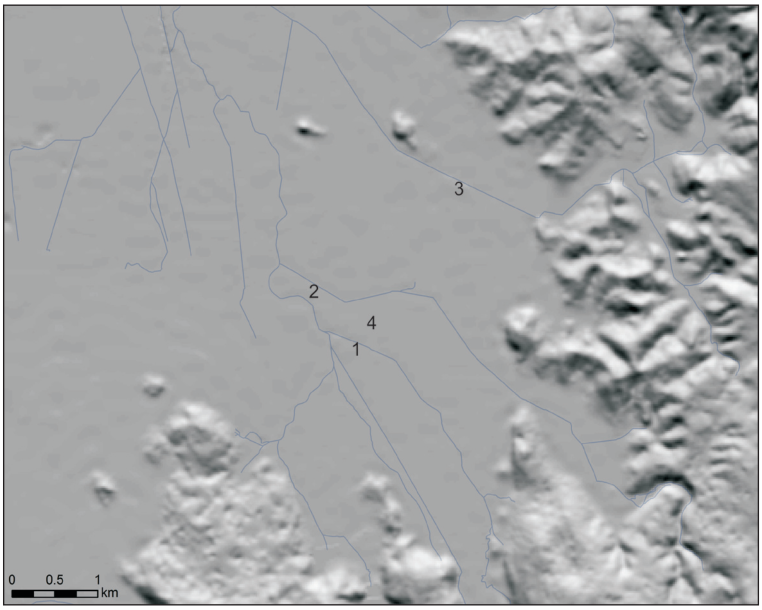

Fig. 1. Map of the eastern part of Ljubljansko barje showing the locations of sites mentioned in the text: 1 Resnikov prekop; 2 Maharski prekop; 3 Breg near Škofljica; 4 Gornje mostišče.

Analytical methods

To identify the pottery technology and the operational sequence or *chaîne opératoire*, the pots were first sampled according to their stratigraphic position, vessel type and ornamentation techniques at each site. The samples were then analysed using a hand lens and following descriptions of pottery published by Milena Horvat (*1999*). Such hand specimen analyses enabled the characterisations of broader technological traits for large pottery assemblages. The basic composition of the pots was described, *i.e.* their inclusions, the abundance and size of the particles and the presence of voids; the hardness, surface colour, firing atmosphere and surface treatment were also recorded. The samples were then grouped into different fabric types, which enabled us to select samples for petrographic analysis. The petrographic description of pottery enhances the identification of different non-plastic inclusions and allows for direct comparisons with regional geology (*Whitbread 2001.451*).

Pottery samples for the petrographic analysis were prepared as standard thin sections of 30μm thickness (*Reedy 2008.1–3*). The samples were then analysed under a polarising light microscope, following the descriptions proposed by Ian Whitbread (*1995. Appendix 3*) and the volume estimates were made using tables published by Richard D. Terry and George V. Chillingar (*1955*). The samples were then sorted into fabric groups, based on the composition of their inclusions, the clay matrix and the voids under the microscope. On the basis of compositional, microstructural and textural criteria, the presence of specific techniques was detected, such as the intentional addition of temper, raw material processing, vessel-forming techniques, and the atmosphere and degree of firing (*Reedy 2008.146–148, 173–189; Rice 1987.409–411; Whitbread 1986; 1995. 393–394*).

In addition, we sampled clays near Resnikov prekop and Maharski prekop. The clay samples were analysed using an X-ray diffractometer in their natural state, and were additionally prepared as approx. 3 x 4cm plates and fired in a controlled oxidising atmosphere at 700°C. The fired clay samples were then analysed using the X-ray diffraction technique, made into thin sections and analysed using a polarising light microscope, following a criteria similar to that applied to the pottery samples (*Whitbread 1995; Terry, Chillingar 1952*).

Pottery technology at Resnikov prekop

The most common types of vessel found at Resnikov prekop are various pots, followed by dishes, pedestal dishes, bowls, cups, jugs, and ladles with cylindrical handles (see *Mlekuž* et al. *2013*). Vessel surfaces were smoothed or burnished, but no surface polishing was detected. These pots were made with the coiling technique, the walls are very fine and less than 5mm thick. The vessels were fired in an incomplete oxidising atmosphere, and only rare pots were fired in an oxidising and reducing atmosphere. The dominant colours of the pottery assemblage are grey, dark brown and light red (*Korošec 1964.29–30; Harej 1975.147; Tomaž, Velušček 2005.88–90*). The most striking feature is the fact that all the ornamentation appears only on the exterior of the upper part of the vessels. The ornaments were made with impressions, incisions or appliqués, or a combination of the three techniques. Some vessels were decorated with a red and, rarely, black slip, that was applied, unlike other ornamentation techniques, to the entire vessel, on the interior and exterior surfaces (*Korošec 1964.33; Harej 1975.149; Velušček 2006.57–58; Tomaž, Velušček 2005*).

For the present study, 120 pottery samples from Resnikov prekop were analysed with a hand lens for the presence of different inclusions, their size and frequency, and the presence of voids. The samples were chosen according to the typology of the published material from the site (*Korošec 1964; Harej 1975; Velušček 2006*) and were in part used also in the biochemical lipid analysis (see *Mlekuž* et al. *2013*). These vessels could be attributed to three technological groups: the first group of vessels, made from non-calcareous clay and only quartz inclusions (31/120); the second group with quartz and calcite/limestone inclusions is the most common (59/120); the third comprised mostly calcite/limestone inclusions (30/120). The majority of vessels, *i.e.* 52.5%, has inclusions in the size range of medium sand (0.25 to 0.50mm) and a further 40.8% has inclusions in the range of very fine sand (less than 0.25mm). Vessels with coarser sand inclusions (0.50 to 2.00mm) are much less common (6.7%) and made mostly with quartz and calcite/limestone inclusions belonging to the second technological group.

Various pots, different types of dishes and pedestal dishes from Resnikov prekop share many technological characteristics and are typically made with inclusions of quartz and calcite/limestone, which are in the medium sand fraction. Different types of bowl are similarly made, but nevertheless exhibit a stronger presence of vessels made only with quartz inclusions and much more fine-grained fabrics, with fine sand inclusions.

Petrographic analysis of the Resnikov prekop pottery

For the petrographic analysis of pottery from Resnikov prekop, 25 samples were chosen and prepared as standard thin sections (Tab. 1). All samples were chosen according to the technological characteristics observed in the hand specimen description (see above) covering all the different technological groups. These samples can be attributed to eight different fabric groups according to the characteristics of clays and inclusions, as well as temper added by the potters at Resnikov prekop (Tab. 2, Fig. 2).

Fabric RP-1 (Fig. 2.A) is a very fine-grained non-calcareous clay with frequent (40%) non-plastic inclusions, with a few sponge spicules present in the paste. The clay appears to be only cleaned of coarser inclusions and no temper was added. The inclusions are well sorted and mostly in the silt size fraction. The inclusions are frequent monocrystalline quartz, frequent muscovite and very rare biotite mica, a few sponge spicules, rare chert grains, common opaques or 'amorphous' concentration features (see *Whitbread 1995.386*) and very rare feldsparsplagioclase grains (Tab. 2). The fabric could be identified in three samples from the Jesse trench I excavated in 1957 (*Harej 1975*), but was not present in any of the other trenches.

Fabric RP-2 (Fig. 2.B) is also a very fine-grained non-calcareous clay, with common (20%) non-plastic inclusions with frequent opaques. The clay was only cleaned of coarser inclusions, since no temper was added by the potters. The inclusions are mostly well sorted and have grains in the silt size fraction. The inclusions are frequent monocrystalline quartz, rare chert grains, common muscovite and a few biotite mica, with very rare sandstone grains and very rare argillaceous rock fragments (see *Whitbread 1986*) (Tab. 2). The fabric was identified in five samples from all excavated trenches and came from vessels such as pots, dishes and pedestal vessels (*e.g., Korošec 1964.T. 10.7*).

Fabric RP-3 (Fig. 2.C) has a coarser texture and is a non-calcareous clay with common (20%) non-plastic inclusions and chert, probably added as temper. The chert grains are common (10%), semi-angular and medium sorted, mostly in the fine to medium sand fraction, and could have been added as temper by the potters. The other inclusions include frequent monocrystalline quartz, frequent muscovite and very rare biotite mica, a few opaques and very rare argillaceous rock fragments (Tab. 2). The fabric could be

Sample No.	Site	Year of excavation	Grid square	Context	Vessel type	Fabric group	Citation
RP5	Resnikov prekop	1957			deep dish	RP–5	*Harej 1975.T. 2.10*
RP15	Resnikov prekop	1957			pot	RP–2	*Harej 1975.T. 6.8*
RP20	Resnikov prekop	1957		Trench 1	small pot	RP–1	Not published
RP21	Resnikov prekop	1957		Trench 1	small pot	RP–1	Not published
RP22	Resnikov prekop	1957		Trench 1	cup	RP–1	Not published
RP23	Resnikov prekop	1957		Trench 1	small pot	RP–2	Not published
RP24	Resnikov prekop	1957		Trench 1	pot	RP–5	Not published
RP30	Resnikov prekop	1962			pot	RP–5	*Korošec 1964.T. 18.1*
RP34	Resnikov prekop	1962			bowl	RP–8	Not published
RP35	Resnikov prekop	1962			pedestal dish	RP–3	Not published
RP44	Resnikov prekop	1962			dish	RP–2	*Korošec 1964.T. 10.7*
RP50	Resnikov prekop	1962			pedestal dish	RP–6	*Korošec 1964.T. 15.4*
RP73	Resnikov prekop	1962			bowl?	RP–8	Not published
RP79	Resnikov prekop	2002	11	Trench 1/SU 005	pot	RP–8	Not published
RP84	Resnikov prekop	2002	9	Trench 1/SU 005	pot	RP–5	Not published
RP85	Resnikov prekop	2002	4	Trench 2/SU 005	pot	RP–6	*Velušček 2006.T. 13.3*
RP89	Resnikov prekop	2002	11	Trench 1/SU 005	pedestal vessel	RP–2	Not published
RP91	Resnikov prekop	2002	11	Trench 1/SU 005	pot	RP–7	Not published
RP92	Resnikov prekop	2002	1	Trench 2/SU 005	pedestal vessel	RP–5	Not published
RP98	Resnikov prekop	2002	9	Trench 3/SU 005	pedestal dish	RP–6	*Velušček 2006.T. 19.4*
RP100	Resnikov prekop	2002	9	Trench 3/SU 005	bowl	RP–8	*Velušček 2006.T. 19.1*
RP107	Resnikov prekop	2002	8	Trench 3/SU 005	pot	RP–6	Not published
RP108	Resnikov prekop	2002	8	Trench 3/SU 005	pot	RP–2	Not published
RP110	Resnikov prekop	2002	7	Trench 2/SU 005	deep dish	RP–7	*Velušček 2006.T. 15.1*
RP111	Resnikov prekop	2002	7	Trench 2/SU 005	dish	RP–4	*Velušček 2006.T. 14.18*
MP22	Maharski prekop	1974	17		pot	MP–1	*Bregant 1975.T. 15.4*
MP26	Maharski prekop	1973	18		pot	MP–1	*Bregant 1975.T. 16.1*
MP47	Maharski prekop	1973	23		pot	MP–1	*Bregant 1975.T. 22.6*
MP55	Maharski prekop	1973	24		pot	MP–1	*Bregant 1975.T. 23.9*
MP79	Maharski prekop	1974	27		dish	MP–1	*Bregant 1975.T. 29.2*
MP103	Maharski prekop	1974	37		pot	MP–1	*Bregant 1975.T. 35.10*
MP104	Maharski prekop	1974	37		pot	MP–1	*Bregant 1975.T. 36.2*
MP199	Maharski prekop	1977	71		bowl	MP–1	Not published
MP206	Maharski prekop	1970	1–8		bowl	MP–1	Not published
MP211	Maharski prekop	1970	1–8		pot	MP–1	Not published
MP13	Maharski prekop	1972	13		pot	MP–2	*Bregant 1974b.T.6.17*
MP133	Maharski prekop	1972	13		pot	MP–2	Not published
MP147	Maharski prekop	1976	44		pot	MP–3	Not published
MP148	Maharski prekop	1976	44		pot	MP–3	Not published
MP185	Maharski prekop	1977	68		pot	MP–4	Not published
BR1	Breg near Škofljica	1997	3	SU 06	pot	B–1	*Tomaž 1999.T. B1.9*
BR5	Breg near Škofljica	1997	3	SU 07	pot	B–3	Not published
BR6	Breg near Škofljica	1997	4	SU 03/3	pot	B–2	Not published
BR7	Breg near Škofljica	1997	4	SU 07	pot	B–1	Not published

Tab. 1. List of pottery and clay samples presented in the article.

identified in only one thin section from a deep dish, with an appliqué from Korošec's trench (unpublished, similar to *Korošec 1964.T. 7.1*).

Fabric RP-4 (Fig. 2.D) has a fine texture and is a non-calcareous clay with a few (10%) non-plastic inclusions and chert, probably added as temper. The chert grains are common, semi-angular and medium sorted, mostly in the sand fraction up to 1.5 mm, and could have been added as temper by the potters. The other inclusions include frequent monocrystalline quartz, very rare sandstone grains, a few muscovite and very few biotite mica, a few opaques and very few clay pellets (Tab. 2). The fabric could be identified in only one thin section from a bowl from trench 2, excavated in 2002 (*Veluščėk 2006.T. 14.18*).

Fabric RP-5 (Fig. 2.E) is a coarse-grained non-calcareous clay with frequent (30–40%) non-plastic inclusions. The inclusions are medium sorted, and especially quartz, sandstone and limestone grains are in the medium to coarse sand and even gravel fraction (more than 2mm). The inclusions include dominant monocrystalline quartz, frequent muscovite and very few biotite mica, very few sandstone and calcareous sandstone, very rare limestone, very few chert, a few opaques and very rare plagioclase feldspars (Tab. 2). It is not clear if the coarse quartz, sandstone, calcareous sandstone and limestone grains were intentionally added to the clay as temper, since the overall fabric and opaques or 'amorphous' concentration features can also be quite coarse in these samples. The samples made with this fabric come mostly from pots, as well as from pedestal vessels and bowls with a red slip (*e.g., Harej 1975.T. 2.10*).

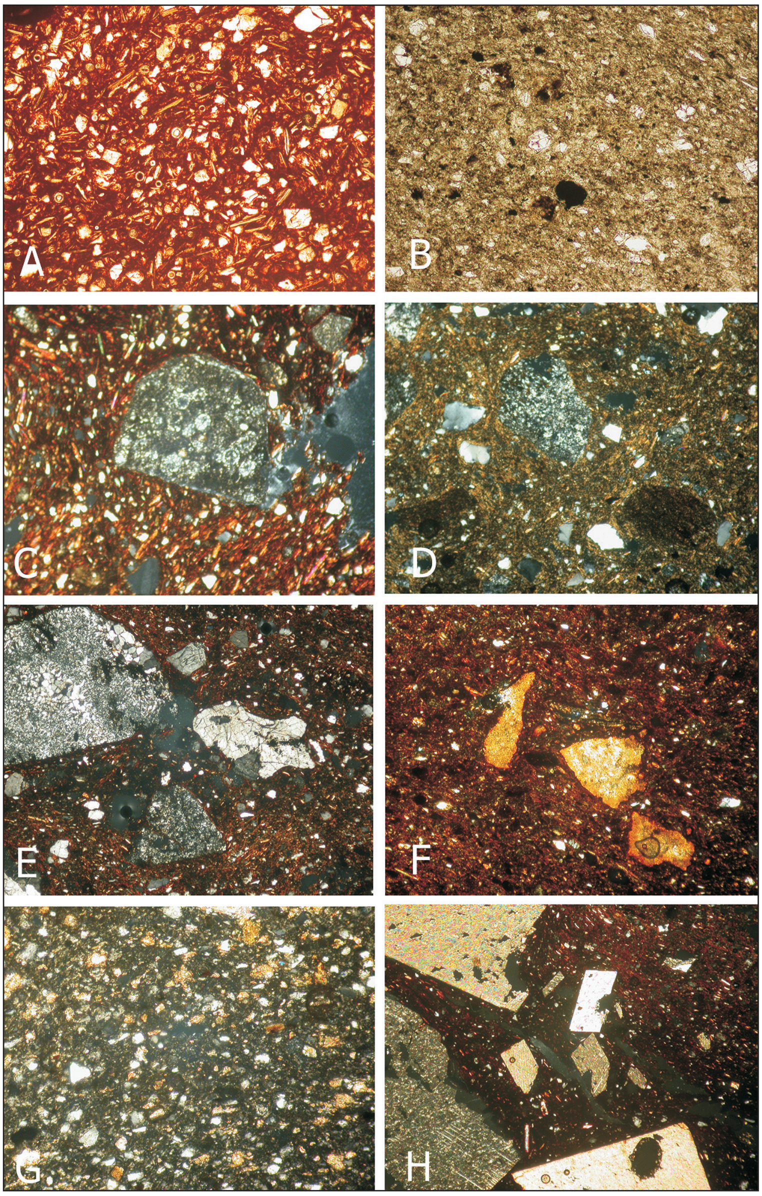

Fig. 2. Photomicrographs of the petrographic fabric groups detected at Resnikov prekop: A – fabric group RP-1; B – fabric group RP-2; C – fabric group RP-3; D – fabric group RP-4; E – fabric group RP-5; F – fabric group RP-6; G – fabric group RP-7; H – fabric group RP-8. Images A–B taken in plane polarised light; image width is 1mm. Images C–H taken in crossed polars; image width is 2mm (photo by the author).

Fabric RP-6 (Fig. 2.F) is a non-calcareous clay with a few (10%) non-plastic inclusions. The inclusions are predominantly monocrystalline quartz, common muscovite and very few biotite mica, very few limestone grains, rare sandstone and chert, common opaques and very rare plagioclase feldspars (Tab. 2). The quartz, sandstone and chert grains are well sorted and mostly in the silt to fine sand fraction, and limestone grains are medium to poorly sorted, in the medium to coarse sand fraction. Limestone could have been added as temper to the clay paste according to the size, shape and sorting of the grains. The fabric is present in dishes, pedestal dishes and pots (*Korošec 1964.T. 15.4; Veluščėk 2006.T. 13.3, T. 19.4*).

Fabric RP-7 (Fig. 2.G) is a non-calcareous clay with common (20%) non-plastic inclusions The inclusions are well to medium sorted and mostly in the silt fraction; the quartz and limestone grains can be up to coarse sand fraction. The inclusions are predominantly monocrystalline quartz, common limestone, few muscovite and rare biotite mica, rare sandstone, very rare chert, very rare plagioclase feldspars and a few opaque grains (Tab. 2). The limestone is subrounded, well sorted and mostly in silt-size fractions, meaning it is a natural inclusion in the clay paste. The fabric is typical of dishes and pots, and found only in vessels excavated in Veluščėk's trench (*e.g., Veluščėk 2006.T. 15.1*).

Fabric groups	Sample No.	Calcite (in %)	Limestone (in %)	Sandstone (in %)	Spicules (in %)	Quartz (in %)	Chert (in %)	Muscovite (in %)	Biotite (in %)	Opaques (in %)
Fabric RP–1	RP20,RP21,RP22	0	0	0	5–15	30–35	0.5–2	35–40	<0.5	10–25
Fabric RP–2	RP15,RP23,RP44, RP89,RP108	0	0	<0.5	0	30–45	0.5–2	15–30	2–15	30–50
Fabric RP–3	RP35	0	0	0	0	40	10	35	<0.5	15
Fabric RP–4	RP111	0	0	<0.5	0	50	10	15	2–5	15
Fabric RP–5	RP5,RP24,RP30, RP84,RP92	0	<0.5	1–5	0	45–60	1–5	30–45	2–5	5–15
Fabric RP–6	RP50,RP85,RP98, RP107	0	1–5	0.5–1	0	40–50	0.5–2	15–40	0.5–3	10–25
Fabric RP–7	RP91,RP110	0	20–40	1	0	40	<0.5	2–10	0.5–2	5–10
Fabric RP–8	RP34,RP73,RP79, RP100	10–25	0	0	0	40–50	<0.5	15–35	0.5–3	10

Tab. 2. The basic mineralogical composition of the eight fabric groups typical of the Resnikov prekop pottery.

Fabric RP–8 (Fig. 2.H) is a non-calcareous clay with added calcite as temper with common to frequent (20–30%) non-plastic inclusions. The natural present inclusions are well sorted, mostly in the silt fraction, and consist mainly of monocrystalline quartz, common muscovite and rare biotite mica, very rare chert and a few opaque grains (Tab. 2). The calcite grains are common, angular, poorly sorted to unsorted and mostly in the fine to coarse sand range; two samples (RP73, RP79) also have calcite grains in the gravel fraction. Calcite temper was added by the potters in at least (30/120) the vessels from Resnikov prekop (see above). Various vessel types such as pots, dishes, bowls and ladles were made from this fabric (*e.g., Velušček 2006.T. 19.1*), but the fabric is very rare to absent in other types, such as jugs.

The fabrics have the characteristics of at least four different natural non-calcareous clay pastes: one paste is very fine grained with sponge spicules (fabric RP–1); the second paste is very fine grained, with frequent opaque minerals (fabric RP–2); the third paste has many natural limestone inclusions and only a few mica grains (fabric RP–7), and the fourth paste has naturally occurring concentrations of chert, sandstone and limestone grains in the silt fraction (fabrics RP–3, RP–4, RP–5, RP–6 and RP–8). Potters prepared these pastes in different recipes, for example with no added temper, as in fabrics RP–1, RP–2 and RP–7, and with added chert (fabric RP–3, RP–4), sandstone (RP–5), limestone (RP–6) and calcite (RP–8) temper to mostly the same naturally occuring clay paste. Therefore, potters made vessels with no temper, using different types of paste; on the other hand, they added various natural inclusions as temper to similar pastes. This shows a variety of technological solutions by these potters in the preparation of the clay body; nevertheless, the forming, decorating and firing techniques of Resnikov prekop pottery were quite similar for most of the vessels made at this site.

Pottery technology at Maharski prekop

We recently analysed the pottery from Maharski prekop excavated from 1970 to 1977 (*Bregant 1974a; 1974b; 1975; and unpublished material*), using a more holistic approach and combining the technology, typology, function and direct dates of the vessels (*Mlekuž* et al. *2012; Ogrinc* et al. *2012*). As many as 349 whole or reconstructed vessels were classified according to typological categories (after *Horvat 1999*) and their capacity into five vessels groups (*Mlekuž* et al. *2012.332–334, Fig. 9–10*). We concluded that most of the pottery shows individual use for consumption or preparation of food for a smaller group of people, since vessels with volumes from 0.5 to 2l were the most common at the site. Large vessels used for the preparation and serving of food for larger groups of people were rare (*Mlekuž* et al. *2012.333*). The vessels were also analysed for their lipid content by gas chromatography-mass spectrometry (GC-MS), gas chromatography-combustion-isotope ratio mass spectrometry (GC-C-IRMS) and soft ionisation electrospray mass spectrometry techniques ESI Q-TOF MS. The results show that the vessels contained residues of ruminant animal fats; many of the pots also show traces of mixed animal and plant fats. In two vessels, traces of goat milk could be identified (*Ogrinc* et al. *2012*).

For the study of pottery technology, we analysed 222 pottery samples from Maharski prekop excavated between 1970 and 1977. The hand specimen analysis showed a great homogeneity in pottery fabrics and recipes. The majority of vessels are made with abundant calcite grains in the clay paste, which is characteristic of more than 95% of the vessels (*Mlekuž* et al. *2012.334–335*). The pottery was mostly fired in a reducing or incomplete oxidised atmosphere; the most common surface colour is dark grey; the surfaces of the vessels are burnished, and the pottery is mostly soft (Mohs scale 2–4). The vessels were all hand made using the coiling technique. All these characteristic give this pottery assemblage a very homogenous appearance (*Bregant 1974a.19–20; 1974b.50–52; 1975.34–35*).

Petrographic analysis of the Maharski prekop pottery

For the petrographic analysis, 15 samples from Maharski prekop were prepared as standard thin sections. The samples were chosen according to the characteristics observed in the hand specimen analysis (Tab. 1). The analysed samples could be classified into four different fabrics according to the temper and the mineralogical composition of the natural clay paste and non-plastic inclusions (Tab. 3, Fig. 3A–3D).

Fabric MP–1 (Fig. 3.A) is a non-calcareous clay with frequent (30%) non-plastic inclusions and calcite grains added as temper. The naturally present inclusions are well sorted and mostly in the silt size fraction. They consist of common to frequent monocrystalline quartz, a few muscovite and very few biotite mica, very rare chert, a few opaques, very rare argillaceous rock fragments, a few grains of organic matter, very rare calcareous sandstone and very rare plagioclase feldspars (Tab. 3). Calcite grains are frequent to dominant, angular, poorly sorted to unsorted and mostly in the fine to coarse sand fraction. The majority of the Maharski prekop pottery was made with this fabric; the fabric is typical of most of the vessel shapes, predominant in all of the excavated houses and from all of the phases, according to the radiocarbon dates.

Fabric MP–2 (Fig. 3.B) is a non-calcareous clay with frequent (30%) non-plastic inclusions and crushed pottery (grog) and calcite grains added as temper. The naturally present inclusions are well sorted and mostly in the silt size fraction. They consist of common monocrystalline quartz, a few muscovite and rare biotite mica, very rare chert, very few opaque grains, very rare argillaceous rock fragments and a few grains of organic matter (Tab. 3). Calcite grains are common, angular, poorly sorted and mostly in the fine to coarse sand fraction. The main characteristic of this fabric is the presence of crushed pottery or grog. The grog grains are semi-angular, poorly sorted and present in the fine sand to coarse sand fraction. The mineralogical compositions of grog are similar to fabric MP–1, which proves that the potters re-used old or damaged pottery as tempering material in addition to crushed calcite grains, which comprised the most common temper at the site. Apart from grog, the non-plastic inclusions and calcite temper of this fabric are similar to fabric MP–1. Fabric MP–2 is rare at the site, and present mostly around house No. 4, which is attributed to the younger occupation phase and was used for making pots (*e.g., Bregant 1974b.T. 6.17*).

Fabric MP–3 (Fig. 3.C) is a non-calcareous clay with few (10%) non-plastic inclusions. The inclusions are frequent monocrystalline quartz, common muscovite and very few biotite mica, a few opaque grains and very rare argillaceous rock fragments. The main characteristic of this fabric is the common presence of organic matter, which was probably added as temper to the natural clay paste (Tab. 3). The fabric is rare at the site, being present in less than 3% of the vessels, mostly used in the preparation of pots (*e.g., Bregant 1975.T. 18.3*).

Fabric MP–4 (Fig. 3D) is a non-calcareous clay with few (10%) non-plastic inclusions. These include frequent monocrystalline quartz, rare sandstone, very few chert, frequent muscovite and a few biotite mica, a few opaque grains and very rare argillaceous rock fragments (Tab. 3). The quartz, sandstone and chert grains are mostly angular and poorly sorted;

Fabric groups	Sample No.	Grog (in %)	Calcite (in %)	Quartz (in %)	Chert (in %)	Muscovite (in %)	Biotite (in %)	Organic matter (in %)	Opaques (in %)
Fabric MP–1	MP22,MP26,MP47, MP55,MP79,MP103, MP104,MP199, MP206,MP211	0	20–50	15–40	0.5–1	10–20	1–5	2–10	5–15
Fabric MP–2	MP13,MP133	5–10	15–30	20–30	0.5–1	10–20	1–3	1–5	3–5
Fabric MP–3	MP147,MP148	0	0	30–40	0.5–1	15–30	1–5	20–30	5–10
Fabric MP–4	MP185	0	0	40	3	30	5	0	10

Tab. 3. The basic mineralogical composition of the four fabric group, typical of the Maharski prekop pottery.

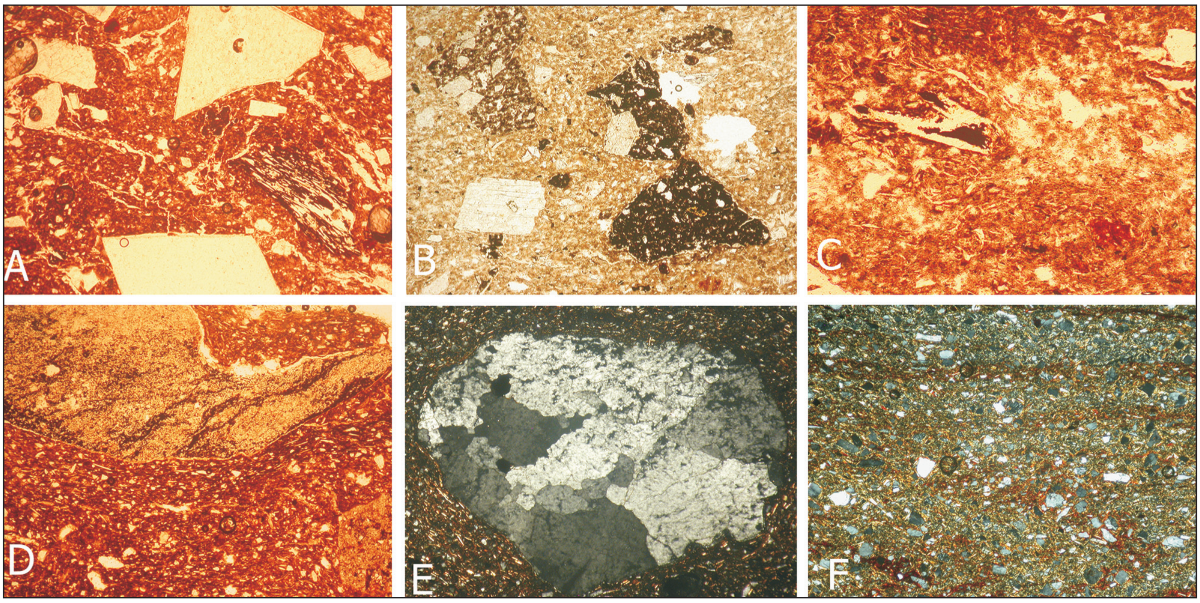

Fig. 3. Photomicrographs of the petrographic fabric groups detected at Maharski prekop, Breg and Gornje mostišče: A – fabric group MP-1; B – fabric group MP-2; C – fabric group MP-3; D – fabric group MP-4; E – fabric group BR-2; F – clay sample GM3. Images A–D taken in plane polarised light; images E–F taken in crossed polars. Image width is 2mm (photo by the author).

the grains can be up to the coarse sand to gravel fraction. These grains could have been added as temper to the clay paste. The fabric was recognised in only one sample from the analysed vessels and is from a small fragment decorated with incised lines that was fired in an oxidising atmosphere. The fragment is similar to pottery from Resnikov prekop (compare with *Korošec 1964.T. 4.6; Harej 1975.T. 2.1, 3, 4; Velušček 2006.T 10.9–14*). This fabric differs significantly from the remaining fabric from Maharski prekop, especially in comparison to fabrics MP-1 and MP-2, which could support the idea that rare fragments with similarities to pottery from Resnikov prekop were carried by rivers to Maharski prekop (see also *Bregant 1974b.52*).

All the fabrics from Maharski prekop have a similar composition of non-plastic inclusions in the clay paste and were therefore made from similar natural clays; the main difference between the fabrics is the type of temper used in pottery preparation techniques. Maharski prekop potters used mostly crushed calcite as temper, but also crushed old pottery or grog; organic materials, quartz, sandstone and chert grains were also used. The majority of pottery, more than 95%, was made with fabric MP-1, in which calcite grains comprise the main tempering material; all the other fabric are represented in less than 5% of the vessels at Maharski prekop. The technological characteristics, with similar forming, decorating and firing techniques, gives the Maharski prekop pottery a very homogenous appearance and point to a very strong pottery tradition at the site that lasted at least 800 years according to new radiocarbon dates.

Pottery technology at Breg near Škofljica

Only 65 fragment of pottery were excavated in two trenches at Breg (37 fragments from trench I – 1997 and 28 fragments from trench II – 1996). The pottery shows great diversity in the hand specimen description. Vessels are made either with calcite/limestone grains, with only quartz grains or with a combination of quartz and calcite/limestone. The pottery from trench II has different characteristics from the pots from trench I, where vessels made with abundant calcite/limestone were rare, the surfaces of vessels were mostly smoothed and rarely burnished, the pots were fired in an incomplete oxidising atmosphere, but a reducing atmosphere is also present (*Tomaž 1999.58–73*). The common characteristics of these pots are the absence of slips and incised decorations. The typological determination of vessels was possible on only two fragments: one pot from trench I and one dish/bowl from trench II (*Tomaž 1999.T. B1.1,9*). The pottery assemblage from Breg near Škofljica has unique characteristics that set this site apart from the contemporaneous pottery at Resnikov prekop, but the overall generalisation of this observation is not possible, since the Breg pottery assemblage is smaller than the one at Resnikov prekop (*Tomaž 1999.73*).

Petrographic analysis of the Breg pottery

For the petrographic analysis, four samples were chosen from trench I, excavated in 1997, according to their technological characteristics in hand specimen analysis (Tab. 1). The samples could be attributed to three different fabrics according to the distributions of inclusions inside the clay matrix and the composition of non-plastic inclusions.

Fabric BR-1 is typical of two of the Breg samples (BR1 and BR7) that were attributed to different stratigraphic units during excavation, but which exhibit such similarities in thin section analysis, as well as in general appearance and decoration techniques that they could be fragments of the same pot. This fabric is a non-calcareous clay, with common (20%) non-plastic inclusions. The inclusions are frequent monocrystalline quartz, common muscovite and few biotite mica, rare sandstone and calcareous sandstone, very rare limestone and chert, a few opaque grains, very rare plagioclase feldspars and organic matter (Tab. 4). Most of the inclusions are in the silt fraction, but a smaller amount of quartz and all the sandstone and limestone grains are in the sand fraction. These coarser grains are mostly semi-rounded and well sorted; therefore, they were part of the natural clay paste. Only some rare quartz sand grains are angular and could have been added as temper by the potters. This fabric was the most common in trench I, since 40% of the fragments shared these characteristics in hand specimen analysis (*Tomaž 1999.Sl. 25*) and most of the fragments made with this fabric could belong to the same pot, as suggested by their technological characteristics and decoration (see *Tomaž 1999.T. B1.9–14*). This fabric is similar to fabrics from Resnikov prekop (fabric RP-5) and Maharski prekop (fabric MP-4).

Fabric BR-2 (Fig. 3E) is present in only one sample from the lowest layer in trench I. The fabric is a non-calcareous clay, with frequent (30%) non-plastic inclusions, composed of frequent monocrystalline quartz, frequent muscovite and rare biotite mica, a few opaque grains, very rare organic matter and very rare grog inclusions (Tab. 4). Around 1% of quartz grains was in the coarse sand to gravel (1–3mm) fraction, sub-angular and well sorted; these grains could have been added to a very fine natural clay paste with frequent muscovite and quartz in the silt fraction; also, very rarely, grog was added to the paste as temper. The sample has less biotite than fabric BR-1 and no chert, sandstone or limestone grains. Only five fragments from trench I were made with a similar fabric, with no calcite or limestone grains, but such characteristics were typical of most of the fragments from trench II (*Tomaž 1999.Sl. 25*). This fabric has no similarities with the fabrics from Resnikov prekop or Maharski prekop.

Fabric BR-3 is a non-calcareous clay, with common (20%) non-plastic inclusions and added calcite temper. The calcite grains are frequently present, semi-angular and poorly sorted; the majority of grains are in the fine to coarse sand fraction, and were added as temper to the clay paste. Other non-plastic inclusions are frequent monocrystalline quartz, a few muscovite mica and opaque grains, very few chert and very rare organic matter (Tab. 4). This fabric differs from the other two in the calcite temper, as well as in the absence of biotite mica, which is present in all the other fabrics from Breg, Resnikov prekop and Maharski prekop. The fabric was rare at Breg, since only three fragments from trench I and four fragments from trench II were made with added calcite grains as temper (*Tomaž 1999.Sl. 25*). This fabric is made with the same potter's recipe as fabric RP-8 from Resnikov prekop and fabric MP-1 from Maharski prekop, but the composition of non-plastic inclusions differs at this site, mostly in the absence of biotite mica grains.

Origin of the clay pastes and temper

Lake marl as raw material for pottery?

Ljubljansko Barje is a tectonic depression filled with Pleistocene sediments such as clays, silts, sands and gravel that were mostly transported to this area by rivers and streams (*e.g.*, Iška, Ižica, Želimeljščica *etc.*). The main rock type of this depression is Triassic dolomite from the Noric-Rhetic stage (*Buser 1965*). Archaeological sites excavated in the eastern part of this region showed that the preserved wo-

Fabric groups	Sample No.	Calcite (in %)	Limestone (in %)	Sandstone (in %)	Quartz (in %)	Chert (in %)	Muscovite (in %)	Biotite (in %)	Opaques (in %)
Fabric BR–1	BR1, BR7	0	<0.5	1	40	<0.5	20	10	15–20
Fabric BR–2	BR6	0	0	0	40	0	40	1	15
Fabric BR–3	BR5	30	0	0	40	5	10	0	10

Tab. 4. The basic mineralogical composition of the thin-section of vessels from Breg near Škofljica.

oden piles were all driven into the lake marl, called *polžarica* because of its abundant mollusc content. This sediment was part of a bigger lake that existed on the Ljubljansko Barje in the Pleistocene before it dried out. The sediment is very fine grey carbonaceous clay, with many mollusc shells and preserved diatoms that point to a lacustrine environment (*Pavlovec 1967; Grimšičar, Ocepek 1967; Golyeva 2006.118–119*). The theory that this sediment was used for pottery production in the Neolithic and Eneolithic period was debated for decades. Several authors dismissed the idea (*Korošec 1964.29; Grimšičar, Ocepek 1967.294*), but others maintained that the material was suitable for pottery production (*Osterc 1975.125*).

To test the idea of the suitability of lake marls as potting clay, a sample from the Maharski prekop canal was acquired and then prepared into three small 3 x 4cm plates and fired in a controlled oxidising temperature at 700°C, 900°C and 1100°C, respectively, for three hours.[1] The dominant calcite content of the samples started decomposition into lime at 700°C, causing the sample to crumble into dust after firing. The same happened to both samples fired at higher temperatures: they maintained neither strength nor shape after firing. Since pottery from Resnikov prekop, Maharski prekop and Breg near Škofljica had no mollusc shells preserved and was mostly made from non-calcareous clays, and combining this with the fact that lake marls are unsuitable for making pottery, we can conclude that *polžarica* was not used by Neolithic and Eneolithic potters in the Ljubljansko barje. Therefore, Valerija Osterc's interpretation (*Osterc 1975.125*) of the petrographical and X-ray diffraction results of pottery from Maharski prekop and Resnikov prekop that lake marl was probably used as the main material for pottery can be disproved.

Clays from Gornje mostišče

Following the premise that prehistoric potters selected materials for pottery production in an area of 5–7km from the settlement (see *Arnold 1985*) and the successful use of petrographical analyses of local clays and pottery (see *Whitbread 1995; Quinn* et al. *2010*), some additional samples of local sediments and clays were obtained from Ljubljansko Barje. At Resnikov prekop, sedimentological and biomorph analyses were already performed during the excavation in 2002 (*Veluščček 2006*). The sedimentological analysis of the excavated layers showed the presence of limestone, tuff, sandstone, dolomite, and chert in grains larger than 2mm (*Turk 2006. 94–96*). The biomorph analysis showed the presence of diatoms in the lake marl and sponge spicules and phytoliths in the layers above (*Golyeva 2006.117–119*).

For the petrographical analysis, we sampled three types of clays from Gornje mostišče (Fig. 1) during a smaller-scale excavation of test trenches in 2012. The site is located near Maharski prekop and Resnikov prekop on an isolated hill. Excavations here showed the presence of a new type of settlement, with a long-term accumulation of anthropogenic activities in the area (the material is not yet published; see *Mlekuž 2013*). The samples came from two test trenches: grey silty clay (sample GM1) was obtained below the excavated wooden platform at the northern trench, and light brownish grey very fine-grained clay (sample GM3) as well as very dark organic clay (sample GM4) came from the trench near the Resnikov prekop canal, where no traces of human activity were found (*Mlekuž 2013*).

The Gornje mostišče samples were analysed with the X-ray diffraction method in their natural state and also prepared as approx. 3 x 4 cm plates and fired in a controlled oxidising temperature at 700°C for three hours. After firing, the samples were prepared as standard thin sections and described under a polarising optical microscope, following Ian Whitbread (*1995.Appendix 3*). All the samples are non-calcareous clays, with frequent (30–40%) non-plastic inclusions comprised of frequent quartz, frequent muscovite and common biotite mica, a few opaque grains, rare plagioclase feldspars and rare chert (Tab. 5). Two samples (GM1 and GM3) contained very little dolomite, as shown with the X-ray diffraction method, and this was already decomposing to mineral periclase at 700°C, which could be observed in thin section (*Cultrone* et al. *2001.630*). The sample of very fine clay (GM3) also yielded very rare sponge spicules in the petrographic analysis and the silty clay below the wooden platform also had rare sandstone grains (Fig. 3F).

The Gornje mostišče samples show a similar mineralogical composition to the natural clay pastes in vessels from Resnikov prekop, Maharski prekop and Breg near Školfjica. Sample GM3 from Gornje mo-

1 The clay samples were fired at temperatures high enough for the reaction of dehydroxylation of clay minerals to occur; it was reported that in T< 700°C no significant mineralogical or textural changes occur in clays (*Cultrone* et al. *2001.629*).

Sample No.	Quartz (in %)	Chert (in %)	Sandstone (in %)	Muscovite (in %)	Biotite (in %)	Periclase (in %)	Feldspars (in %)	Opaques (in %)	Spicules (in %)
GM1	40	2	2	30	15	2	0.5	15	0
GM3	50	2	0	30	15	0	2	5	0.5
GM4	40	0.5	0	30	15	5	0.5	5	0

Tab. 5. The basic mineralogical composition of the thin-section of fired clay samples from Gornje Mostišče on the Ljubljansko barje.

stišče is a very fine clay that would be suitable for the making of pottery and had the most similar mineralogical composition to the analysed Neolithic and Eneolithic vessels from this area. Similar grey to light brown clay deposits were also documented above the archaeological layers at Resnikov prekop (*Bregant 1964.14–15; Harej 1975. 146*) as well as at Maharski prekop (here interpreted as alluvial sediment covering most of the site in a flood; *Bregant 1974a.8–9; 1974b.40–41; 1975.12–13*). Clearly this clay is younger than the pottery taken from Resnikov prekop and Maharski prekop, since it covers the cultural layers at the sites; however, a similar very fine alluvial sediment that was transported by rivers from the karstic outskirts probably existed in the Barje floodplain in the Neolithic and Eneolithic period and was later removed from the area by seasonal floods. The fact that a substantial quantity of sediments was removed in this period was attested at Resnikov prekop and other sites (see *Velušček 2006; Budja, Mlekuž 2008; Verbič 2011*).

The origin of fabric RP-1

The vessels made with pastes containing sponge spicules from Resnikov prekop are also of particular interest (fabric RP-1; Fig. 2A). Some sponges are made of a mineral skeleton of siliceous structures termed spicules and an organic skeleton of collagen. Three general categories of spicules are called *megascleres*, *microscleres* and *gemmoscleres*. *Megascleres* are needle-shaped structures that range in length from 150 to 450μm (*Thorp, Covich 2010.94–95, Fig. 4.7; Fig. 4.28*) and, due to their size, can be recognised at low magnification. Freshwater sponges produce much smaller spicules than marine sponges; they are typically silt rather than sand-sized. All freshwater sponges belong to the class *Demospongiae* and include a distinct suborder called the *Spongillina* (*Thorp, Covich 2010. 105*) which is found not only in lakes and rivers, but also bogs and waterlogged soils. They have been found to date in the soils of all continents except Antarctica (see *Clarke 2003* with references). Surface soil samples can contain from 1 to 30% sponge spicules; the highest counts come from poorly drained soils such as lakes or ponds. Whole spicules are usually preserved in very wet areas, and broken and pitted spicules were probably moved by water or wind (*Schwandes, Collins 1994. 243–255*).

The biomorph analysis of soil samples from the 2002 excavations at Resnikov prekop showed the presence of phytoliths, diatoms and sponge spicules (*Golyeva 2006*). The soils from Resnikov prekop yielded many unbroken sponge spicules and phytoliths in the sample up to 120cm depth; below 126cm, diatoms typical of lacustrine deposits were the most common. Freshwater sponges indicate soils subject to flooding, such as alluvial soils, and their content in a soil sample may be indicative of the duration and intensity of floods at the studied site. These results indicate that Resnikov prekop was under hydromorphic conditions all the time, with a lake at the beginning, and later with a stream or small river (perhaps only seasonally) present at this site (*Golyeva 2006.116–119*).

The presence of unbroken sponge spicules in fabric RP-1 at Resnikov prekop shows that the clay for these vessels was gathered locally, as shown by the similar mineralogical composition and presence of spicules from clay sample GM3 at Gornje mostišče, and the presence of spicules in the layers above the lake marl at the excavations in 2002. Nevertheless, the higher number of spicules counted in the pottery could point to clay gathered in a pond or small lake, not near a river or stream. This hypothesis will be tested in the future with new clay samples from this area.

The origin of tempering materials

If we take a closer look at the different tempers used in the production of pottery in the Neolithic and Eneolithic on Ljubljansko barje, we see that tempering material such as quartz sand, chert, various types of sandstones and limestone (as seen in fabrics RP-3, RP-4, RP-5, RP-6, MP-4, BR-1) are an integral part of various Pleistocene sediments in this area (*Busar 1965; Turk 2006*). Therefore, this temper could have been collected near the settlements. This also applies to the use of grasses and similar organic material as temper, as shown in fabric MP-3 at Maharski prekop. Nonetheless, potters probably had to travel longer distances to collect calcite as temper, since a pure form of calcite is not present in this area, where limestone and dolomite are more common, but could be acquired on the karstic outskirts south of the Ljubljanske barje, where this mineral is present as veins in limestone or as speleothems in caves (*Gams 2004.361–364*). Further proof that calcite was indeed collected on the outskirts of Barje is the presence of calcite and limestone blocks found at the Stare gmajne pile-dwelling (*Turk 2009. 284*). As shown above, calcite temper was the most frequently used recipe at Maharski prekop (fabric MP-1), but is also present in about 25% of the samples from Resnikov prekop (fabric RP-8) and is rare at Breg near Škofljica (fabric BR-3).

In Ljubljansko barje, the calcite-tempered fabric was present from the earliest stages of pottery production, and was used in the production process in a third of the vessels made at Resnikov prekop and Breg. The fabric with calcite temper later became the most common recipe in Ljubljansko barje area, as demonstrated in the Eneolithic pottery production at Maharski prekop. The tradition of using calcite as an important raw material in the making of ceramic vessels has a long tradition in the Barje, as well as in western parts of Slovenia. The vessels from the Vlaška group found in caves and rock shelters in the Karst are made with this fabric, and this pottery tradition remains dominant through the Neolithic and Eneolithic period (*Žibrat Gašparič 2004; 2008*). Other contemporaneous sites from central, southern and eastern parts of Slovenia show the preference for other recipes and technologies (see *Tomaž 1999; 2005; Turk, Svetličič 2005; Žibrat Gašparič 2008. 127–174; Kramberger 2010.312, 317*).

The use of calcite temper was a technological choice of Neolithic and Eneolithic potters, since experiments have shown that the greater toughness and higher thermal shock resistance useful for cooking pots are achieved by a high concentration of temper (especially limestone/calcite, shell or grog temper) and low firing temperatures (*Tite* et al. *2001.321*). On the other hand, it has also been suggested, based on the earliest Neolithic pottery from Franchthi cave in Greece, that the use of calcium carbonate as temper was a shamanic procedure and the glittering calcite crystals were important in the mystical or curative powers of the recipe. This makes sense in connection with the observation that in the Early Neolithic the process of making pottery was more important than the actual product (*Vitelli 1999.193*). Calcite was probably seen as valuable material by the people from Maharski prekop. They used calcite abundantly in pottery production, but also made jewellery from its crystals, which is demonstrated by a necklace made from 33 calcite beads, and several individual beads were found at the site (*Bregant 1984b.49, T. 4.11; 1975.30, T. 8.15–17, 19, T. 12.1; Strmole 1974*).

We can also regard crushed pottery or grog temper in a similar fashion. This fabric is known only from Maharski prekop, and even there in only a handful of pots (see fabric MP-2). Here, the choice of grog as tempering material could represent renewal or memory of the deceased, but can be also linked to potters' individual choice and artistic expression (*Quinn, Burton 2009.288*).

Pottery traditions in Ljubljansko barje

The operational sequence or *chaîne opératoire* at Resnikov prekop, Maharski prekop and Breg included the selection of raw materials from a local area of less than 5km for clay and more than 5km for the acquisition of tempering materials, especially calcite. Therefore, potters used mostly locally available raw materials, although it is known that they had connections with other areas, shown especially in the use of different stone materials procured more than 100km to the north, west and south of Ljubljansko barje (*Bernardini* et al. *2009*). Potters used various fabrics in the preparation of clay bodies: at least eight different fabrics (RP-1 to RP-8) were recognised at Resnikov prekop, four at Maharski prekop (MP-1 to MP-4) and three at Breg near Škofljica (BR-1 to BR-3). Certain fabrics were used at all of the sites, such as the fabric with added calcite temper (fabric RP-8, MP-1 and BR-3) or the fabric with added sandstone temper (fabrics RP-5, MP-4 and BR-1). The pottery from all three analysed sites was produced using mostly local materials, but with different recipes or fabrics. Similarly, the clays used by potters show some variability, especially at Resnikov prekop, which suggests that a variety of different locally available natural sources was used.

After the preparation of clays and temper, the pots were mostly made with the coiling technique (*Bregant 1975.34–35*), which is typical of pottery production in a household economy and where pottery making is only a part-time occupation (*Arnold 1985*). For smoothing and burnishing the vessels surfaces, various tools were used, such as the bone tools discovered at Maharski prekop (*Bregant 1974a.T. 4.3, T.*

7.3; 1974b.T. 4.1–2; 1975.T. 8.8, T. 12.7). Areas for pottery production, such as the remains of kilns or firing sites have not been discovered in this region. The pottery from Resnikov prekop and Breg was mostly fired in an open firing, since most of the vessels were fired in an incomplete atmosphere. However, pottery from Maharski prekop was probably fired in kilns in a reducing atmosphere (*Bregant 1974b.50*). This is supported by the fact that the pottery had well-preserved organic matter in the fabrics, typical of ceramics fired in a reducing rather than oxidising atmosphere (*Reedy 2008.185–186*), and the fact that copper metallurgy was known and used at the settlement (*Veluščček, Greif 1998*). Wood for fuel (as well as an important building material) could have been acquired in the vicinity, south of the settlement on the outskirts of the Barje region (*Bregant 1975.17–30; Šercelj 1975.115–120*).

The optically active clay paste as observed under the microscope shows that the pottery was not fired at very high temperature. At around 600°C, clay minerals lose their water of hydration and this marks major alterations in their chemical and minerals structures. At around 900°C, their structures collapse irreversibly and clay minerals lose their optical characteristics (*Grimshaw 1971.221–227; Rice 1987.90–92*). Additionally, the fabrics with calcite and limestone inclusions show that these minerals were not fired to the temperature of calcite decomposition into lime, which occurs in the 650 to 850°C temperature interval (*Rice 1987.97–98; Cultrone* et al. *2001.624*). This reaction starts at a lower temperature when pottery is fired in oxidising conditions and at higher temperatures in reducing conditions (*Reedy 2008.187–189*). In most of the fabrics, the monocrystalline quartz grains exhibit shattering of the grains connected to the first inversion reaction, typical of this mineral, which starts at 573°C (*Grimshaw 1971.221–227*). Since pottery from all three sites in Ljubljansko barje exhibits similar changes in the mineralogical composition of fabrics, we conclude that the pottery with calcite or limestone inclusions was fired at lower temperatures, between 600 to 700°C, which is typical of pottery of this period (*Žibrat Gašparič 2004.212–213; 2008.86–88*). Nevertheless, the fabrics without calcareous inclusions could have been fired to 800°C, but not significantly higher, since muscovite and biotite mica grains did not start to transform into higher temperature minerals such as mullite (*Cultrone* et al. *2001.624*).

The oldest pottery tradition in Ljubljansko barje is linked to vessels at Resnikov prekop, since the making of ceramic vessels was performed at the site already in the 6th millennium calBC, as was proved with new radiocarbon dates. The typological analysis of vessels from Resnikov prekop shows great variability, with various types of pots being the most common. In addition, dishes, footed dishes, bowls, cups, pitchers, beakers and lades are also present. Pots and dishes were made from all the fabrics recognised at Resnikov prekop; however, bowls, cups, beakers and jugs were mostly made of fabrics with added quartz, sandstone or limestone temper (fabrics RP-5 and RP-6) and only rarely with added calcite (RP-8) or with a very fine-grained clay (RP-2). Since different fabrics and recipes were used for the production of similar vessel types, we can assume that they reflect the personal choice of potters. The predominant lipid content was of ruminant fats and mixed fats, but also milk in one of the bowls (*Mlekuž* et al. *2013*; bowl – *Harej 1975.T. 3.7*).

The pottery tradition from Breg near Škofljica resembles the material from Resnikov prekop, although the few excavated vessels also exhibit special characteristics not present in the pottery from Resnikov prekop. In vessel typology, the pottery assemblage from Breg is modest, since only one vessel could be reconstructed: one pot decorated with grooved incisions (*Tomaž 1999.T. B1.9*) which is similar to pots from Resnikov prekop. The petrographic analysis showed that similar decorated fragments found at Breg were all part of the same pot (*Tomaž 1999.T. 1.10–14*), making the number of possible vessels found at the site even smaller. The total number of possible different vessels at Breg is below twenty and the pottery was made from at least three different fabrics, two of which resemble fabrics from Resnikov prekop, which makes for great variability in a small assemblage, which could reflect individual choices by potters.

The other pottery tradition is linked to the younger assemblage at Maharski prekop. The vessels from Maharski preko show great variability in their shapes and dimensions, and we propose that they had different functions, as serving and cooking vessels as well as for storage (*Mlekuž* et al. *2012.332–336*). This is further supported by the fact that the four fabrics are not correlated to vessel types; for example, the most common fabric, MP-1, was used for a series of different vessel types that had different functions and their function was not predetermined during production (*Mlekuž* et al. *2012.336; Ogrinc* et al. *2012.346*). The pottery assemblage from Maharski prekop shows a long tradition in pottery production, spanning almost 900 years, according to new radiocarbon dates (*Mlekuž* et al. *2012.T. 1*). This tradition included the use of four pottery fabrics, the predominant use of calcite temper and the use of local raw materials.

Conclusions

Every pot encountered at archaeological sites is the result of a series of decisions made by the potters, who had a choice of various natural raw materials, tools, sources of energy and manufacturing techniques. Consequently, each pot is a unique result of a potter who had a choice between alternative techniques. Pottery technology analyses should therefore focus on the whole operational sequence in pottery production, which involves the manipulation of tools as well as natural resources within local cultural perceptions of the suitability of certain methods and techniques (*Sillar, Tite 2000.3–4*). The development of technological traditions comes from an interaction between the more conservative cultural choice and the more innovative nature of personal choice. Prehistoric potters only rarely recognised all the potential manufacturing techniques for pottery production and used only a handful; the techniques used were probably considered as traditional inside a community and were learnt from other potters. Innovations did happen mostly if the innovator obtained materials, tools or techniques from a different sphere of technological activities and modified them for his/her needs (*Sillar, Tite 2000.10*). Therefore, pottery technology should be considered in comparison with other contemporaneous techniques, since all techniques are choices made in the wider contexts of local perceptions (*Lemmonier 1986*) and are the result of different practical possibilities that were evaluated and chosen through cultural criteria (*Sillar, Tite 2000.7–9*).

The operational sequence at the Neolithic and Eneolithic sites on the Ljubljansko barje included the procurement of raw materials locally, but also over an area more than 5km from the sites, which was a common procedure in all the analysed pottery traditions. Nevertheless, the preparation of pottery fabrics, the shaping and decorating, as well as firing of the vessels were different in traditions at Resnikov prekop and Breg from those at Maharski prekop. At the oldest settlements at Resnikov prekop and Breg, the potters used a variety of different recipes for their pots, dishes, bowls, cups *etc.*, although the vessels have a very similar general appearance. In addition, the fabrics used for pottery at Resnikov prekop and Breg show that the potters used different types of raw materials, probably procured locally, but at different locations. At the moment, we cannot explain whether clay and tempering materials were collected even farther away than 5km on the Ljubljansko barje or on its fringes, since only a handful of clay samples have been analysed thus far. The choice of different natural raw materials in a small area could be related to the individual potters working at these sites. On the other hand, at the younger Maharski prekop site, the number of different recipes, fabrics and clays dropped significantly and the vessels show a very strong tradition, and appear more homogenous in their preparation, shapes and decoration, although they had different functions.

The selection of raw material, the shaping and decorating of pots, their firing and use were probably more related to different traditions and individual choices of potters at these sites than being purely technological choices. This can be seen in the use of a variety of different tempers and clay pastes acquired near the settlements on the flood plain as well as on the karstic fringes. Some materials could have had a special position for these prehistoric potters and their communities, such as the addition of calcite, which was also used for personal ornaments, and crushed pottery or grog. In addition, other raw materials, especially stone tools and ornaments, were acquired from distances far from Ljubljansko barje (*e.g., Skaberne, Mladenovič 2004; Bernardini* et al. *2009*), supporting the idea that different materials had different meanings for the Neolithic and Eneolithic communities in this area and that their choices were not always based on the best technological solutions or the nearest procurement sites.

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Interdisciplinary research of the Neolithic Volga-Kama pottery

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ABSTRACT – *In this article, we present a new method of studying Neolithic Volga-Kama pottery, which involves typological and technological analysis and the radiocarbon dating of vessels. As a result of the research, areas with Early Neolithic Volga-Kama pottery traditions are presented.*

IZVLEČEK – *V članku predstavljava novo metodo preučevanja neolitske lončenine kulture Volga-Kama, ki vključuje tipološko in tehnološko analizo ter radiokarbonsko datiranje posod. V nadaljevanju predstavljava rezultate teh analiz, s katerimi sva prepoznala območja, kjer so razširjene lončarske tradicije z zgodnje neolitsko Volga-Kama keramiko.*

KEY WORDS – *Neolithic; Volga-Kama; pottery; radiocarbon dating; pottery technology*

Introduction

The majority of Russian researchers link the advent of pottery production to the beginning of the Neolithic. The identification of pottery origins and areas of expansion of early ceramic traditions are priorities in study of Neolithisation of the Volga-Kama culture. The study is based in ^{14}C dates of events and their contexts.

Our research is aimed at the following problems:
❶ ancient pottery nucleation in the Volga-Kama region;
❷ detection of areas with an early pottery tradition;
❸ establishing the chronological frameworks of this process with the help of radiocarbon dating of pottery;
❹ the identification of the developmental stages and peculiarities of the cultural correlation of the Neolithic cultures of Volga-Kama groups with people from neighbouring regions.

The territory of expansion of settlements comprises semi-deserts, steppe, forest-steppe and the forests in the region (Fig. 1).

A series of new methods were used in the analyses of pottery that were previously not implemented in archaeological studies of the Volga-Kama region:
❶ detailed morphological grouping of pottery based on the technique of ornamentation and the peculiarities of vessel forms (*Vybornov 2008a*);
❷ radiocarbon dating of precise cultural and chronological pottery groups (*Skripkin, Kovalyukh 1998; Vybornov* et al. *2009; 2012; Zaitseva* et al. *2009*);
❸ the technological analysis of pottery (*Bobrinsky 1978; 1999*).

Pottery technology of the Volga-Kama region

By studying the technologies of Neolithic pottery we could reconstruct some cultural processes of the Volga-Kama culture. Nevertheless, to identify the dynamics of cultural processes radiocarbon dates of pottery must be obtained first. Since it is impossible to date each Neolithic vessel individually, morphological grouping of pottery plays an important role in our research. As a result of this procedure, only vessels with clearly defined cultural and relative chronological contexts were the subject of radiocarbon dating. There were only a few Neolithic sites known from the Volga-Kama region before 2007. The pottery analyses were made on the basis of different initial materials in different laboratories, which was the subject of various discussions. In recent years,

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we have obtained a series of new radiocarbon dates (*c.* 250) from a large number of Neolithic sites from the region from charred organic remains on pottery samples, chosen on the basis of previously defined cultural contexts (Tab. 3).

The study of the Neolithic pottery technology was performed according to descriptions by Alexander A. Bobrinsky (*1978; 1999*). This approach includes the use of a binocular microscope, the analysis of use wear traces on artefacs, *i.e.* trasology, and experiments. Approximately 2000 vessels from the Volga-Kama and neighbouring regions were the subject of technological analyses (Tabs. 1–2). First, a general description of the Neolithic pottery in the studied regions was created. The most important elements for studying the problem of the origin and expansion of Neolithic pottery were identified, that include the identification of initial raw material and pottery fabrics. Our research are based on Bobrinsky's hypothesis on pottery origins, which he supported with scientific arguments, numerous ethnographic studies, experimental data and the results of the microscopic study of Neolithic pottery in Eastern Europe and the Near East (*Bobrinsky 1978; 1993; 2006*). The main point of Bobrinsky's hypothesis is that there was a presumably long pre-pottery period in the so-called 'centres' of pottery origin where organic and

Fig. 1. Map of Neolithic sites in the Volga-Kama region.

other natural raw materials resembling clays were used. Items made from these raw materials were not fired, but only dried, and were used for food storage and transport. The evolution of ancient pottery traditions lay in adding clay to these organic sediments

AC, monuments	Types of initial plastic raw stuff			Total
	Silts	Silty clays	Clays	
Northern Prikaspy [1]				
	304/100%	–		304/100%
North-west Prikaspy				
Jangar	15/60%	10/40%	–	25/100%
The Don Region				
Razdorskaya I	5	–		5/100%
Rakushechny Jar	11/100%	–	–	11/100%
Ukraine				
Surskaya AC [2]	15/72%	6/28%	–	21/100%
Bugo-Dnestr AC [3]	60/100%	–	–	60/100%
Dnepr-Don AC [4]	81/100%	–	–	81/100%
The steppe Volga Region				
Varfolomeyevka	48/15%	179/57%	88/28%	315/100%
Orlovka	8/80%	2/20%	–	10/100%
The Middle Volga Region				
Elshanskaya AC [5]	47/14%	297/86%	–	344/100%
The Middle Volga Region AC	155/48%	161/50%	8/2%	324/100%
Prikamye [6]				
Kama AC		89/49,7%	90/50,3%	179/100%
Volga-Kama AC		125/70%	53/30%	178/100%
Total	749/40%	869/47%	239/13%	1857/100%

1 Northern Prikaspy – Kairshak I–IV, Tenteksor I–III, Kyzyl Khack, Tau Tube, Kugat IV, Zhe Kazgan I, Konbakte, *etc.*

2 Sura AC – Razdolnoye, Strilchey Skelya.

3 Bugo-Dnestr AC – Skibentsy, Bazykov Island, Pechera, Glinskoye, Sokoltsy, Sanchintsy, Zenkovtsy, Shumilovo-Chernyatka.

4 Dnepr-Don AC – Pustynka, Buzki, Grini, Vishenki II.

5 Elshanskaya AC – Ivanovka, Vilovatoye, Chekalino IV, Ilinka, Nizhnyaya Orlyanka II, Staraya Elshanka, Lebyazhinka IV–V, *etc.*

6 Prikamye – Ziarat, Chashkinskoye lake IV, VI, VIII, Khutorskaya, Tetyushkinskaya IV, Shcherbetskaya II, *etc.*

Tab. 1. Results of the raw material analyses of Neolithic ceramics in the Volga-Kama and neighbouring regions.

and, at the same time, firing technology improved from very low temperatures (up to 450°C) to low temperature (450–650°C) and finally to temperatures of 650–750°C.

Due to Bobrinsky's work, it became obvious that the origin of pottery can be explained in other ways, namely, by studying Early Neolithic pottery and the peculiarities of technological choices made by ancient potters about the suitability of different raw materials for pottery making. The various types of these raw materials may prove that Early Neolithic pottery came from different pottery centres.

The microscopic analyses show three types of raw materials of ancient pottery: silts, silty clay and clays (Figs. 2–4). Silts from rivers and silty lake sediments are located in the waterlogged coastal edges of ponds. Silts are natural fabrics suitable for pottery. They include a loamy substratum and mineral inclusions, the rotten remains of vegetation and animal matter. Silts also include filamentous algae, the roots, leaves and stems of rotted hydrophytes and terrestrial plants, the remains of aquatic wildlife (fish bones and scales), fresh water shellfish *etc*. (*Bobrinsky, Vasilyeva 2012*). In freshly broken pottery sherds, these inclusions in silts can be observed whole or broken (Fig. 2). Silty clays were gathered near ponds, but can be also found in waterside deposits and more condensed layers of clays (*Vasilyeva 2011*). At the same time, silty clays have some features of silts, namely their organic and mineral inclusions, but these are usually in a crumbled form, rotten and sparsely distributed (Fig. 3). Clays, *i.e.* sedimentary compacted rocks, can be found both on the banks of basins and reservoirs and in remote areas. The difference between clays, silts and silty clays is the absence of aquatic vegetation and plants that grow near basins and reservoirs (Fig. 4).

The expansion of Volga-Kama pottery traditions

According to the analysis of different types of raw material, from which Neolithic pottery in the Volga-Kama region was made, we could identify three areas of expansion of Early Neolithic pottery traditions:

❶ Areas, where ceramics were made from silts. Cultures with painted and incised decorations on vessels in the Ukraine and in the south of East European Russia in the 6th to 5th millennium BC are included.

❷ Areas of Elshansky culture in the Middle Volga region, where silty clays and chamotte-temper were used as the main ceramic fabrics. It is dated from the 6th to the first half of the 5th millenium BC.

❸ The area of the Kama culture is characterised by the use of natural clays converted into dry matter and mixed with chamotte temper and organic matter in similar quantities. In Prikamye region near the Kama river it was dated to the 5th to 4th millennium BC.

The first pottery tradition can be linked to the area north and northwest of Prikaspy in the steppe Volga Region. According to preliminary results, this area includes the expansion of Sursk, Dnepr and Donetsk, Bug-Dniester and shell-Yarsky cultures. Ves-

AC, monuments	Main recipes of pottery fabrics			Total
	with organic solution	with broken shells	with chamotte	
Northern Prikaspy				
	304/100%	–		304/100%
North-west Prikaspy				
Jangar	15/60%	10/40%	–	25/100%
The Don Region				
Razdorskaya I	5/100%	–	–	5/100%
Rakushechny Jar	11/100%	–	–	11/100%
Ukraine				
Surskaya AC	19/90%	2/10%	–	21/100%
Bugo-Dnestr AC	60/100%	–	–	60/100%
Dnepr-Don AC	81/100%	–	–	81/100%
The steppe Volga Region				
Varfolomeyevka	57/18%	258/82%	–	315/100%
Orlovka	9/90%	1/10%	–	10/100%
The Middle Volga Region				
Elshanskaya AC	294/85%	–	50/15%	344/100%
The Middle Volga Region AC	240/74%	1/0,4%	83/25,6%	324/100%
Prikamye				
Kama AC	1/0,6%	–	178/99,4%	179/100%
Volga-Kama AC	15/8%	–	163/92%	178/100%
Total	1111/60%	272/15%	474/25%	1857/100%

Tab. 2. Results of the study of Neolithic pottery fabrics in the Volga-Kama and neighbouring regions.

Culture, site	Lab.	Material	Date – BP
Northern Prikspy			
Kairshak III	Ki –14471	pottery	7780±90 BP
Kairshak III	Ua 41359	ceramic food crust	7775±42 BP
Tenteksor	Ki –14101	pottery	6640±80 BP
Tenteksor	Ua 35267	pottery carbon	6695±40 BP
North-west Prikaspy			
Jangar 3	Ki – 14639	pottery	7080±90 BP
Jangar 3	Ki – 14640	pottery	6990±90 BP
Jangar 3 – 2		charcoal	6870±130 BP
Jangar 2	Ki – 14641	pottery	6680±90 BP
The Don Region			
Razdorskaya II	Le – 6950	charcoal	7450±100 BP
Rakushechnyi Yar 20	Ki – 6476	pottery carbon	7930±140 BP
Rakushechnyi Yar 20	Ua 37097	ceramic food crust	7290±50 BP
Ukraine			
Surskaya culture:			
Kamennaya mogila	Ki – 4022	bone	7250±95 BP
Surskoy ostrov	Ki – 6691	bone	7245±60 BP
Bugo – Dnestrovskaya culture:			
Sokolchy II	Ki – 6697	bone	7440±60 BP
Dobryanka III	Ki – 11104	bone	7320±130 BP
Dobryanka III	Ki – 11108	pottery	7260±170 BP
Sokolchy I	Ki – 8165	bone	7260±80 BP
Dnepro – Donechkaya culture:			
Buzki	Ki – 8699	pottery	6380±90 BP
Dobryanka	Ki – 9834	pottery	6360±150 BP
The steppe Volga Region			
Orlovskaya culture			
Varfolomeevska 2 A	Ki – 14613	pottery	6540±80 BP
Varfolomeevska 2A	Ua 41361	ceramic food crust	6544±38 BP
The Middle Volga Region			
Elshanien culture:			
Ivanovskaya	Ki –14568	pottery	7930±90 BP
Ivanovskaya	Le – 2343	bone	8020±90 BP
Chekalino IV	Spb – 424	pottery	7660±200 BP
Srednevolzhskaya culture:			
Vilovatovskaya	Ki –14090	pottery	6320±90BP
Prikamye			
Kama AC			
Ziarat	Ki – 15087	pottery	6110± 80 BP
Ziarat	Hela – 2991	crust	6323 ± 43 BP
Volga-Kama AC			
Sherbetskaya	Ki – 14531	pottery	6270 ±90 BP
Sherbetskaya	Ki –14098	pottery	6530±90 BP

Tab. 3. ^{14}C dates of the Neolithic sites in the Volga-Kama and neighbouring regions.

sels are characterised by flat-bottomed vessels with painted and incised decorations (Fig. 5) made from silts (*Vasilyeva 1999*).

The earliest ceramics made of silts at the site Kair-Shak III was ^{14}C AMS dated to the first quarter of the 6th millenium BC (*Vybornov 2008b; Zaitseva* et al. *2009; Baratskov* et al. *2012*) (Tab. 3). At the advanced stage of the Neolithic in the steppe Volga region, a switch to new raw materials in the form of silty clays and clays has been noted. We consider the use of silty clays as an inter-medium in the evolution of pottery, where first silts and later clays were used as the main raw materials for ceramics. This conclusion is confirmed by results of the study of the stratified Bartholomew site (*Vasilyeva 2009*) and its dates (*Vybornov* et al. *2012*) (Fig. 6). It was found that the technological switch to silty clays was not immediate. This change did not occur in settlements at the late Neolithic site Tenteksor I in the northern Kaspy region (Fig. 5), which is dated to the second quarter of the 5th millenium BC (*Vybornov 2008a*). It should be noted that fabrics with chamotte temper were not found among Neolithic materials in the Lower Volga region.

Parellel to the change in the use of silts to silty clays and clays, one pottery tradition was formed *i.e.* the use of an artificially added broken shells as temper. If we consider the hypothesis of pottery origins in connection to the use of organic and silty materials, there should be signs of a pre-pottery period in early ceramic complexes at pottery production centres. These signs of a pre-pottery period are connected to fabric characteristics and to the use of fire more as an object of worships with purifying and magical characteristics than a simple technique (*Bobrinsky 1999.96–97*). All these characteristics were traced in the assemblages of the Northern Caspian region, and according to this we assume an independent origin of pottery in this region.

The second pottery tradition appears in the Volga-Ural and Middle Volga regions. The earliest pottery of the Elshansky culture dates to the first quarter of the 6th millennium BC (*Andreyev* et al. *2012*) (Tab. 3). These are thin-walled vessels, with straight or smooth profiles and conical bottoms. Later, under the influence of Neolithic communities from the Lower Volga region, the Elshansky people began to make flat-bottomed ware. Some 20–50% of pottery at different sites has no ornamentations. The remaining vessels are mostly decorated with a horizontal indent around the mouth of the vessels (Fig. 7).

The most popular features of Elshansky pottery are: silty clays used as raw material; sandy ferrous raw materials without shells; and two pottery traditions in the preparation of ceramic fabrics, one with added organic temper (OS) and the other with organic and chamotte temper (SH) (*Vasilyeva 2011*). Elshansky pottery was mostly made with silty clays, and only some of the vessels were made from silty clays with added mineral inclusions (chamotte). These facts may reflect two processes: firstly, the evolution of the attitude of Elshansky potters to raw materials, *i.e.* from proto-pottery to archae-pottery (*Bobrinsky 1999*), or, secondly, a certain primordial heterogeneity in the population of the Volga region during its migration to the Volga-Ural region. Due to the analyses of pottery technology, we infer that the pottery was not of local origin. When the Elshansky pottery appeared in the Volga-Ural region, it was more technologically developed than the already present painted pottery and pottery decorated with incisions. We assume that Elshansky pottery evolved in the eastern Caspian region and in central Asia, not in the Volga-Ural and Middle Volga region (*Vybornov 2011*).

The formation of a Neolithic culture in the Middle Volga region (Fig. 8) dates back to the middle of the 5th millennium BC. The pottery is characterised by a mixture of the two Early Neolithic pottery traditions mentioned above and their development (*Vasilyeva, Vybornov 2012a*).

The third pottery tradition is linked to the Prikamye region and is connected to the Kama culture. This pottery consists of round-bottomed thick-walled vessels, decorated with a comb and prepared with a specific fabric (Fig. 9). The earliest pottery, excavated at the Ziarat site, dates to the last quarter of the 5th millennium BC (*Vybornov 2008*). Pottery traditions in this region include specific attitudes to natural raw materials, which is reflected in using dry mixtures of rich clays, mixed with chamotte temper in equal quantities. The clay and temper were then 'pasted' together with an organic solution (*Vasilyeva, Vybornov 2012b*).

The chronology of the Kama culture is based on radiocarbon dates from organic matter on pottery (*Vybornov 2008c*) and corroborated by AMS radiocarbon dates on pottery (*Vybornov* et al. *2013*). Interestingly, chamotte temper was mixed with raw materials in lower proportions in the Elshansky culture (in most cases, the concentration is no more than 1:5, *i.e.* one part chamotte to five parts of raw material) than in the Kama pottery tradition, where the proportion of clay and chamotte was 1:1 or 1:3. The origin of this pottery tradition is not obvious, but we assume it is not connected to Neolithic cultures of the Middle Volga region.

The Volga-Kama region became an area of blending and interaction of two different Neolithic cultures, the populations of the Middle Volga region that migrated here from the south, and the Kama population, which was perhaps also immigrant to this region. The Volga-Kama culture appeared as a combination of the Middle Volga and Kama culture. The presented results of the complex studies of Neolithic pottery in the Volga-Kama region are still in their preliminary stages. In the future, we will continue our research of Neolithic pottery from the Don and Higher Volga regions and from the right bank of the Middle Volga region.

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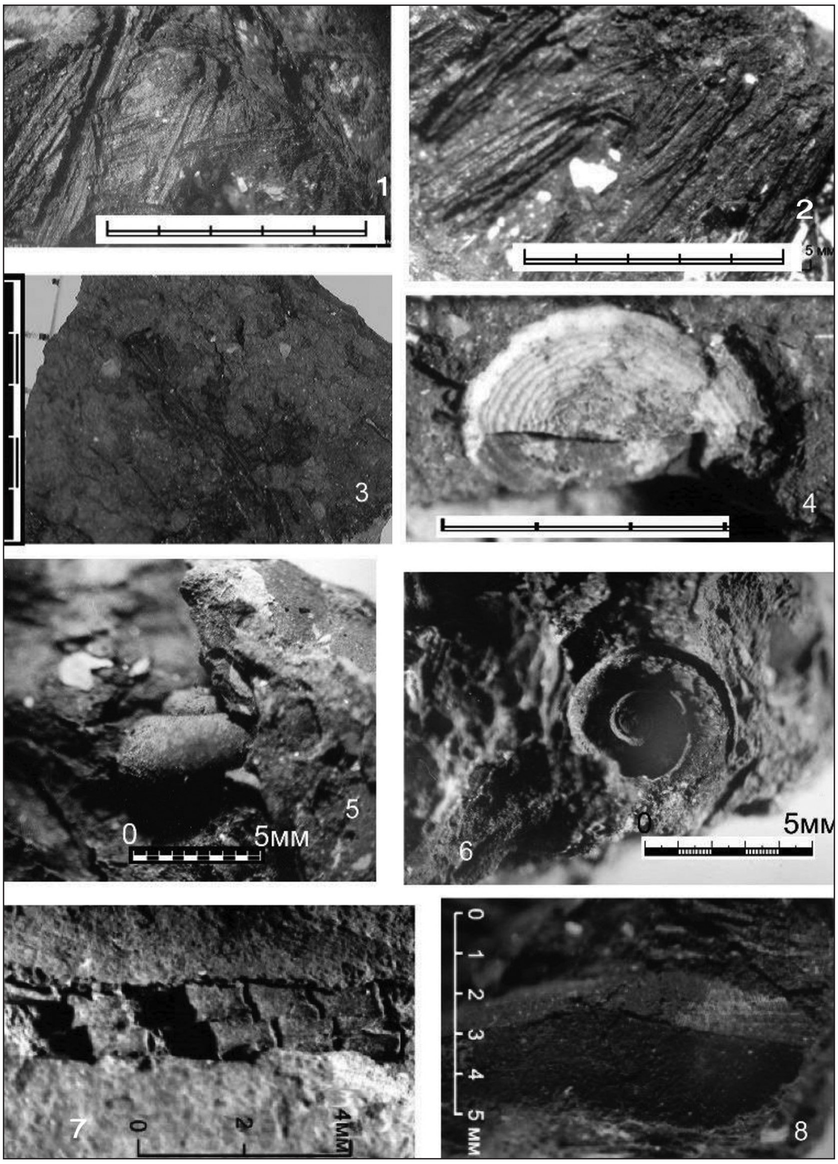

Fig. 2. Photomicrograph of raw materials of Neolithic pottery in the lower Volga region (silts): 1 to 3 impressions of water plants (1 Varfolomeyevka; 2 Kair-Shack III; 3 Lebiazhinka V); 4 to 6 shells of fresh water molluscs (Kair-Shack III, Tenteksor); 7 fish bones (Kair-Shack III); 8 impressions of fish scales (Kair-Shack III).

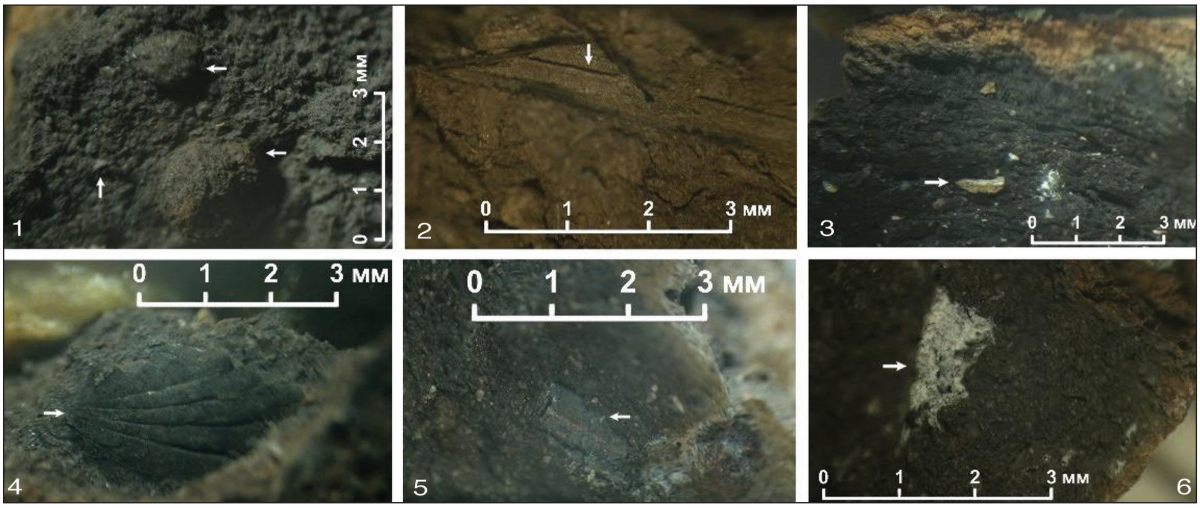

Fig. 3. Photomicrograph of raw materials of Neolithic pottery in the Middle Volga region (silty clays): 1 sandy initial raw material with clay pellets (Nizhnyaya Orlyanka); 2 impressions of plants (Ivanovka); 3 single inclusions of shells (Lebyazhinka IV); 4 impression of fish scale (Ilinka); 5 fragment of fish bone (Ilinka); 6 organic solution (Lebyazhinka IV).

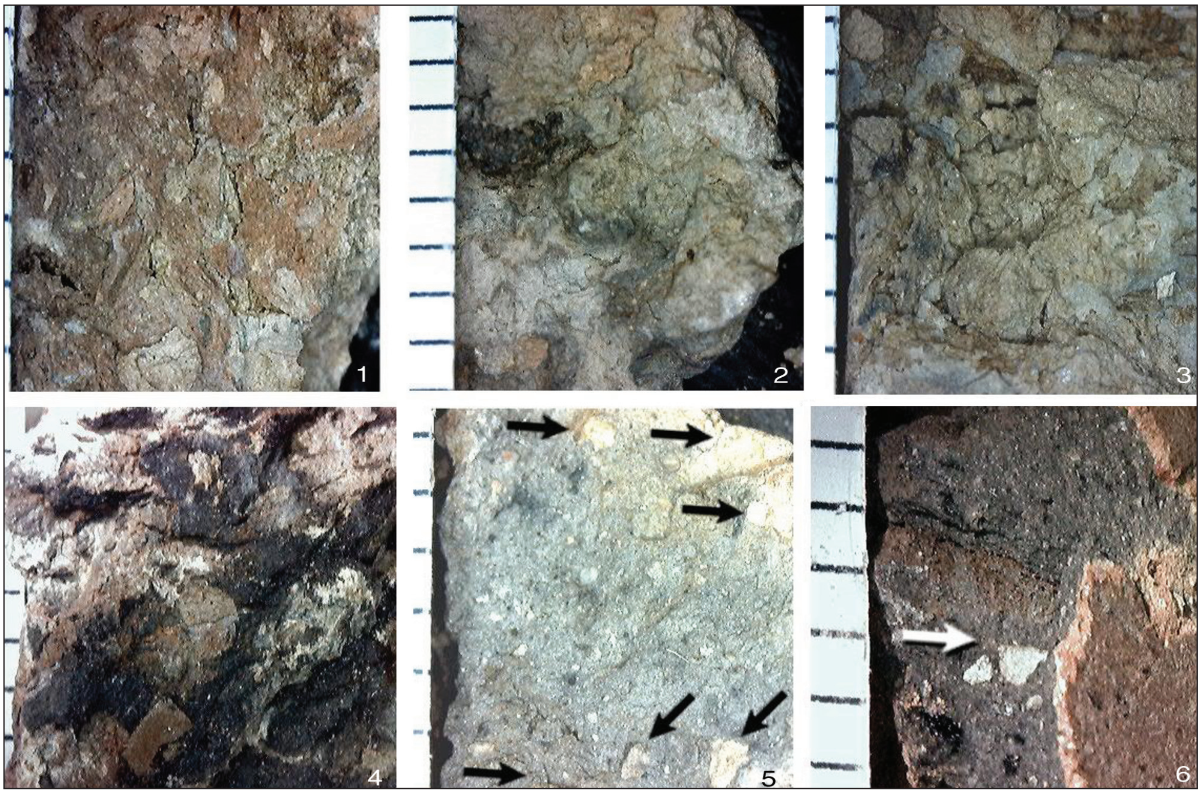

Fig. 4. Photomicrograph of raw materials and fabrics of Neolithic pottery at Prikamye: 1 to 4 broken plastic raw material, fabric with high concentrations of chamotte and organic solution in pottery with comb decoration (1 and 2 Ziarat; 3 Lebedino I; 4 Balakhchinskaya site); 5 and 6 raw materials in natural condition, fabric with low concentration of chamotte and organic solution in pottery with incised decoration (II Sherbetskaya site).

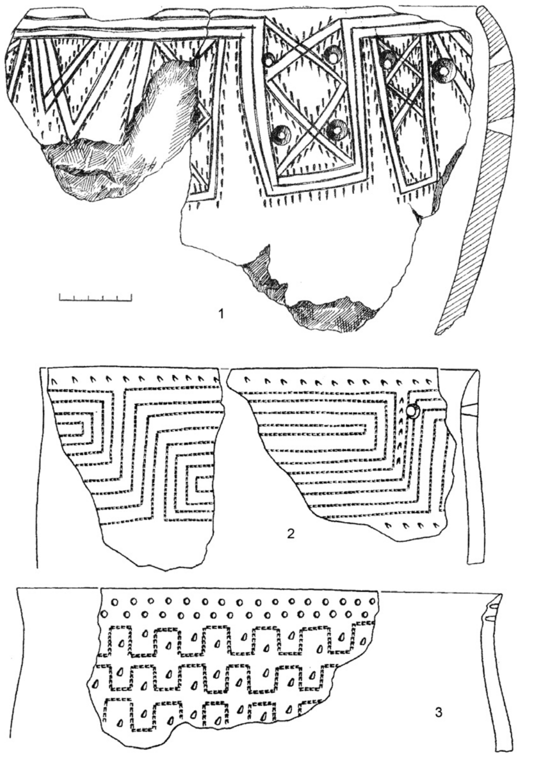

Fig. 5. Pottery. 1 Kairshak III site; 2–3 Tenteksor I site.

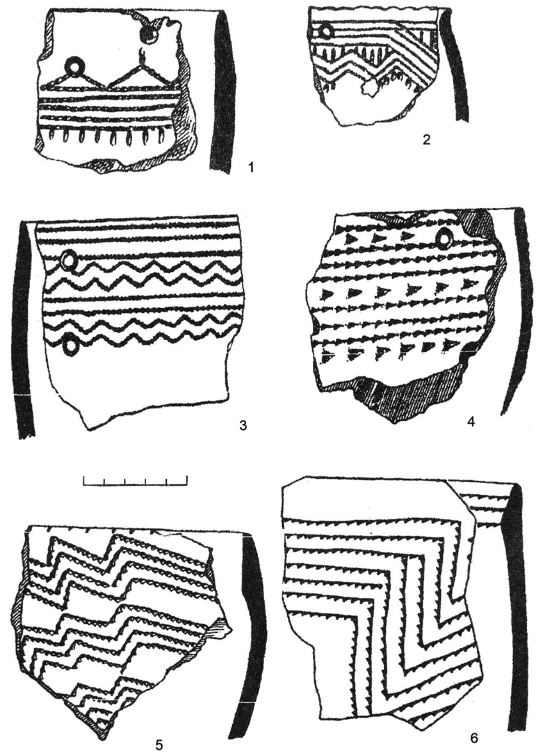

Fig. 6. Varfolomeevskaya site. Pottery. 1–2 layer 3; 3–4 layer 2B; 5–6 layer 2A.

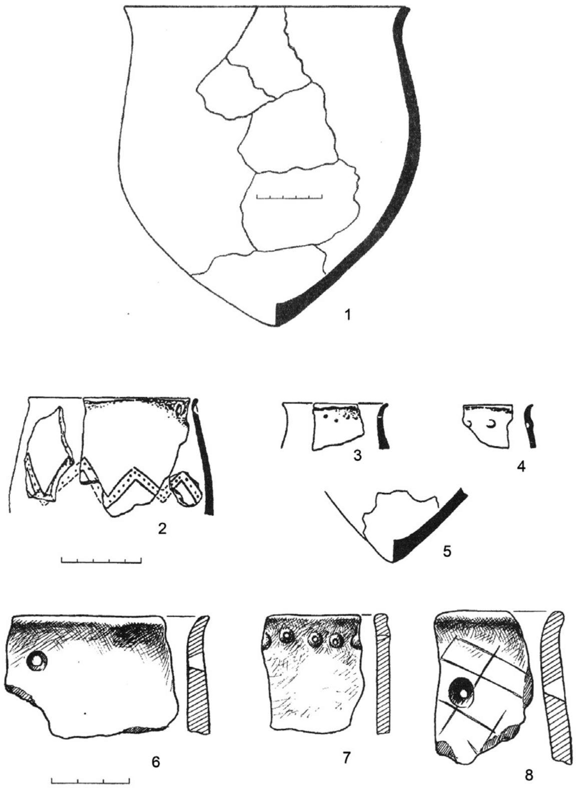

Fig. 7. Pottery. 1 Ivanovskaya site; 2–5 Chekalino IV site; 6–8 Bolshaya Rakovka site.

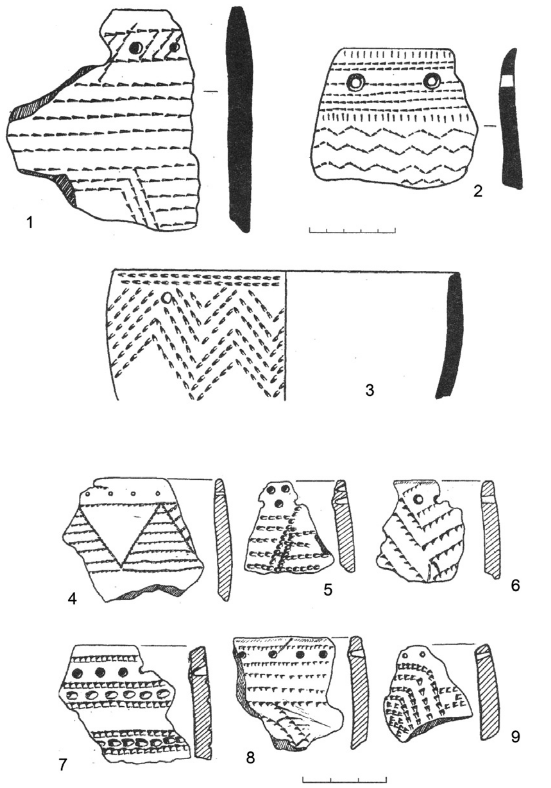

Fig. 8. Pottery. 1–3 Ivanovskaya site; 4–9 Vilovatovskaya site.

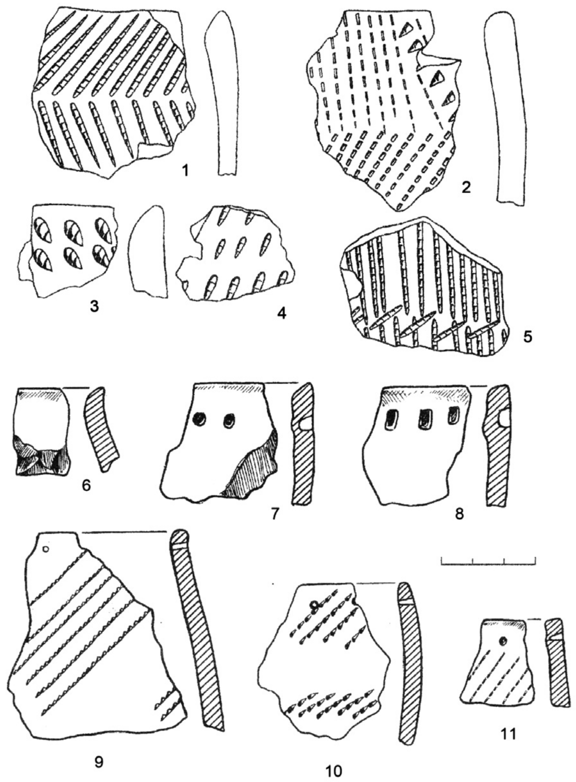

Fig. 9. Pottery. 1–5 Ziarat site; 6–11 Sherbetskaya site II.

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Pietrele in the Lower Danube region: integrating archaeological, faunal and environmental investigations

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ABSTRACT – *The* c. *9m high tell-settlement of Pietrele-Măgura Gorgana, situated close to the Danube river, is one of the westernmost sites of the Kodžadermen-Gumelniţa-Karanovo VI cultural complex that spread over the whole Westpontic region during the 5th millennium BC. Until recently tells were equated with the site when, in fact, they represent only the outstanding part of a far more complex settlement system as we now know from Pietrele thanks to geomagnetic prospections and subsequent excavations. People living on the tell, together with the inhabitants from the flat area around it, formed a vast community that must have had a strong impact on its habitat and, vice-versa, was strongly affected by the immediate surroundings. During the settlement period a lake covered huge parts of the floodplain. It provided not only a considerable part of the diet, but ensured, through the direct access to the main river, continuous and extensive over-regional exchange.*

IZVLEČEK – *Okoli 9 metrov visoka naselbina tipa tell Pietrele-Măgura Gorgana se nahaja blizu reke Donave in je ena najbolj zahodnih naselbin kulturnega kompleksa Kodžadermen-Gumelniţa-Karanovo VI, ki se je širil čez celotno zahodno pontsko regijo v času 5. tisočletja BC. V preteklosti so tell enačili z naseljem, danes pa zahvaljujoč geomagnetskim preiskavam in kasnejšim izkopavanjem na najdišču Pietrele vemo, da sama naselbina tell predstavlja le najbolj izjemen del veliko bolj kompleksnega naselja. Tisti ljudje, ki so živeli na tellu, in tisti, ki so živeli v ravnici okrog tella, so bili skupaj del velike skupnosti, ki je morala imeti močan vpliv na okolje, in na katero je tudi neposredna okolica morala imeti pomemben učinek. V času obstoja te naselbine se je v tej ravnici nahajalo veliko jezero. Le-to je predstavljajo pomemben vir za prehrano takratnih ljudi, prek neposrednega dostopa do glavne reke pa je omogočalo tudi stalno in obsežno menjavo na nadregionalni ravni.*

KEY WORDS – *Copper Age; Gumelniţa-culture; Pietrele; geomorphology; palaeolake; fauna; hunting; fishing; symbols on pottery*

Introduction

In archaeological investigations, bodies of flowing water are considered the main arteries by means of which groups of human populations disseminated, and with them knowledge and goods also spread. In this regard, the Danube played a special role, as first pointed out by Vere Gordon Childe (*1929*). He dedicated (*1925*) one of his first books to this watercourse, although even earlier in his pioneer work *The Dawn of European Civilization* one chapter carries the title 'Danubian Civilization'. In the German literature, the Early Neolithic has been designated as *Donauländischer Kulturkreis* (*Buttler 1938*), the first farmers being conceived as population groups that immigrated to Southeast Europe from the Near East.

Following the course of the Danube, they spread west, thereby driving out the post Ice Age hunter-gatherers of Central Europe.

Standing bodies of water in Southeast Europe, unlike those in the circum-Alpine sphere, have received far less attention in research. Exceptions are the excavations led by Giorgos Chourmouziades at Lake Orestida in Kastoria, Greece (*Chourmouziades 2002*) and at Ezerovo, near the Lake Varna led by H. Todorova (*Todorova, Tončeva 1975.30–46*). Lakeside settlements or wetland settlements in Switzerland and south-western Germany have been the focus of investigations since 1854 (*Schlichtherle 1997*). Between *c.* 4200 and 850 calBC, Neolithic and Bronze Age communities built their houses close to the water, in some cases on posts or piles in waterlogged soils which excluded oxygen and thus remained preserved through time (*Wolf 1998.27–35*). In the course of the first measures to regulate the Jura from 1868 to 1891, the decline in the water level of over 2m revealed sites with so-called pile dwellings (*e.g.*, Cortaillod, Lake Neuenburger; *Schlichtherle 1997*).

In contrast, during land drainage measure along the Lower Danube in the 1960s, no traces of prehistoric settlements were noted, although deep channels must have been dug into the meadow ground. Yet, during the drainage of the Danube flood plains in 1961–1967, mainly already known tell settlements were investigated anew by means of soundings by Vladimir Dumitrescu (Gumelniţa and Căscioarele: *Dumitrescu 1965.215–234; Dumitrescu 1966.51–99*). Additionally, Eugen Comşa explored the settlement at Radovanu between 1960 and 1970 (*Comşa 1972. 44–45*). Although land drainage activities had a dramatic impact on the hydrological balance of the entire Lower Danube, thereby causing extensive changes to the line of adjoining terraces and intrusions into the soils, none of these consequences were noted in the archaeological literature.

The Danube flood plain prior to drainage

As late as the 1960s, a number of lakes extended between Giurgiu and Călăraşi, a lacustrine landscape, which was fed by the Danube and abundant tributaries to the north (Fig. 1). Some of the standing bodies of water west of the Argeş river valley were interconnected; to the west, they ended at about the site of Pietrele (at the edge of the terrace) and Gostinu (in the flood plain). East of the Argeş and as far as the separation of the Borcea canal at Călăraşi, the lake plateau was supplied by the Mostiştea River. Once a bountiful aqueous biotope, today it is traversed by drainage canals.

Excavations at some tell settlements along the Danube were conducted during or even before World War I. After beginning with a trial trench in 1904, by 1953 the tell near Ruse had been almost completely excavated (*Černakov 2009.30–31*); C. Schuchhardt excavated at Cernavodă until 1917 (*Schuchhardt 1924.9–27*); whereas, unfortunately, the work of Leo Frobenius at Cuneşti during World War I remained unpublished (*Popescu 1935–36.109*).

In the 1920s, members of the Institute of Archaeology in Bucharest undertook investigations at the tell settlements of Gumelniţa (*Dumitrescu 1924; 1925*), Sultana (*Andrieşescu 1924.51–107*), Căscioarele (*Ştefan 1925.138–197*) and the prehistoric settlements on what was then the peninsula in Lake Boian (*Christescu 1925*). The expeditions were immediately published in the first two volumes of the newly-founded journal Dacia in the form of detailed preliminary reports. Between 1940 and 1960, during and after World War II and before the Danube mea-

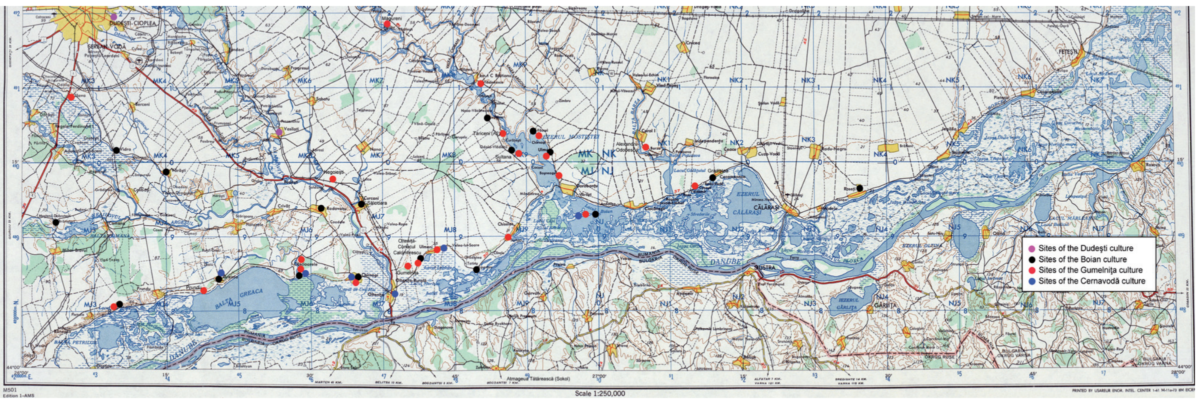


Fig. 1. Map of the Lower Danube Region (U. S. Army, Corps of Engineers, 1955) with some of the main Neolithic and Chalcolithic sites (A. Reingruber).

dows were drained, excavations were conducted – as far as verifiable – only in Pietrele and Spanţov; smaller investigations were undertaken in Sultana by local museums, but never published. Dumitru Berciu excavated in Pietrele for a maximum of six weeks in 1943 and 1948 (*Berciu 1956.504*); after that, in 1956–1957 he was occupied with work in Tangâru, another tell settlement northwest of Pietrele (*Berciu 1961*). Sebastian Morintz excavated in Spanţov in 1952 and 1956 (*Şantierul Spanţov 1953; Morintz, Preda 1959.163*).

The aforementioned settlements of the Neolithic Boian and Copper Age Gumelniţa cultures appear at regular intervals, at a distance of approx. 20–40km apart. Multi-layered or flat settlements, scarcely visible today, can surely be presumed in the terrain in between. Those sites that have been recognised and excavated, however, suffered the same fate as the tells: the finds recovered from Prundu, Chiseleţ, Boşneagu, Vărăşti and Alexandru Odobescu remain more or less unpublished.

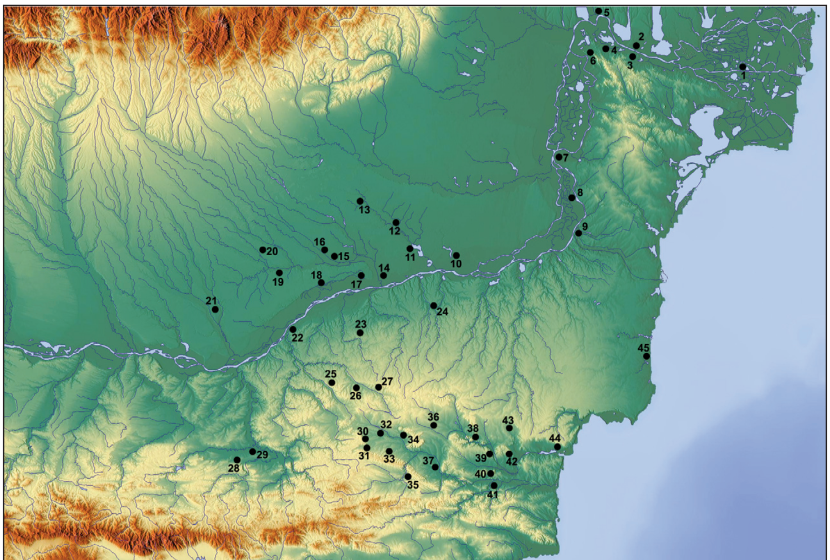
When plotting these Neolithic and Eneolithic settlements on a map, their relation to the former lake landscape becomes quite obvious; investigated settlements are particularly numerous in areas in which flowing water meets standing water (near the present-day localities Olteniţa und Dorobanţu). The absence of higher tells to the south of the present course of the Danube cannot be attributed solely to a gap in research. No larger rivers flow there, except for the Lom, at whose confluence with the Danube the Ruse tell is located (Fig. 2). Moreover, although numerous rivulets drain the Ludgorie plateau east of the Lom, they do not carry water all year round. So, apparently this southern area – with a more limited amount of not only water but also sun in comparison to the northern banks – did not attract prehistoric settlers as the north did.

Similarly, no tell-settlements are known from the Neolithic or Copper Age in the area extending from the bend east of Cuneşti near Călăraşi as far as Cernavodă. By contrast, high tells are located along the Danube flowing south-north, such as Cernavodă (at the mouth of the Carasu River into the Danube, that is, with the Danube-Black Sea canal built into the riverbed, 1949–1987), Borduşani and Hârşova (near the confluence with the Ialomiţa). Settlements are even more numerous in the area around the northern knee of the Danube, where smaller lakes are found to the south of the river and large lakes to the north (Fig. 2).

Undoubtedly, this ecological situation cannot be applied directly to the 5th millennium BC. Likewise, the morphology of the Danube meadowscape between Giurgiu and Călăraşi, much less as far as the Danube delta, cannot be reconstructed within the time limits of a single project. However, based on more than 160 core drillings in the stretch between the tell sites of Pietrele and Gumelniţa, new results regarding the palaeo-landscape of the Danube valley were obtained.

Reconstruction of a palaeolake in the Lower Danube valley

Until now, studies of the fluvial history of the Lower Danube and of landscape development along that stretch of the Danube are rare. An overall view of the geomorphological and geological setting within the study area was produced by *Institutul de Geologie şi Geografie al Academiei Republicii Socialiste România* (*1969*). More detailed geoarchaeological research within the framework of the joint Romanian-British Southern Romanian Archaeological Pro-



1. Taraschina, **2**. Orlovka, **3**. Isaccea, **4**. Luncaviţa, **5**. Giurgiuleşti, **6**. Carcaliu, **7**. Hârşova, **8**. Borduşani, **9**. Cernavodă, **10**. Cuneşti, **11**. Sultana, **12**. Şenoiu, **13**. Măriuţa, **14**. Gumelniţa, **15**. Vărăşti, **16**. Vidra, **17**. Căscioarele, **18**. Pietrele, **19**. Tangâru, **20**. Bucşani, **21**. Vităneşti, **22**. Ruse, **23**. Kubrat, **24**. Sokol, **25**. Golian Izvor, **26**. Hisarlik, **27**. Radingrad, **28**. Hotnica, **29**. Samovodene, **30**. Poljanitsa, **31**. Omurtag, **32**. Nevski, **33**. Ovčarovo, **34**. Loveč, **35**. Vinica, **36**. Kodžadermen, **37**. Smjadovo, **38**. Slatina, **39**. Provadija, **40**. Sava, **41**. Goljamo Delčevo, **42**. Devnja, **43**. Suvorovo, **44**. Varna, **45**. Durankulak

Fig. 2. Map of the Lower Danube Region with sites of the Gumelniţa-Kodžadermen culture (A. Reingruber).

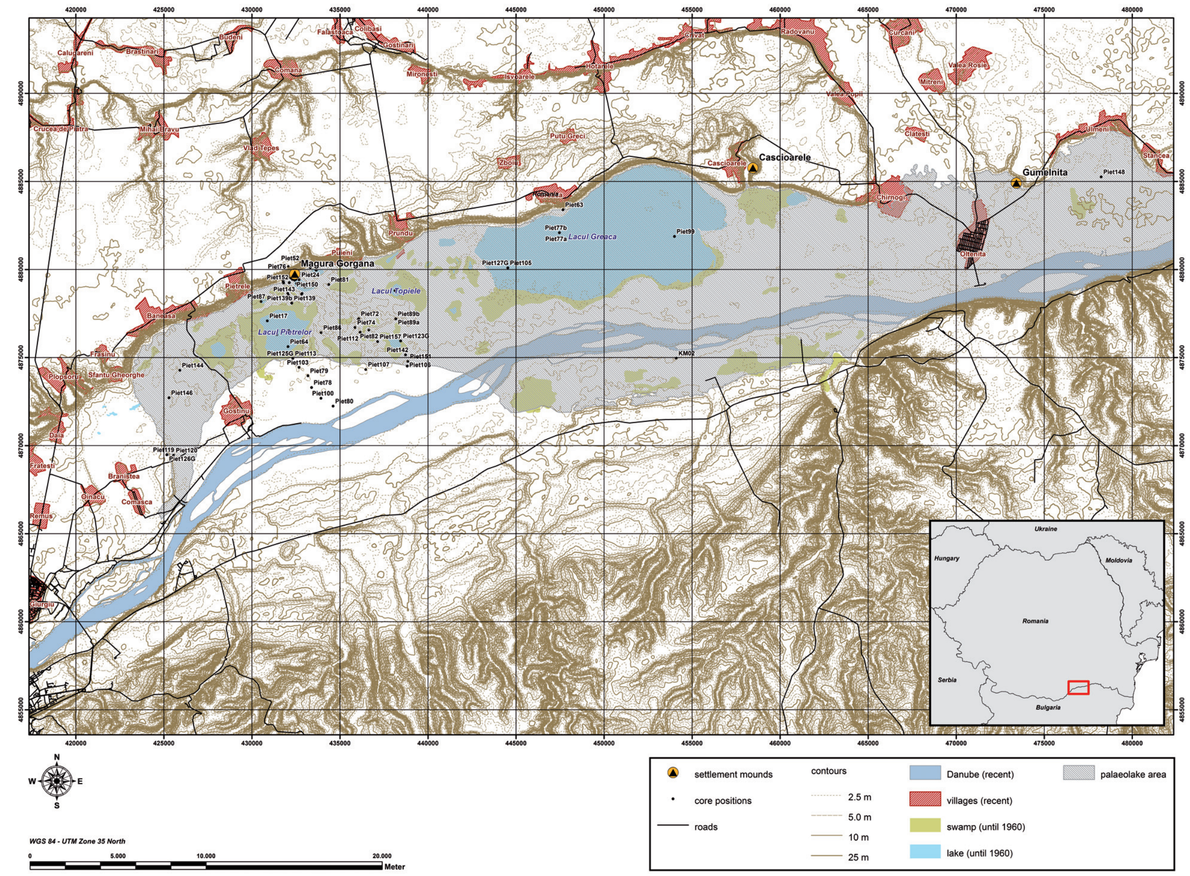


Fig. 3. Topographic map of the study area at the Lower Danube showing the locations of corings, positions of former lakes and the supposed palaeolake with an area of approx. 60km that might have developed in the 7th millennium BC and existed for more than 5000 years (D. Nowacki).

ject (SRAP) project (*Howard* et al. *2004; Macklin* et al. *2011*) focused on the Teleorman Valley, about 70km west of Pietrele. Furthermore, Alexandru M. F. Tomescu (*2000*) and Maria Lazarova and Elissaveta Bozilova (*2001*) provided information on the regional vegetation history based on palynological studies in southern Romania and northern Bulgaria. Much more research has been conducted on the Holocene and late Pleistocene evolution of the Danube delta and changes in the level of the Black Sea (*e.g., Panin 2003; Giosan* et al. *2006; Yanko-Hombach* et al. *2007*). A discussion of the chronology of sea-level changes and the impact on the archaeological sites along the Black Sea coast is still underway.

To have a closer view of the development of the Holocene flood plain within the study area between Giurgiu and Olteniţa, a multi-proxy approach based on a variety of methods (*e.g.*, the evaluation of historical and recent topographic maps and satellite images, corings as much as 17m in depth, geoelectric profiling, sedimentological, geochemical, microfaunal and pollen analyses) have been applied (*Wunderlich* et al. *2012; Nowacki, Wunderlich 2012*).

A comparison of historical topographic maps and satellite images allowed the detection of recent geomorphological changes, as natural or anthropogenic modifications to channel beds and the silting up of ancient lakes. Furthermore, these sources provided the geographical background for taking sediment cores, and enabled the regionalisation of data attained from various analyses of the sediments. More than 160 sediment cores were taken by vibracoring (Fig. 3), using open and closed sections. In addition to grain-size analyses, chemical elements such as iron, aluminium, titanium, strontium, magnesium, calcium, copper, manganese, sulphur, nitrogen, phosphate, total organic and inorganic carbon (TOC, TIC) were identified. Furthermore, conductivity was measured and the remains of microfossils and pollen analysed. The chronological framework of the stratigraphy is based on AMS ^{14}C and OSL dating.

The corings and following analyses allowed the identification of distinct sediment layers, which can be assigned to different sedimentary environments. The time bar in Figure 4 shows the different lithological units, starting with fluvial sediments at the base, overlain by limnic sediments, which are mostly covered by channel and flood plain deposits. In detail, the following facies units from base to top could be distinguished:

Fluvial deposits

These sediments are characterised by olive-coloured sand and partly gravel. OSL-dates vary from 32.7 ± 1.5 ka BP (HDS–1570) to 15.9 ± 0.9 ka BP (HDS–1573) indicating that the deposition of this layer occurred at least until the late Pleistocene. It can be attributed to a braided river system.

Limnic deposits – grey

These grey deposits are characterised by a fining upward sequence, but with slightly alternating grain-size distribution in every analysed core. The only OSL date available from the lower part of this layer gives an age of 9.03 ± 0.4 ka BP (HDS–1574; *cf.* Fig. 4). Due to the results of geochemical and microfossil analyses – for example, comparatively low C/N ratios (*e.g., Meyers, Ishiwatari 1993*) – these sediments can be attributed to a limnic environment. It can be assumed that vast parts of the Lower Danube valley were inundated as a result of the rapid rise in the level of the Black Sea. The extent of the palaeolake as reconstructed from the corings is depicted in Figure 3. After a period of 2000 years, the environmental conditions changed and the following sequence was deposited. This was when the Neolithic settlement was founded at Pietrele.

Limnic deposits – very dark grey/black

A limnic environment continued to prevail in the study area. However, the sediments of this sequence are characterised by a very dark grey or even black colour. This dark layer (DL I), which could be identified in nearly every core, was dated by several AMS-^{14}C and one OSL dating to the time span of the Copper Age settlement period (Fig. 4). Near the centre of the palaeolake, DL I is predominantly characterised by clay, whereas next to the littoral, the layer mainly consists of coarser material. This is evidence that the sediments originated from the adjacent slopes, where they were possibly eroded due to increasing human impact.

Limnic deposits – dark grey

The lake sediments above DL I are characterised by a dark greyish colour and consist predominantly of clay and silt, respectively. Further dark layers are intercalated, varying in number and thickness from core to core. For example, the dark layer DL II is not

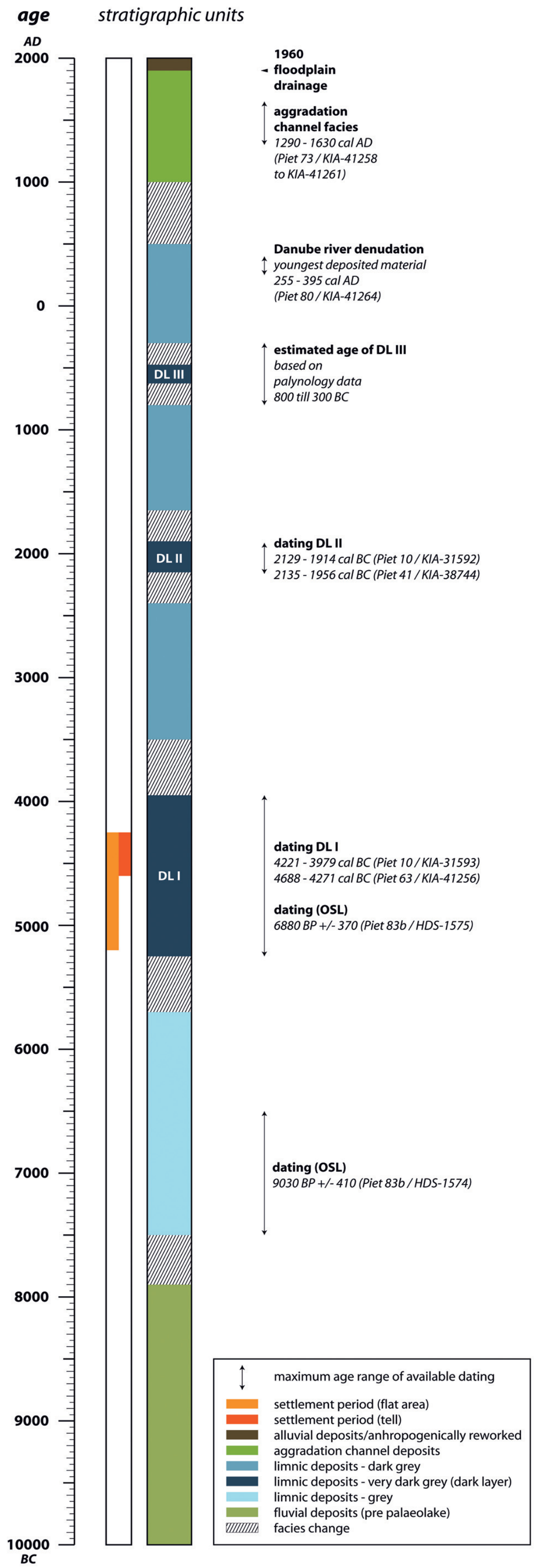


Fig. 4. Time bar showing the different stratigraphic units in the sedimentary record of the Danube floodplain derived from more than 160 corings, as well as AMS ^{14}C and OSL ages providing the chronological framework (D. Nowacki).

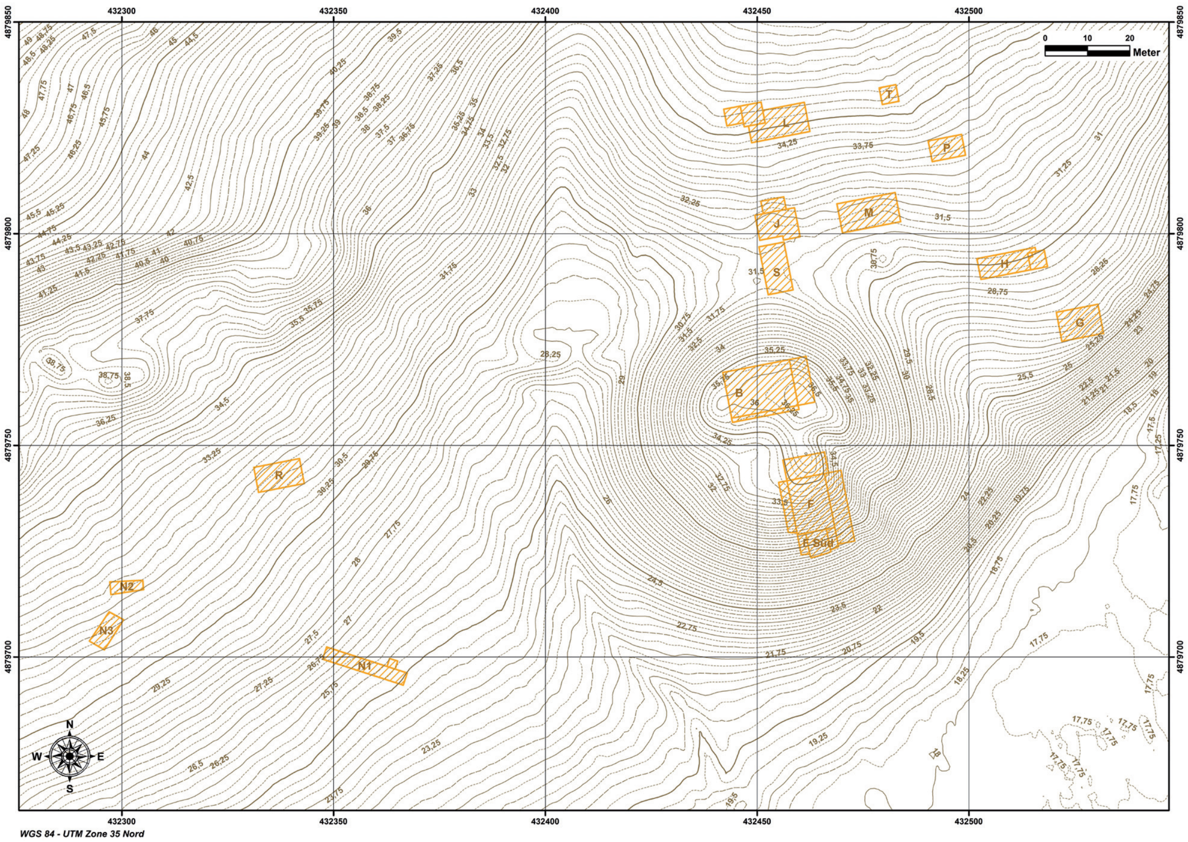


Fig. 5. The tell site of Pietrele, Măgura Gorgana and its immediate surroundings with trenches from 2002–2012 (D. Nowacki).

as thick as DL I and occurs only in the western part of the palaeolake. This layer was dated to approximately 2000 calBC (Fig. 4). The whole stratigraphic layer is interpreted as the main palaeolake period, which ended with the silting up of the lake.

Aggradation channel deposits

The period of aggradation was characterised by a prograding channel system, which fragmented the whole lake area into smaller basins. This channel system and the small lakes in between existed until the flood plain was drained in the 1960s; the remnants thereof can still be identified in the landscape on recent satellite images and topographic maps. The channel and levee deposits of the 'aggradation channel deposits' are separated from the 'limnic deposits' below by a sharp unconformity, indicating that the limnic sediments were locally eroded during the aggradation phase. In the small basins between the channels, lake sediments reach the surface. At these locations, lakes prevailed, since they were drained some 50 years ago.

Alluvial deposits/anthropogenically reworked

The uppermost stratigraphic layer close to the surface contains reworked material that came up during the digging of drainage canals. Furthermore, it consists of alluvial sediments that were affected by pedogenesis after drainage and severe changes in the groundwater table. This stratigraphic layer alternates in grain-size and colour from core to core.

The results presented here of our geomorphological research in the area close to the site provide evidence that during the Neolithic and Copper Age settlement at Pietrele people lived close to a vast lake extending over about 500km^2. The western boundary of the palaeolake could be located about 10km west of Pietrele. There, the Danube probably entered the lake. To the east, limnic deposits were found as far as Gumelniţa, defining the minimum extent of the lake, and even in Bulgaria south of the Danube comparable lake deposits were found. Possibly, the lake extended even further to the east, connecting the settlements of the 5th millennium BC. Along the lakeshore, swampy wetlands constituted suitable habitats for wild animals such as wild boar, which was proven to have been a major source of food for the people at tell Pietrele (see contribution by N. Benecke). The finds of fish bones within the settlement layers also corroborate the existence of a lake, as the majority could be assigned to species preferring still waters (see contribution by K. Ritchie). The changing properties of the sediments within the record of limnic deposit, for example, the dark layer DL I that was partly accumulated during the main settlement period at Pietrele and neighbouring settlements from 4600 to 4250 calBC, might have been due to human impact. Intensified agriculture causing soil erosion as well as the input of organic matter from the settlements around the lake possibly changed the ecological conditions of the palaeolake.

Pietrele – 1000 years of settlement history

Still towering some 9m above the surroundings today, the Măgura Gorgana settlement mound near Pietrele was without doubt an imposing feature in the 5th millennium BC (Fig. 5). Upon a relatively steep projecting socle of settlement debris, heightened with additional deposits, stood large two-storied structures in close alignment. Settlement mounds were an architectural innovation on the Lower Danube, for never before had such a form of settlement appeared in this region, an otherwise characteristic appearance during the late 7th and 6th millennium BC in Southeast Europe. However, in the middle of the 5th millennium BC, when the Măgura Gorgana tell began to be built, settlement mounds were already an anachronism: this form had been given up elsewhere in Southeast Europe. According to the available data, it seems presumable that the erection of this tell was an organised process that occurred prior to 4600 calBC on the Lower Danube. However, we can establish the beginnings of the settlement hill in Pietrele with certainty only when the corresponding settlement layers have been reached.

It has been a long-held view that the mound represented the settlement as a whole. Our investigations could show for the first time that the tell was only a part of a substantially larger settlement. According to findings made thus far, the surrounding flatland settlement existed long before the mound was built: it existed further during the entire duration of habitation atop the mound and ended *c.* 4250 calBC with the end of the tell. Excavations conducted in the flatland settlement since 2009 have brought forth astonishing new perspectives. The hitherto oldest recorded habitation there can be dated to the last two centuries of the 6th millennium BC (*Hansen* et al. *in press.Fig. 59*). In the north-eastern area of the flatland settlement, habitation layers were uncovered that held pottery from an early phase of the southern Romanian Late Neolithic (*Hansen* et al. *in press.Fig. 2–3, 28*). Radiocarbon dates of the layers from which the pottery derives are still being processed, but stylistically the vessels can be dated to the beginning of the 5th millennium BC. At present, no further radiocarbon dates for the various Late Neolithic find contexts are available, yet all stylistic phases of Boian culture are probably represented in the flat settlement around the tell. The research on the Late Neolithic period in southern Romania is full of gaps (*e.g., Neagu 1999*); hence, it can be anticipated that future excavation in Pietrele will lead to a basic revision of the actual temporal sequence in the cultural development of the Late Neolithic period. There are signs that the settlement existed for some 1000 years, which is a significantly longer time than could have been assumed until now.

With the discovery of Late Neolithic layers in Pietrele, there is now the promising expectation that the development of the settlement until the forma-

species	Danube meadow floodplain forest		slope area water bodies	high terrace
mammals	wild pig	beaver	roe deer	aurochs
	red deer	otter	wolf	wild horse
	polecat		fox	red deer
			badger	roe deer
			hare	bear
				lynx
				wild cat
				wolf
				pine marten
				hare
birds		ducks	birds of prey	birds of prey
		geese		
		swans		
		herons, storks		
		cormorant		
		pelican		
		crane		
fish		all species		
reptiles		pond turtle		
mollusca		river mussels		

Fig. 6. The ecotope in the surroundings of the settlement at Măgura Gorgana and the wild animals occurring inside as derived from their preference for a specific habitat.

tion of the settlement mound can be followed more precisely, a potential that is of profound importance for explaining the genesis of the 'tell phenomenon' on the Lower Danube. Furthermore, the economic strategies and their changes in the course of a lengthy settlement history can be determined, thanks to abundant plant and animal remains obtained by hand-collecting as well as by dry sieving and flotation.

Animal husbandry and hunting

Excavations at the settlement mound of Măgura Gorgana in the community of Pietrele have yielded comprehensive collections of animal remains, thanks to the favourable conditions for preservation. The remains enable insight into the economic basis of the settlement site, as well as aspects of local environmental conditions (*Benecke 2004; 2006*). From a chronological point of view, the finds can be roughly assigned to two phases in time, namely the Late Neolithic Boian culture and the Copper Age Gumelniţa culture. Assemblages of animal bones from the time of the Boian settlement phase are available from the outer settlement, although the size of these collections is relatively small. By contrast, excavations on the tell yielded exclusively animal remains of the Gumelniţa settlement phase, encompassing very comprehensive inventories. A comparison of finds from these two temporal phases reveals differences in the use or management of animal resources.

The Boian settlement in Pietrele is typical mainly of an agrarian oriented food economy. Animal husbandry focused primarily on cattle. Thus, among the bones of economic domestic animals, *c.* 70% are cattle, while pig and small ruminants (sheep and goat) are each represented by *c.* 15%. The small inventories do not enable any deductions about aspects of secondary use. Compared to animal husbandry, hunting played only a minor role in the food supply. The proportion of game among the bones of mammals amounts to only 8%. Wild boar and red deer were among the most frequently hunted wild animals. The number of finds of other, potentially easily obtainable, natural animal resources in the surroundings of the settlement, such as birds, fish, mussels and turtles, suggests that exploitation was very low.

Animal remains from the subsequent Gumelniţa settlement attest to the extensive use of natural animal resources as nourishment for the inhabitants and a source of raw materials. Only half of the meat documented in waste deposits derives from domesticated animals. In contrast with the Boian settlement, pig is the most frequent among domestic animals, amounting to 56%. The cattle bones amount to 33% and those of sheep/goat are 11% of the bone material. Available data on stock composition (age, sex) show that pig were kept mainly for meat, while cattle, sheep and goat were probably also raised for milk.

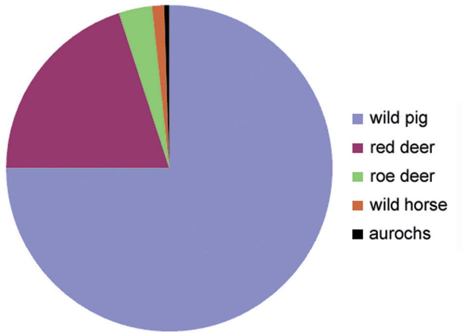


Fig. 7. Relative frequency of the principal game species (ungulates only) from the Gumelniţa layers in the tell (according to total number of finds).

Wild mammals comprise a numerically significant group, rich in species, among the finds of the Gumelniţa settlement. They include various ungulates such as wild boar, red deer, roe deer, aurochs and wild horse, predators, and beaver and hare. They comprise between 45% and 55% of the mammalian bone material a proportion that allows the conclusion that hunting was widely practiced.

Wild boar is by far the predominant species among game animals (Fig. 6). The surrounding deciduous and mixed forests, alder swamps and aggradation zones of lakes and old coniferous groves with abundant underbrush offered an optimal environment for this species (*Herre 1986.51*). Considering this beneficial ecotope in the environs of the settlement site, animals probably took advantage of these ideal conditions, especially in the Danube meadows, and, consequently, were hunted. The second most frequent game species is red deer. This species is a typical inhabitant of sparse woods and wooded river valleys and meadows. However, it is also found in open grassland and heather landscapes if they are expansive enough to offer sufficient possibilities of escape (*Bützler 1986.125*). Accordingly, red deer could be hunted in the surrounding Danube meadows as well as on the high terraces near Măgura Gorgana. Unlike red deer, roe deer is characterised rather by its preference for the periphery of woods (*Lehmann, Sägesser 1986.254*), where it can seek refuge. However, it also prefers vast open spaces, a landscape that can be presumed to have existed on high terraces. Roe deer could also appear occasionally in slope areas. The presence of wild horse is relatively clear. As specialised grass eaters and a typical element of the steppe fauna, these animals are primarily assumed to have been inhabitants of high terraces along the Danube. Presumably, sparse wooded cover and park-like landscapes and the steppe were the preferred habitat of auroch (*Requate 1957. 325*). Groups of these large wild cattle probably also inhabited the high terraces. Figure 6 shows potential habitats, including areas of other species of wild game attested in the bone material from Măgura Gorgana.

In addition to wild mammals, bone material found in the Gumelniţa settlement phase attests the hunting of various species of birds as well, above all ducks, geese, swans, herons and cranes. Fishing was another important branch of the food economy (see contribution by K. Ritchie). This was augmented by the regular exploitation of mussels and turtles for food. The shells of river mussels (*Unio* spec.) were present in almost every unit of finds, and sometimes whole storage units were discovered, such as in contexts P10L241 and L254, where 5121 mussels were counted. Assuming two shells per complete bivalve, 2560 mussels were disposed. Considering that the shells were disposed of in middens after the organic matter had been consumed, their accumulation cannot indicate the storage of fresh food, as shown by the almost complete absence of mussels that were still closed, *i.e.* complete bivalves. Furthermore, in areas B and F on the tell, species of *Unio* appear mainly in the alleyways. Hence, river mussels must have been part of the common diet. In addition K. Ritchie identified a minimum number of individuals (MNI) of nine turtle shells in area B on the tell in one single unit of finds (feature P12B-246).

All in all, this demonstrates that all of the ecotopes in the surroundings of the settlement site – the Danube meadows and the bodies of water there, the slopes as well as the high terrace – were integrated in the exploitation of natural animal resources. As can be recognised in the compilation in Figure 6, the focus of these activities was evidently on the Danube meadows, where the most frequently hunted animal was presumably wild boar (Fig. 7), but the other attested and quite frequent kinds of animals or groups also stem from the meadows. Possibly the local animal husbandry made use of the natural sphere as well, in which case, the domestic pig could easily have found food.

Fish bones in and off of the tell

The analysis of fish bones from Pietrele is in its beginnings. The results presented here are based primarily on sieved samples and do not yet include the hand-collected material from these contexts. The samples included have been recovered mainly by wet-sieving using mesh-sizes of 0.5mm (P10F345 and F346, P11 B024, F811 and F821) and 4mm (P12B270). On the other hand, the fish materials included in shell middens P10L241 and L254 (see contribution by N. Benecke) were obtained by manual sorting. Some elements (*e.g.*, loose teeth, ribs, spines) are not included in the totals, because they would bias the results in an unrepresentative manner. It should be noted that it is possible, for example, that *Siluridae* (catfish) are under-represented and *Acipenseridae* (sturgeon) are missing, as most were large individuals, and the bones from these fish were noticed in the field and set aside with the other bone material where they await identification.

The taxa listed in Figure 8 are fish typically classified as limnophillic (preferring still waters), but they also adapt to a variety of habitats (*Dinu 2010; Froese, Pauly 2013; Kottelat, Freyhof 2007*). The one exception to this is *Alosa* sp., which keeps to the main channel of the Danube during its migration into freshwater (*Kottelat 1997; Whitehead 1985*). Although not present in any of these samples, the identification of Acipenseridae (sturgeon) in other contexts by N. Benecke (*2004*) also supports at least oc-

Family	Species	English	Romanian	German
Clupeidae	*Alosa sp.*	shad	scrumbie	Maifisch
Cyprinidae	*Abramis brama*	bream	plătică	Brasse
	Cyprinus carpio	carp	crap	Karpfen
	Aspius sp.	asp	peşte lup	Rapfen
	Rutilus sp.			
	Scardinius sp.	rudd	roşioară	Rotflosser
	cf. Alburnus sp.	bleak	albişoară	Ukelei
	cf. Phoxinus sp.	minnow	crăiete	Elritze
Esocidae	*Esox lucius*	pike	ştiucă	Hecht
Percidae	*Gymnocephalus sp.*			
	Perca fluviatilis	perch	biban	Barsch
	Sander lucioperca	pike-perch	şalău	Zander
Siluridae	*Siluris glanis*	wels catfish	somn	Wels

Fig. 8. Species of fish analysed in the units listed in Figure 9.

casional fishing in the main channel of the river, where there are deep, strong currents.

Chronologically, six of the eight collections analysed in this paper are from an early period of the Gumelniţa culture: four units derived from the lowest levels excavated in trenches B and F on the tell so far, and two from a coeval level revealed in trench L in the outer settlement. The units belonging to P10F were dated radiometrically to 4500– 4450 calBC; no ^{14}C dates are available for the two units in trench B, but they are from features that can be typologically dated to the same period as P10F. The features from off the tell in trench L yielded pottery that also date them to an early phase. The other two units in trench F (P11F811 and F821) are considerable younger, dating from the end of the tell-sequence at around 4250 calBC.

The data show that, internally, the samples from trenches B and L are relatively homogenous, although the contexts from trench F display considerable variation (Fig. 9). Because of the small sample sizes and differences in recovery methods, caution is needed when interpreting differences between the samples, and any conclusions must be considered preliminary. However, the available data do show variability between the trenches that is of some interest. Fish bones from the shell middens in trench L are overwhelmingly cyprinids, with a small number of other species included. In trench B, the cyprinids are also the most important species, but here there are larger numbers of pike and fish of the perch family, and it is in this trench that catfish are most significant. The results from trench F 2011 (P11F) are similar to trench B, although catfish are less common. Trench F 2010 (P10F) has an even larger percentage of pike and perch family remains, although cyprinids still comprise almost half of the identified bones (though note that P10F346 is very similar to trench B). The difference between the absolute dominance of cyprinids from contexts off the tell and the more balanced representation of fish from the two trenches in the tell indicates that the processes responsible for creating these deposits were not the same. Further work is necessary to clarify whether this is the result of contextual, cultural, temporal, or other factors.

One conclusion that can be drawn from these preliminary investigations regards fishing techniques. The presence of many specimens of very small fish, together with *Alosa sp.* (an anadromous fish that does not feed during its migration into freshwater – meaning that it will not respond to fishing methods relying on the use of bait), strongly point to the use of nets or traps in addition to the spears/harpoons and/or fishhooks that were probably employed to catch some of the impressively large specimens present in the assemblage.

Fishing in Pietrele

The Danube River and the lakes were important food sources for the inhabitants of Pietrele and neighbouring settlements in prehistory and well into modern

	Clupeidae	Clupeidae %	Cyprinidae	Cyprinidae %	Esocidae	Esocidae %	Percidae	Percidae %	Siluridae	Siluridae %	Total
P11B024	1	0.2%	301	69.0%	62	14.2%	55	12.6%	17	3.9%	436
P12B270	0	0.0%	305	63.8%	72	15.1%	75	15.7%	26	5.4%	478
Trench B	**1**	**0.1%**	**606**	**66.3%**	**134**	**14.7%**	**130**	**14.2%**	**43**	**4.7%**	**914**
P10F345	0	0.0%	82	26.3%	114	36.5%	115	36.9%	1	0.3%	312
P10F346	0	0.0%	168	60.2%	57	20.4%	42	15.1%	12	4.3%	279
Trench F, 2010	**0**	**0.0%**	**250**	**42.3%**	**171**	**28.9%**	**157**	**26.6%**	**13**	**2.2%**	**591**
P11F811	0	0.0%	130	75.1%	27	15.6%	15	8.7%	1	0.6%	173
P11F821	1	0.6%	102	64.6%	28	17.7%	22	13.9%	5	3.2%	158
Trench F, 2011	**1**	**0.3%**	**232**	**70.1%**	**55**	**16.6%**	**37**	**11.2%**	**6**	**1.8%**	**331**
P10L241	0	0.0%	181	86.2%	18	8.6%	10	4.8%	1	0.5%	210
P10L254	0	0.0%	196	84.5%	7	3.0%	26	11.2%	3	1.3%	232
P10L241/L254	0	0.0%	378	88.7%	19	4.5%	27	6.3%	2	0.5%	426
Trench L	**0**	**0.0%**	**755**	**87.0%**	**44**	**5.1%**	**63**	**7.3%**	**6**	**0.7%**	**868**
Totals	**2**		**1843**		**404**		**387**		**68**		**2704**

Fig. 9. Fish bones identified in eight features from three trenches in Pietrele.

times, too. Fishing activities in Pietrele, however, came to an end with the drainage of the meadows. Therefore, this traditional quest for food has ceased in Pietrele and the surroundings. Yet, historical studies on Danube fishery are at hand and offer important comparative sources for evaluating the finds from Pietrele (*e.g., Zirojević 1995*). Ground-laying work on prehistoric fishing was presented by Laszlo Bartosiewicz and Clive Bonsall (*2004*), upon which further investigations can be based. As attested by faunal remains, fishing played an enormous role in the Copper Age settlement at Pietrele. Only a small quantity of the artefacts used for fishing was preserved. Unlike fishing artefacts found elsewhere in wetland settlements (*Mertens 2000; Hartz, Kraus 2009. 209–211*), nets, fish traps, wooden anglers and the like were no longer preserved at Pietrele. Net fishing must have played an important role in Pietrele, which would explain the large amount of remains of smaller fish identified by K. Ritchie. Perforated pottery sherds could possibly have served as net sinkers (Fig. 10).

Fig. 10. Pietrele. Perforated clay discs and sherds (photo: S. Hansen).

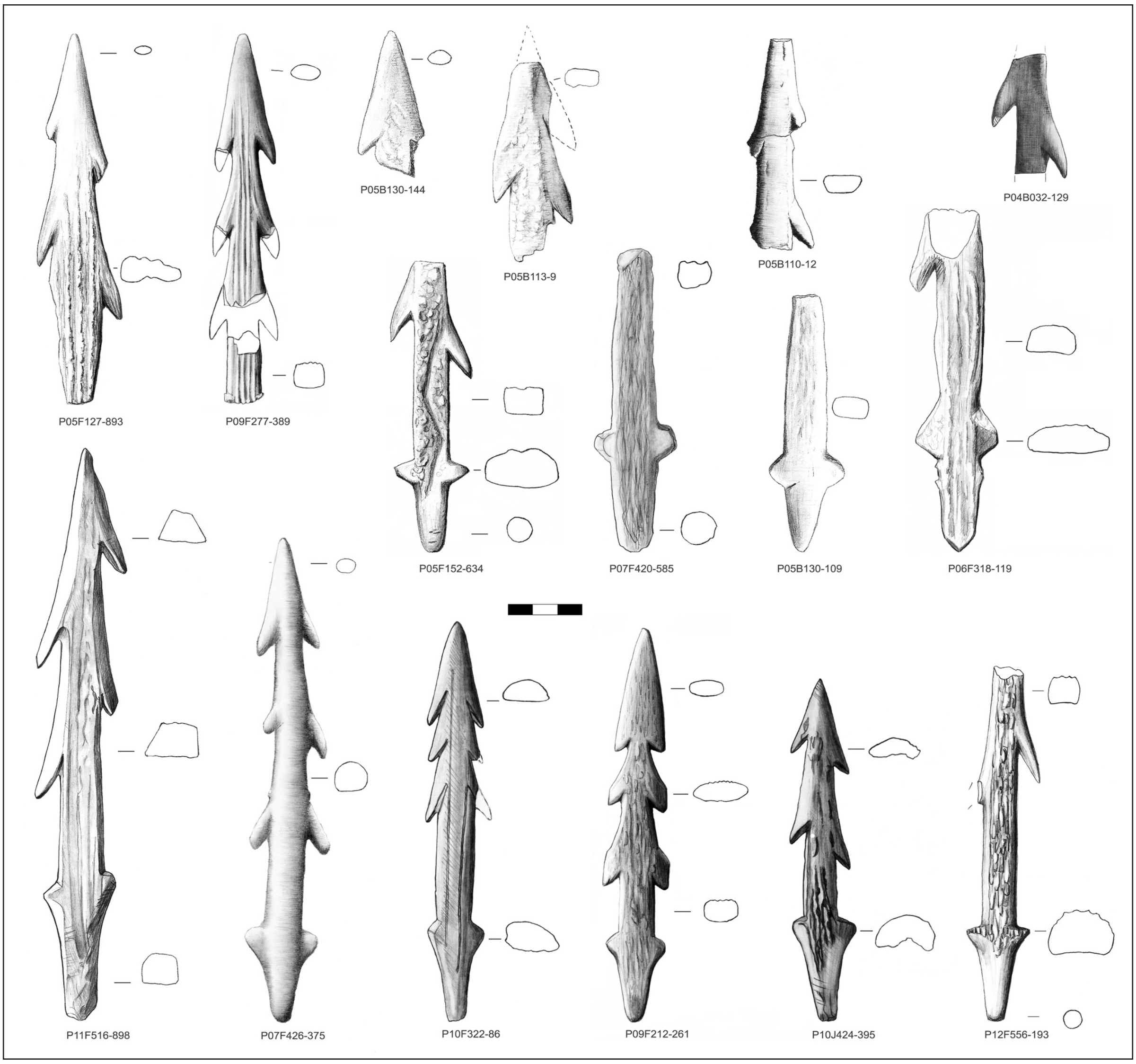


Fig. 11. Rod harpoons from Pietrele (drawings: I. Berdženishvili, T. Vachta; graphic C. Schröder).

Fig. 12. Toggle harpoons from Pietrele (photo: S. Hansen).

One of the most impressive groups of finds in Pietrele is of rod harpoons (Fig. 11); made of antler, the longish rod shape has two rows of barbs. The largest preserved example measures 24.5cm in length. A total of 38 harpoons were found in Pietrele, more than is known from other settlements of Gumelniţa culture. The majority of finds in Pietrele are fragmentary; only five pieces could be assessed as functional. Presumably, four of these examples had been reworked at least one or several times. Several typological variants can be distinguished, including harpoons with barbs arranged symmetrically or asymmetrically. A more detailed study of harpoons found in Pietrele and neighbouring settlements that would provide information about standard sizes, methods of production and the manner of shafting, among others, is still lacking. The antler harpoons at hand are components of composite tools.

Thus far, harpoons have not appeared in large quantities in find contexts of the Late Neolithic along the Lower Danube. One fragment was found in the settlement of Radovanu, which is dated to the end of the Late Neolithic (*Comşa 1986.45, Fig. 1; 1990*). Whether or not the tradition of producing rod-shaped harpoons reaches back to the Mesolithic period on the Lower Danube cannot be decided at this point. Apparently, only two rod-shaped harpoons derive from the area of the Mesolithic and Early Neolithic settlements at the Iron Gates, the two examples from Vlasac (*Dinu 2010.305*).

As far as we know, harpoons first appeared in greater numbers during the Gumelniţa culture. A large collection of double-row harpoon tips stems from the settlement mound at Ruse on the right bank of the Danube; it belongs to the narrower circle of Gumelniţa culture (*Georgiev, Angelov 1952.134, Fig. 104–105; 1957.67, Fig. 28*). Further harpoons were found at Ulmeni (*Comşa 1986.45, Fig. 2,1–7, Fig. 4.4*), Căscioarele (*Ştefan 1925.191, Fig. 45.1–13*), Vărăşti, Station B (*Christescu 1925.284, Pl. 25.16–21; Comşa 1986.45, Fig. 2.8–13*), Gumelniţa (*Dumitrescu 1925.88, Fig. 66.20–26*), Lişcoteanca, Chiselet (*Comşa 1986.45, Fig. 3*), Hârşova, Carcaliu (*Haşotti 1997. Fig. 90.1–4*) and Borduşani (*Schuster 2002.168, Pl. 1.5; 169, Pl. 2.4*). Only a small fragment of a harpoon has been published from older excavations in Pietrele (*Berciu 1956.523, Fig. 34.4*). In terms of the quantity of finds, Pietrele is indeed extraordinary.

Another form of harpoon found at Pietrele is the toggle harpoon (ger. *Knebelharpune*): projectile points with barbs and lines (Figs. 12 and 13). These are made from red deer antler. In general, this type of harpoon has not been further elucidated archaeologically. Comparable harpoons are attested in the Ertebølle phase in northern Germany (*Hartz* et al. *2007.577, Fig. 6.1, 584, Fig. 16.6*), where they were used for seal hunting. In southern Germany, harpoons are attested well into the Bronze Age (*Torke 1993.59–65*).

Transverse fish-hooks (ger. *Querangeln*) are the simplest form known in hook-and-line fishing. In Pietrele, this form has two pointed ends and a thicker middle part (Fig. 14). Besides this 'symmetrical' form, some asymmetrical examples may have served as projectile points (Fig. 15). The best evidence of the transverse hook derives from the settlement at Forschner near Bad Buchau, Baden-Württemberg, where parts of the head of a pike, the remains of a tench (*Tinca tinca*) and such a bone point were found close together (*Torke 1993.53–56, Fig. 5; 6.2*). Only one end of this transverse hook was pointed; the other was blunt. Therefore, a narrowly functional attribution of the piece is problematic, as is the case with bone tools in general. Comparable artefacts found in the settlement of Arbon-Bleiche 3 have been treated as projectile points (*Deschler-Erb* et al. *2002.295–296*). There, double-pointed rib artefacts functioned as transverse hooks. The symmetrical double-points from settlements on Lake Biel were used as projectile points, as evidenced by the residue of pitch on the objects. A small number of these points have been regarded as transverse hooks (*Schibler 2000*).

There are clear signs at Pietrele of the existence of specialised households, as was recently identified at other Neolithic and Copper Age settlements (*Müller* et al. *2013; Hüster-Plogmann 2004.273*). Houses in northern trench B were distinguished primarily by signs of grain processing (*Reingruber 2010*). Textile production also played a role. The preponderant number of artefacts connected with fishing, by contrast, stems from houses in the southerly row of houses lying near the lakes. Distinct differences in the distribution of artefacts for hunting, as well as further indications, suggest that some households in Pietrele specialised in certain activities for generations. In any case, the five superimposed houses in trench F represent a time span of 300 years. This is where the largest concentration of other antler artefacts as well as semi-finished products was noted, allowing the presumption that they were a site of harpoon production.

The large number of harpoons found in Pietrele and other settlements on the 'big lake' is certainly the result of the favourable conditions for preservation present in the settlement mounds. Yet, harpoons are also an element of economic specialisation. They are a kind of hunting artefact that presupposes training and experience. The precise analysis of the distribution of fishing equipment within the settlement and in the various layers is still in progress. In association with the analysis of fish bones, investigations of fishing implements offer new insight into Neolithic and Copper Age fishing.

Symbols on Neolithic and Copper Age pottery

The two trenches B and F on the Măgura Gorgana tell near Pietrele have now been excavated to a depth of 4.5 and 6.3m. The five superimposed house phases distinguished so far reflect 300 years of permanent habitation that can be assigned to phases A1 and A2 of Gumelniţa culture. A further two metres of settlement layers, verified by core drillings, surely reach back to the Late Neolithic, to the period prior to 4600 calBC; they have not been excavated yet. Accordingly, the ceramic sequence is in a continuous vertical stratigraphy only for the second half of the 5th millennium BC. Late Neolithic structures were recorded in the flat settlement around the tell, the horizontal stratigraphy of which has not been completely clarified yet. Nevertheless, two aspects of pottery production should be pointed out here: the cen-

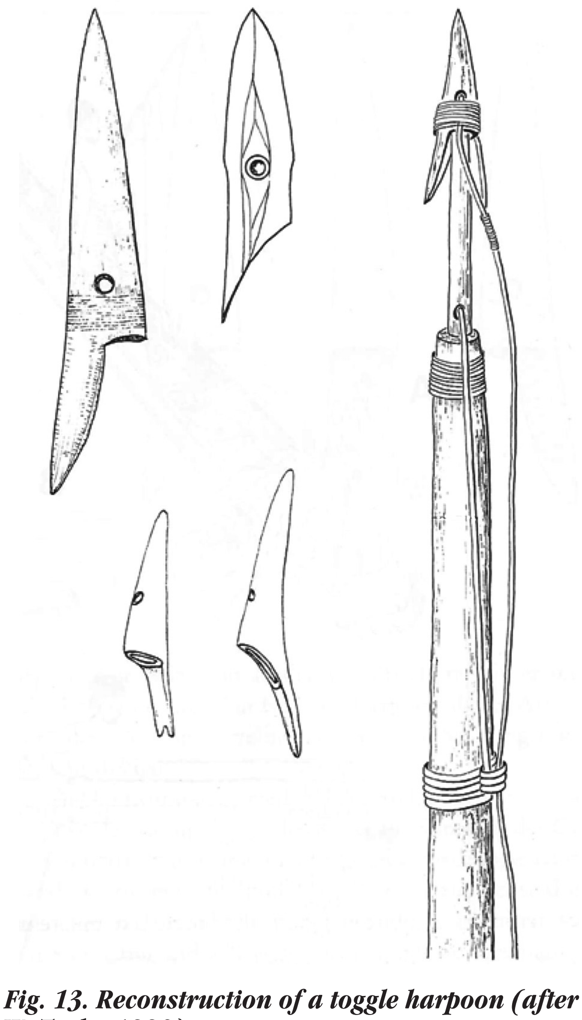


Fig. 13. Reconstruction of a toggle harpoon (after* W. Torke 1993*).

tral motifs of each period and the techniques in which they were executed.

Fig. 14. Pietrele. Transverse fish hooks (photo: S. Hansen).

One motif that stands out in the Late Neolithic material is the helix. This symbol was already present as early as the mid 6th millennium BC in the Arapi phase in Greece (*Hauptmann 1981.Pl. B.2*) and in the late Starčevo-Körös-Criş culture, painted in black on a red background. It also occurs incised and then filled with a white paste on vessels of *Notenkopf* pottery. In Pietrele, the helix is rendered as both an incised pattern and as polished ripples as of *c.* 5200 calBC. It also appears in barbotine, at the beginning of the Copper Age, and until the end of the Gumelniţa culture, is incised on large vessels and fashioned with colours after firing (Fig. 16.1). In this way, a white paste colour is often preserved in deep incised lines and a red paste colour in the roughened parts (*Hansen* et al. *2011.Fig. 7*). The decorative technique continues in the Copper Age, with the helix remaining a principal symbol until the end of the settlement.

Although the helix was a continued tradition in the Copper Age, the motif was never rendered in graphite; other motifs were depicted with this technique. As early as the lowermost excavated layer on the tell, *i.e., c.* 4550 calBC, a new kind of pattern appeared, firstly in incised fashion (Fig. 16.3). According to what we know so far, primarily large vessels and their covers were decorated with 3 or 5 identical interconnecting curvilinear motifs. Only one house generation later, the surface of the lids was divided into 2 or 4 symmetrical zones (Fig. 16.2). This motif subsequently predominates in graphite painting (Fig. 17): thereafter, the interplay of the main motif repeated two or four times, with smaller accompanying motifs, dictates the painted outer surfaces of vessel covers and/or the inner surface of wide-mouthed bowls. The surface of beakers and small bowls is often decorated with this motif in a typical twofold or fourfold manner.

The oldest rod-like motif with broadly executed, simple symmetry appears in Pietrele around *c.* 4550 calBC (Fig. 17.1). Only one generation, later rods with one rounded end emerge, interpreted in the literature as 'snakes' (*Todorova 2003.307*) and 'sun symbol' (*Gimbutas 1982.89–90*) or neutrally designated as an 'S-motif' (*Voinea 2005.Pl. 52*) (Fig. 17. 2–3). The result of doubling the rounded ends can be seen as a breaking wave, especially compared with the strongly curvilinear versions on later examples (Fig. 17.4), and additionally bearing in mind the incised wavy motifs (Fig. 16.3). A further motif is the 'drop', often executed positively (Fig. 17.5); circles also serve as fill elements. These motifs are bound within a scheme of a geometrically quartered surface with broad stripes; occasionally, one broad central stripe consisting of a rhombic net pattern divides the painted surface into two halves (Fig. 17. 2,4). On pottery from later layers, these stripes have become thin bundles of lines and the rhombuses a net-like web or complex mesh, precisely measured in millimetres (Fig. 17.5).

In the manner of abstract modern logos, these motifs are universally interpretable, even if the original meaning really cannot be deduced. So, not everyone is aware that the logo of BMW is based on the rotation of a propeller; yet, it conveys the idea of dynamics and movement to the viewer. It is quite pos-

Fig. 15. Pietrele. Projectile points (photo: S. Hansen).

sible that this was also the message of these motifs in Gumelniţa culture. Considering the close relationship to nearby waterways, the symbols could be abstractions of the wavy movement of water and drops or spray. They are framed by bundles of lines made with very narrow, single strokes. One of several possible interpretations of this motif is the net that was thrown into moving water to catch fish. Whatever these motifs did indeed convey, it is surely not unfounded to see a distinct allusion to water in the symbolism at Pietrele as of *c.* 4550 calBC.

Conclusions

The existence of a lake surface of more than 500km² in the Danube valley has been confirmed by core drillings carried out in the study area along a 60km transect. It is quite possible that the lake extended even farther east, so that most of the settlements of the 5th millennium BC were interconnected through this body of water. Based on ^{14}C and OSL dates it can be placed within a time frame from the 8th millennium BC to the 1st millennium AD.

The results achieved through interdisciplinary investigations have shown that the lake did not initially have the economic importance attested after 4600/4500 calBC by the archaeological material. During that time, the settlement at Pietrele and neighbouring lakeshore settlements reached their acme. The increased anthropogenic impact on the ecological conditions can be detected as a dark layer (DL I) in the lake sediments. Analyses of the faunal remains of lacustrine and terrestrial animals clearly show that hunting first increased with the onset of the Copper Age: hunting of large game was then complemented by fishing with harpoons. Nets and transverse hooks were used for fishing, above all, for limnophillic species that preferred calm waters. The numerous mus-

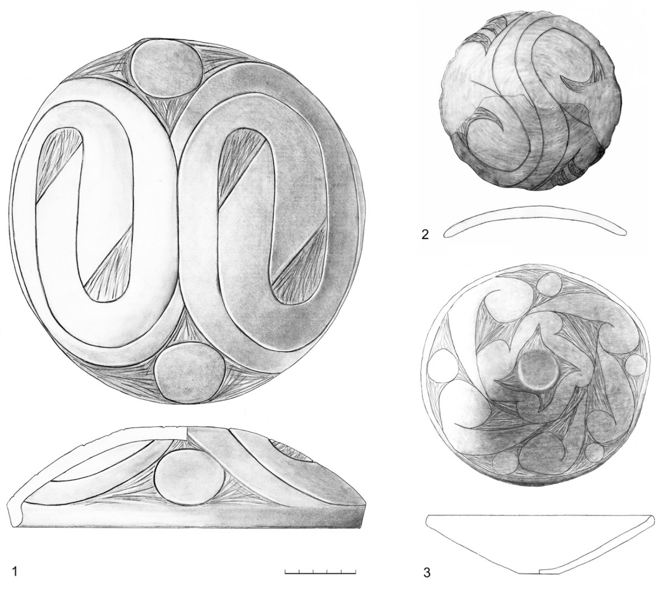


Fig. 16. Pietrele. Incised helixes and waves (drawings: 1 I. Berdženishvili, 2 H. Nørgaard, 3 E. Gavrilă).

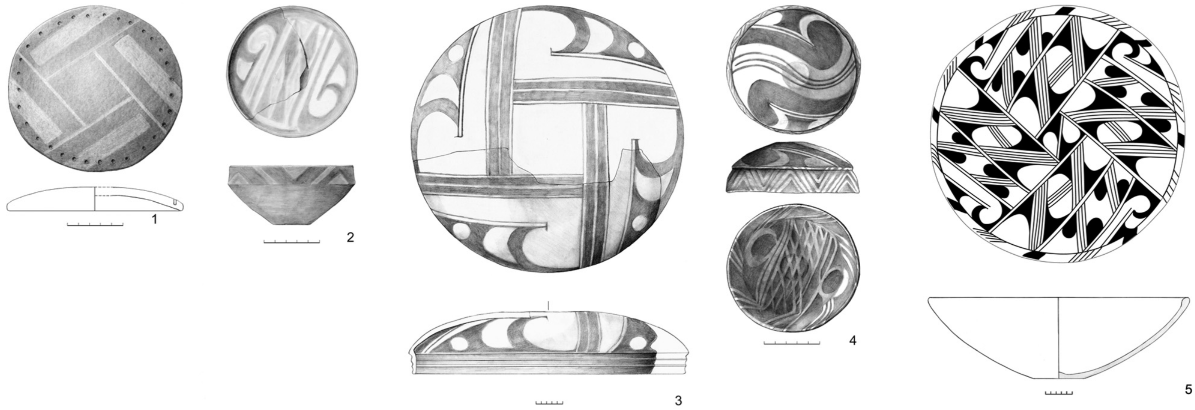


Fig. 17. Pietrele. Graphite painted motifs: rods, simple and breaking waves, net-like motifs (drawings: 1 T. Vachta; 2 H. Nørgaard; 3–4 C. Georgescu; 5 W. Rust).

sel deposits and turtle shells show that aquatic resources were a firm source of nutrition.

Seen against this background, the inhabitants of Măgura Gorgana near Pietrele may not be viewed as sedentary farming communities, but far more as fishers and hunters. Moreover, the Copper Age community was apparently quite differentiated: specific activities were conducted by individual groups, as demonstrated by the distribution of artefacts and tools in the settlements. Not all households were engaged in hunting or fishing. With the change in economic strategies at the transition to the Copper Age came an innovation in the set of decorative motifs as exemplified on pottery: *c.* 4550 calBC new motifs appeared with those known from Neolithic times, symbols that display a strong link to water.

With all this the contours of a European lacustrine culture become visible. It is older than the lake Neolithic in Switzerland, where the lakeshores were settled only as late as *c.* 4300 calBC due to climatic deterioration. The fundamental, interdisciplinary results gained for interpreting the Copper Age on the Lower Danube should form a point of departure for future field research, especially surveys and aerial photography, in order to recognise further sites and thus to gain a realistic picture of the process of settlement on lake shores in the 5th millennium BC.

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Neolithic and Chalcolithic settlement patterns in central Moldavia (Romania)

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ABSTRACT – *Despite a long tradition of studies of the Moldavian Neolithic and Chalcolithic cultures, the analysis of the territorial behaviour of human communities remains underexploited. This work combines concepts used in landscape archaeology with the potential of the Geographic Information System (GIS) to mobilise archaeological artefacts in a large-scale setting and for many thematic purposes. This paper aims to compare the spatial and temporal distributions of archaeological evidence in central Moldavia. Applying integrated approaches through GIS analysis, it explores the natural, economic and social phenomena involved in territorial trajectories during the Later Prehistory (6000–3500 BC). In the chronological framework of the Starčevo-Criş, Linear Pottery, Precucuteni and Cucuteni cultures, different types of spatial analysis are computed in order to underline territorial control and supply strategies in an area well known for its density of its fortified settlements, extremely rich soils and abundance of salt springs.*

IZVLEČEK – *Kljub dolgi tradiciji študija neolitskih in halkolitskih kultur v Moldaviji je delovanje človeških skupnosti v prostoru še vedno premalo raziskano. To omogočajo koncepti prostorske arheologije v povezavi z geografskimi informacijskimi sistemi (GIS), s katerimi povezujemo arheološke artefakte na večjem območju v mnoge tematske sklope. V članku primerjamo prostorsko in časovno razprostranjenost arheoloških zapisov v centralni Moldaviji. Z uporabo integriranega pristopa preko analize GIS raziskujemo naravne, ekološke in družbene fenomene, ki so bili vključeni v teritorialne trajektorije v mlajši prazgodovini (6000–3500 BC). Predstavljamo različne tipe prostorskih analiz v kontekstu kultur Starčevo - Criş, Linearno-trakaste keramike, Precucuteni in Cucuteni, da bi poudarili pomen nadzora skupnosti nad ozemljem in strategije oskrbe na področju, ki je znano po veliki gostoti utrjenih naselbin, po zelo rodovitni zemlji in številnih slanih izvirih.*

KEY WORDS – *Later Prehistory; territories; salt springs; Moldavia; GIS*

Introduction

Towards the end of the 6th and especially during the 5th millennium, an evolution of social and economic needs is perceived in Romanian Moldavia. This is observed through the densification and diversification of settlement patterns, as well as an increasing exploitation of natural resources strictly correlated to the expansion of exchange networks. This transfer of ideas and objects occurs in the context of the assertion of major cultural groups of Central and Eastern Balkans in a largely amended social and economic framework.

The intensification of agricultural production arising in a territorial framework largely organised around stable settlements, generally fortified and dispersed, is similar to a Neolithic 'second revolution'. From a terminological point of view, it leads to the Chalcolithic period (second half of the 5th millennium),

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which corresponds to the thriving of economic structures and production processes. Our research consists in a global approach to Later Prehistory settlements patterns that persisted for almost three millennia, in order to underline the nature and dynamics of settlements in the long term. The study will first assess the structuring resources of settlements (primarily salt and soil), before offering viewpoints on how to broaden our understanding of the territorial strategies of Neolithic and Chalcolithic Moldavian communities.

Study area

The study area covers 8900km^2, from the Eastern Carpathians Mountains to the River Prut (Fig. 1). It covers Neamţ and Iaşi Counties and clearly distinct geographical environments: the Eastern Carpathians Mountains (more precisely the flysch zone); the Carpathian Depression and Sub Carpathian hills (Suceava Plateau); and the Moldavian Plain. Yet, this study does not dwell on the mountainous zone of the Carpathians, as it was indeed little occupied by Later Prehistoric communities, due to rugged areas and steep slopes. The transitional area with the Carpathian Depression, bounded by the confluence of the Siret and Moldova rivers, is marked by outcrops of Aquitanian and Tortonian salt deposits (*Velcea, Savu 1982.239–243*).

Many salt springs (Fig. 2A) and chlorinated waters with sodium originate from this salt belt. Many old and recent studies (*Meruţiu 1912; Şandru 1952; Monah 2002; Weller, Brigand and Alexianu 2007; 2010*) have specified the nature, chemical composition and distribution of these resources. In the depression, the Sub Carpathian hills composed of sandstone, marl, clay and conglomerate deposits can be found between 200 and 300m a.s.l.; while they can be found up to 300 to 350m in the glacis areas (*Lupaşcu 1996.17–28*). In structural terms, the Moldavian Plain is a monocline oriented NW-SE, bounded in the west and south by 'cuesta landforms', steep slopes exceeding 250m. Sarmatian deposits (clay and marl) can be found only on very steep slopes affected by erosive trends (*Băcăuanu 1968.77–82*). They are covered by loess deposits on ridges, plateaus or gentle slopes. To the south, the Central Plateau is made of more resistant sandstones and limestone bedrocks, thus explaining the more rugged relief.

Soils and their agronomic potential are a record of geological heritage and anthropic management. Two main categories have been defined by climatic zoning (*Băcăuanu 1968; Lupaşcu 1996*):

Type 1. The level of alluvial clay, made up of brown and grey steppe soils, occasionally found on the plateaus that limit the Moldavian Plain (west and south). They are most commonly found in the Carpathian Depression.

Type 2. The level of mollisols (chernozem) that predominate in the Moldavian Plain and the Bistriţa Valley, which includes the backs of cuestas and low interfluves, terraces and lower parts. Steep slopes heighten the probability of landslides, more so in the Moldavian Plain. The intensification of agricultural and deforestation activities were the principal causes of accelerated erosion. In lower areas, hydromorphic and saline soils are common (*Băcăuanu 1968.81*).

Landsat remote sensing data acquired on 05/13/2003 were used to distinguish soil patterns and current land use (Fig. 1). The enhanced multispectral image (using the 15m pixel size panchromatic image) and its classification, along with the use of a soil map published in 1990, enabled us to obtain good information on soil moisture and the main soil categories. Brown soils (soil type I) are commonly found in the Carpathian Depression; Chernozem (soils type II) seem to be widespread in the Moldavian Plain as well as in the Carpathian Depression alluvial plain.

The first clearings were made through slash-and-burn by the first farming groups in the Neolithic era. According to Lupaşcu (*1996*), the intensification of agriculture and pastoral land use since the Neolithic were the main cause for the processes that formed the specific characteristics of soil such as chernozem. Paleo-environmental analyses should probably enlighten us on this matter. Due in part to the lack of sampling areas likely to trap organic material in sediment cores to reconstruct changes in the Holocene, these are as yet too few to be significant (*Carciumaru, Monah 1987; Volontir 1990; Danu* et al. *2010*). However, they suggest the long-term stability of forest composition, canopy coverage being reduced since the later sub-boreal climate.

Archaeological data

The mapping and geographical analysis of settlement patterns has been made possible by the use of geographical information systems or GIS to put archaeological databases into a spatial framework. Since the

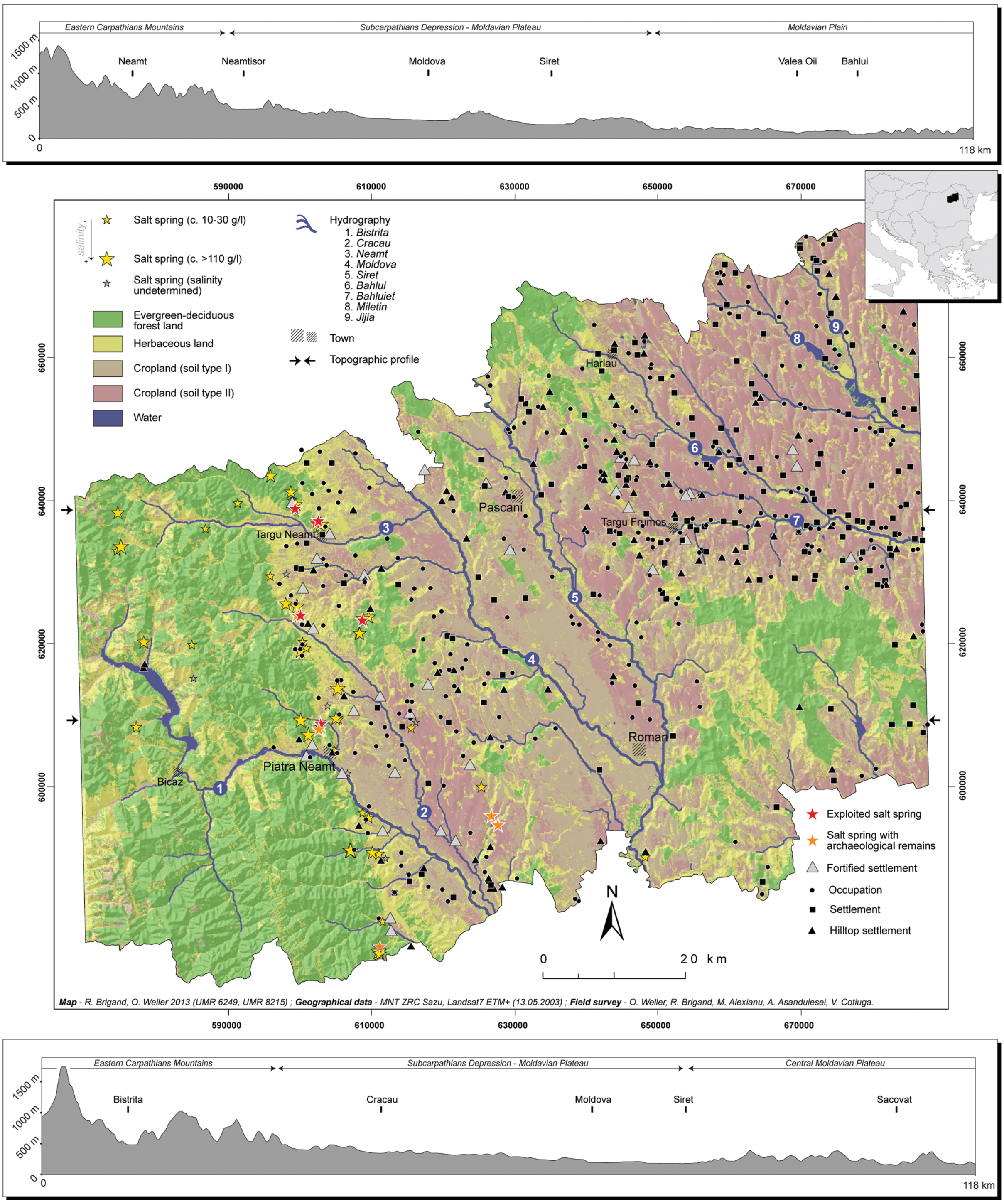

Fig. 1. Study area: topographic profile, land cover, stream reconstruction, salt spring and archaeological sites (6000–3500 BC).

end of the 19th century, various stakeholders have contributed to a general knowledge about the prehistoric archaeology of Moldavia. Important publications are now part of the institutional historiography of the Neolithic and Chalcolithic cultures (*Zaharia* et al. *1970; Chirica, Tanasachi 1984; Monah, Cucoş 1985; Marinescu-Bîlcu 1993; Cucoş 1999; Popovici 2000; Ursulescu 2000; Văleanu 2003; Boghian 2004; Bem 2007*). Our study has benefited from these numerous inventories, while sharing with local researchers and field prospectors (among others, G. Dumitroaia, R. Munteanu and D. Garvăn from the History and Archaeology Museum of Piatra Neamţ; D. Monah, V. Cotiugă and A. Asăndulesei from the Iaşi Institute and University). Given the complex history of research and the undeniable wealth of data, an exhaustive yet critical database has been created for Neamţ and Iaşi counties. All the available information has been stored in an SQL environment database.

Reliability
The aim is to assess the validity of archaeological information. A confirmed settlement must be distinguished from a duplicate or uncertain one. As field surveys are rarely coordinated, a large set of points overlap, thus needing to be eliminated. For instance, only 603 archaeological sites referred to 6000–3500 BC out of a total of 737 could be calibrated to the Neolithic and Chalcolithic periods.

Quality
This is an important section, as it allows the initial data classification to be built (Fig. 1). The issue of archaeological classification has greatly mobilised scientific communities. Researchers started to use topographical criteria in order to distinguish between different types of archaeological site in the 1970s (*Zaharia* et al. *1970.32–34; Monah, Cucoş 1985. 42–43*). A look at former inventories shows a more or less elaborate classification between higher, lower and medium positions. These, however, are not always relevant, given that their variability depends on territorial topography. A single topographical criterion cannot establish a valid hierarchy; it must necessarily be associated with other data, such as the nature and quantities of archaeological artefacts. Four standard types were retained in the study:

• Occupations (49%). The lowest level – also the largest group – is constituted by small sites that provided only a limited number of ceramic remains, with no obvious element of domestic architecture or materials of quality. This probably includes temporary sites characterised by high mobility. Yet, they are often poorly delineated and insufficiently surveyed.

• Settlements (42%). Simple settlements (28%) display architectural structures (benches or abundant clay wall) and artefacts of quality (figurines, painted ceramics, bone, millstone and flint tools). They differ from hilltop settlements (14%), which are limited by steep slopes forming a headland opening onto a wide site. Low terrace settlements, closed on one side, are considered as simple settlements rather than hilltop ones.

• Fortified settlements (7%). These include sites characterised by man-made fortifications, with abundant archaeological remains and house remains (Fig. 2B,

Fig. 2. Fortified settlements, salt spring exploitation and current landscape: A Hălăbutoaia-Ţolici (Petricani, Neamţ) salt spring and archaeological deposit in the background; B Ferma de Vaci-Valea Seacă (Bălţăteşti, Neamţ) dating to Cucuteni A; C Precucuteni and Cucuteni enclosed settlement of Văleni (Piatra Neamţ) up to Bistriţa River; D the Bistriţa valley in the southern part of Piatra Neamţ; E Valea Oii fluvial landform and two Cucuteni A settlements on low (bottom left corner) and high (right) eroded terraces (Filiaşi, Bălţăţi, Iaşi). Photo: O. Weller (A, B, C, D) and A. Asăndulesei (E).

2C, 2E). Due to the temporary or reuse aspect of these constructions, numerous fortified structures can no longer be detected.

● Salt exploitation (2%). Eight salt springs give the most direct and accurate indications of salt exploitation, which dates to the Neolithic and Chalcolithic periods (*Dumitroaia 1994; Weller, Dumitroaia 2005; Weller* et al. *2007*). The evidence of exploitation comprises salt moulds, ceramic containers for salt-water crystallisation, and charcoal (an indication of salt production by burning). Six other salt springs contained indirect remains of salt exploitation during Later Prehistory.

Discovery

A reliable piece of evidence on research dynamics in this area has been provided by the relatively large number of excavated sites: 104 have been found (17%). The inclusion of surface surveyed sites is justified by the elaboration of archaeological mapping. However, difficulties arise when it comes to analysing the settlement pattern and comparing all sites because the data are uneven.

Chronology

Site excavation provides a relative chronological framework. Dating a site from archaeological remains collected by field survey raises doubts as to how representative and reliable they are for periodic maps. Significant and recurring observations have been made for almost a century in Neamţ and Iaşi counties, making an evaluation of the dynamics of settlement patterns possible: Starčevo-Criş (10%), 6000–5300 BC; Linear Pottery (3%), 5300–5000 BC; Precucuteni (10%), 5000–4600 BC; Cucuteni (77%), 4600–3500 BC (Fig. 3). The Cucuteni period is divided into two or three phases.

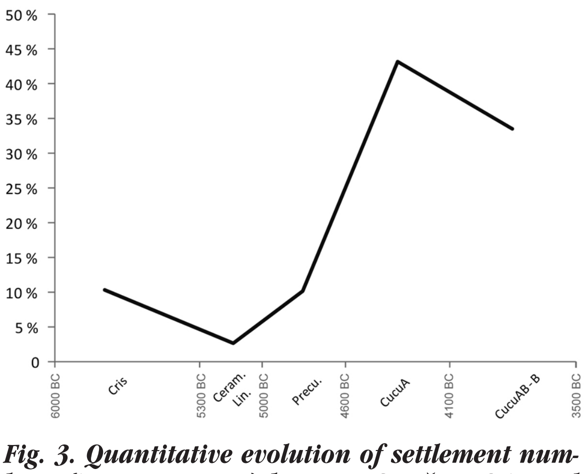

Fig. 3. Quantitative evolution of settlement numbers (in percentages) between Starčevo-Criş and Cucuteni A–B/B.

● The highest number of archaeological sites is in the Cucuteni A period (4600–4100 BC): 261 sites (43%), of which 184 are no longer occupied.

● Concerning the Cucuteni A–B period (4100–3850 BC), researchers have noted the very low number of sites for this period: 38 sites (6%) in our study. This reflects the lack of abundant painted ceramics, rather than a decline in the numbers of settlements (*Zaharia* et al. *1970.32–34; Monah-Cucoş 1985.42–43; Văleanu 2003.49–51*). More than half of these sites were dated after scheduled archaeological excavation.

● As our study took a particular interest in the long term, it seemed appropriate to group together Cucuteni A–B and Cucuteni B sites (4100–3500 BC) with 193 sites (32%), because it is difficult to discriminate between both periods on the sole basis of material collected by field survey. Besides, almost all Cucuteni A–B sites extend to the Cucuteni B. Added to Cucuteni B, the number of sites is 203 (34%).

Almost 79 sites (17% from all Cucuteni sites) were occupied from the Cucuteni A to Cucuteni A–B/B period. These present stable, generally significant sites from an economic, social and territorial point of view due to their appeal over a thousand years.

Geo-referencing

Surveyed sites have been mapped by differential GPS or precisely located on cadastral maps (14%). The other sites were located with the use of descriptions found in archaeological inventories, discussions with field prospectors, and with the combined use of topographical maps and orthophotographs. The position of 54% of archaeological points can be mapped within a spatial margin of error of about 50m. Some 28% of sites are located within a 50–200m spectrum, and 4% remain inaccurate. The latter are not taken into account for several spatial analyses, which require an accurate topographic precision, such as viewshed analyses.

Starting from this pattern of dots, a series of spatial analyses were undertaken, relying on a wealth of specialised literature (*Wheatley, Gillings 2002; Conolly, Lake 2006; Rodier 2011*), as well as on several European programmes on spatial process modelling (*van der Leeuw* et al. *2003; Gandini* et al. *2012*) and some experiments carried out in Neamţ County (*Weller* et al. *2011; Brigand, Weller 2012*) and the Bahlueţ Valley (*Brigand* et al. *2012, Asăndulesei* et al. *2012*).

Spatial analysis

The study of Neolithic and Chalcolithic settlement patterns relies on several GIS tools that produce distribution and density maps, such as a visibility analysis. We should point out that these pioneering works on archaeological Moldavian data are essentially based on field survey results: their contemporaneity beyond wide chronological and cultural phases cannot be accurately assessed. The main point of this study is to go beyond the lack of available information in order to identify the multiple polarities and spatial/temporal dynamics of Late Prehistoric settlements. Let us briefly outline the spatial methodological background.

Density and dynamics

A density study is based on kernel density estimation. It provides an estimate of site density defined by a moving window. This method has been well known since the 1980s (*Silverman 1986*) and has been mainly used for archaeological applications in intra- or inter-sites analysis (*Baxter* et al. *1995; Wheatley, Gillings 2002.186–187; Conolly, Lake 2006.175–177; Alexakis* et al. *2011; Nuninger* et al. *2012*). As this has been discussed elsewhere (*Weller* et al. *2011.73–75; Brigand* et al. *2012.19–21*), it is not presented in this article.

Using density maps that allow a broad view by chronological-cultural period, differential density maps have been proposed in order to visualise evolutions between two sequences (Fig. 4). These maps, whether the instability is negative or positive, are obtained by subtracting site density. Negative values correspond to decreasing sites or abandonment areas; conversely, positive values correspond to increasing sites (new site or a rise in a site's status). Medium

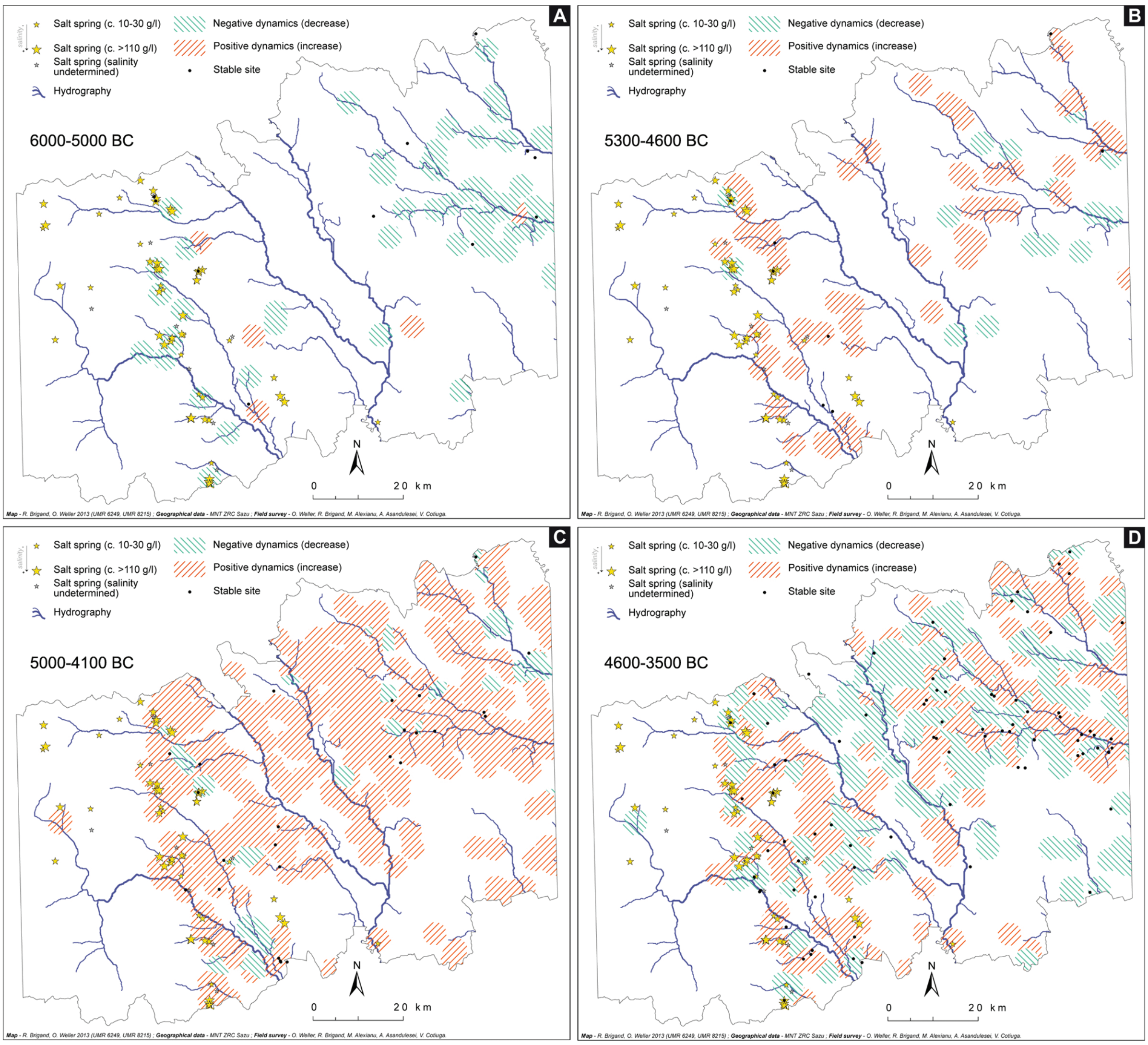

Fig. 4. Maps of the change in occupation density between: A Starčevo-Criş and Linear Pottery; B Linear Pottery and Precucuteni; C Precucuteni and Cucuteni A; D Cucuteni A and Cucuteni A–B/B.

values emphasise the overall stability in a given place; hence the location of stable sites has been specified.

Visibility analysis

Viewshed analyses are among the classic tools offered by the GIS in order to highlight territorial control and areas of strategic interest (*Wheathley, Gillings 2002.202–216; Conolly, Lake 2006.225–233*). Visibility analyses determine areas that can theoretically be seen from one or different observation points. The DEM resolution (25m), elaborated by Krištof Oštir at the Research Centre of the Slovenian Academy of Sciences and Arts allows for accurate and precise results. Several analyses have been carried out based on the theoretical assumption of an observer 1.7m above ground, according to a standard offset. The field of vision is limited to 12km, according to field observation and ethnographic information. This paper assumes that a village, a small group of domestic units, or a herd located in an open landscape are clearly visible from 12km in favourable weather conditions.

- The simplest means of visibility calculation is a binary map that distinguishes between visible or invisible target cells from a specified viewpoint. The visible spectrum might be quantified in square kilometres, or in percentages: its classification offers a first hierarchy according to the importance of theoretical visibilities. The average viewshed by chronological-cultural period allows for a discussion of its evolution in the long term (Fig. 5). Counting sites that are seen by a contemporary observer offers the possibility of evaluating the viewshed quality and its evolution (Fig. 6). Associating one or more viewshed maps shows which visible values can be seen from at least one viewpoint (Fig. 7).

- The algebraic sum of two or more viewshed maps creates a cumulative viewshed (Fig. 8). The cell values are then integrated, ranging from 0 to a theoretical maximum number of viewpoints. This occurs if at least one cell is visible from all viewpoints. The field of view being given, the maximum values cannot be equal to the number of archaeological sites.

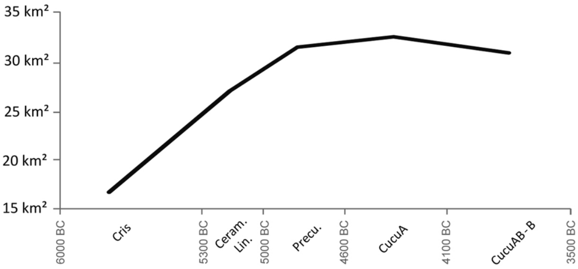

Fig. 5. Changes in the average viewshed by chronological phase.

Spatial analysis methodology needs to be put into perspective at several levels. The first assesses the spatial organisation of archaeological sites in the light of discriminating environmental parameters: topography, hydrography, soil qualities and salt resources. The second highlights the issue of spatial analysis as part of a more general thought process on settlement pattern dynamics between 6000–3500 BC.

Results and discussion

This study aims to show settlement organisation and strategies in an area actively surveyed by the Piatra Neamţ Museum and Iaşi University field researches.

Regional distribution

Late Prehistoric settlements developed to the east of the Carpathian Mountains. Indeed, the surfacing zone of salt water in the Piedmont area constitutes the western margin of settlements. To the south, the heights of the Central Plateau are not occupied. The vegetation canopies, covering these areas, make field surveys more difficult. Is it possible to suggest that a settlement was absent above an elevation of 500m in currently forested areas?

At most, one may assume that climate, altitude and scarcity of resources for agriculture contributed to low occupation in this area. Yet, in the absence of systematic field surveys of forest land, this hypothesis is hard to demonstrate. The few major rescue excavations that have been carried out suggest a limited occupation in semi-mountainous environments. The building of Bicaz Lake dam on the Bistriţa exposed two Cucuteni A sites (*Nicolăescu-Plopşor, Petrescu-Dîmboviţa 1959*). The distribution map raises the question of the visibility of archaeological remains. In the agricultural fields of the Moldavian Plain, where anthropogenic pressure on the environment – and consequently on archaeological research – is greatest, a consistent number of sites have been found. Conversely, where land use is dedicated to herbaceous or forests land, the intensity of settlement is low or absent. It may thus be inferred that in this case the distribution map does not effectively translate the actual occupation/settlement in Later Prehistory. Despite this fundamental limitation, the settlement pattern characteristics highlighted by this map should be studied (Fig. 1).

In accordance with the standards of Later Prehistory, settlements are closely tied to the stream channels, since they usually stand on the edges of alluvial or eroded terraces, as well as on the ridges of cuesta landforms running alongside watercourses (*Monah, Cucoş 1985.41–42; Marinescu-Bîlcu 1993; Popovici 2000.33; Lazarovici, Lazarovici 2003; Boghian 2004.55–58*).

• On the Moldavian Plain (the eastern stretch of the River Siret), settlements cluster along the Bahlui and Bahlueţ valleys and in the downstream part of Târgu Frumos. To the south of the Central Plateau, and more precisely on the right bank of the River Bahlueţ, loose settlement patterns have been observed. They do not reach the concentration of other settlements close to Târgu Frumos. To the north, a significant difference appears in the central and northern part of the Moldavian Plain: occupation is structured around several centres (the high valley of Valea Oii – around the eponymous site of Cucuteni culture, the Hârlău area, the Jijia Valley and its major tributaries). On the interfluve of the Bahlui/Jijia, several sites correspond to more diffuse territorial networks. Few settlements have been documented in the area between the Siret and Moldova rivers. These sites are strategically located between the Suceava Plateau and the Moldavian Plain, halfway between the Carpathian Mountains and the high Bahlui/Bahlueţ valleys.

• To the west of the Siret, the situation is more diverse. On the one hand, the settlements in the Cracău and Bistriţa valleys are clustered along fluvial corridors. On the other, settlements generally form a more diffuse framework. A greater density of occupation can be observed in areas with salt resources (the Carpathian foothills). In the south of the Bistriţa Valley, two salt springs with high salinity have remained isolated, with nearby sites situated between 6 and 8km away. The question arises as to why these salt springs remained separated from the nearest settlements since the settlements in the Cracău/Bistriţa valley were located close to the stream confluence. This fact might indicate that control of access to a resource was more important than direct settlement near that resource. This fact is confirmed by observation alongside Târgu Neamţ or Piatra Neamţ: hilltop and fortified settlements are located downstream, at the mouth of the valleys that lead to salt springs, even though the edges of river terraces are in general preferred to marshlands and flood plains.

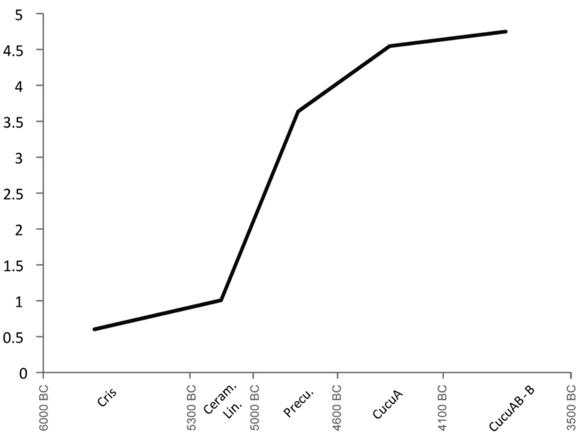

Fig. 6. Changes in the average of visual links by chronological phase.

Most settlements are located where agricultural prospects are more favourable to cultivation. Whether on the Moldovian Plain or in the Sub Carpathian Depression, archaeological sites are strictly linked to the availability of soils suitable for agriculture (Fig. 1). Areas of settlement are generally established on chernozem (soil type II), more precisely along the eastern bank of the Siret. In the western part, brown soils (soil type I) are favoured over chernozem for settlement. Whatever the area, the establishment of sites was always made at a meeting point between several types of soil, in order to use various and optimal ways to exploit resources.

Proximity of fluvial corridors and availability of water, as well as easier territorial control were sought. Viewshed maps, whether multiple (Fig. 7) or cumulative (Fig. 8), tend to show this fact, although a general trend towards hilltop settlement is observed between the earlier Neolithic and Chalcolithic periods.

Settlement pattern dynamics

The evolution of settlement patterns between 6000 and 3500 BC is well established (Fig. 3, Fig. 4). The principal phases of occupation are as follows: 1. a marked decline in the number of sites between Starčevo-Criş and Linear Pottery; 2. a continuous increase during the mid-Neolithic up to the Early Chalcolithic (Precucuteni); 3. a true explosion in the number of sites during the first stage of the Cucuteni period; 4. a marked a decline between 4100 and 3500 BC (Cucuteni A–B/B).

• The ***Starčevo-Cris*** (6000–5300 BC) is characterised by settlements occurring on fertile lowlands and first terraces close to stream confluences. Viewsheds are reduced (Fig. 5), the average viewshed being

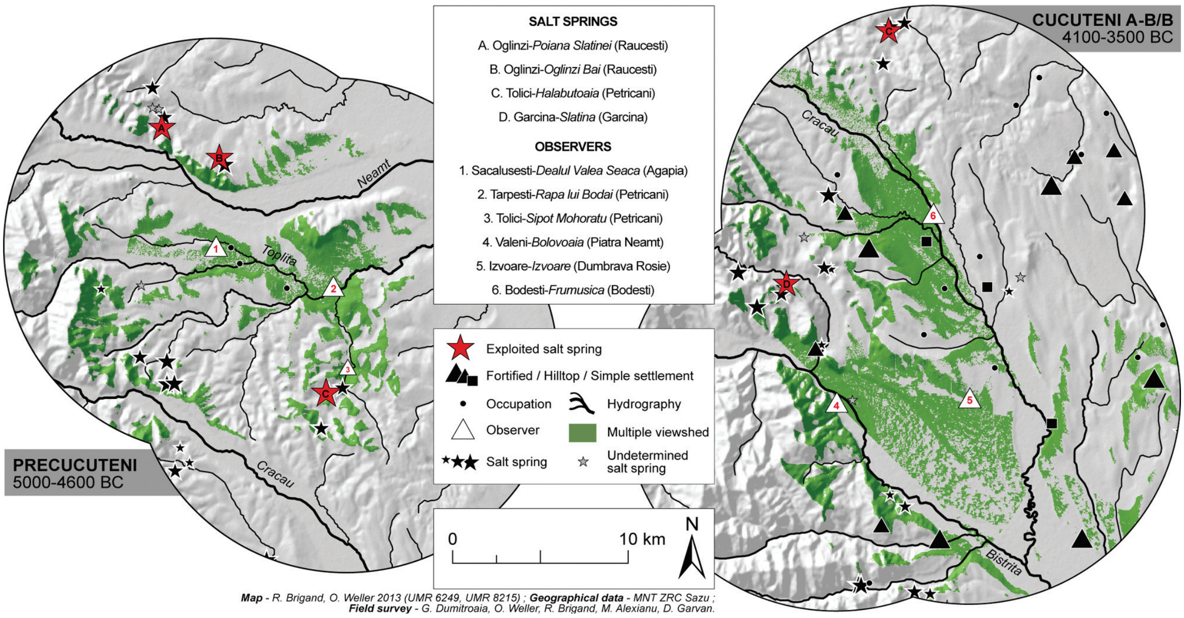

Fig. 7. Multiple viewshed map in the Târgu Neamţ (left) and Piatra Neamţ areas (right) respectively during Precucuteni and Cucuteni A–B/B.

close to 18km², and the need for intervisibility is almost non-existent (Fig. 6) as the average level of visual links is close to 0.6. This type of pioneering front is structured by a rural sprawl along major streams – the Bahlueţ, Bahlui, Jijia – of the Moldavian plain (Fig. 8A).

Close to the Carpathian Mountains, occupations, few in number, are concentrated close to salt springs (with maximum distance of 7km). The first indications of crystallised salt production have been documented at some of them (3 certain, 2 uncertain) located on the north side. These production centres are not connected to major settlements; the springs are neither visually controlled in a direct way, nor are their accesses particularly under control. Regarding salt production, we believe that it is not the structuring element of the settlement pattern, even if the availability of this resource is well known and clearly integrated with salt and brine supply networks. This situation may suggest the existence of seasonal or temporary movements in search of salt water, as in transhumance. Only a few settlements would be stable (Bistriţa Valley), perhaps at the end of this first phase of Neolithisation.

• Between Starčevo-Criş and ***Linear Pottery*** (5300–5000 BC), a significant general reduction is observed in the number of sites (Fig. 4A), including those close to salt springs. The scarcity of Linear Pottery archaeological sites may be due to the research conditions rather than an actual decline in settlement numbers.

Despite the low number, the emergence of the first important settlements can be observed. These are located strategically: on hilltops and locations close to stream confluences, with good visibility of the surrounding area – average visibility coverage is close to 27km² (Fig. 5). Implantations are scarcely distributed, which in turn produces a low level of intervisibility (Fig. 6) – the average level of visual links is close to 1.

Compared to the Starčevo-Criş period, the end of the 6th millennium shows a strengthening of territorial control over river corridors. Salt resources are also exploited in the northern and central foothill area, even if few dwellings have been documented close to it, except for the early occupation of Târpeşti-Râpa lui Bodai which relates to contemporary and continuous salt exploitation from Hălăbutoaia at Ţolici; Traian-Dealul Viei and Dealul Fântânilor connected to the Bistriţa/Cracău confluence on one hand and the proximity of the Negriteşti salt springs on the other. Small and probably seasonal occupations emerge during this period. This reflects the first settlement differentiation, where major sites were surrounded by small occupations.

• The ***Precucuteni*** period (5000–4600 BC), is characterised by a slight increase in the number of sites (Fig. 4B), which takes the numbers back to the Starčevo-Criş site numbers through an intensification of previous dynamics. Increased territorial control is observed, since the viewshed average (33km²) is at its highest level (Fig. 5). Most high terraces are

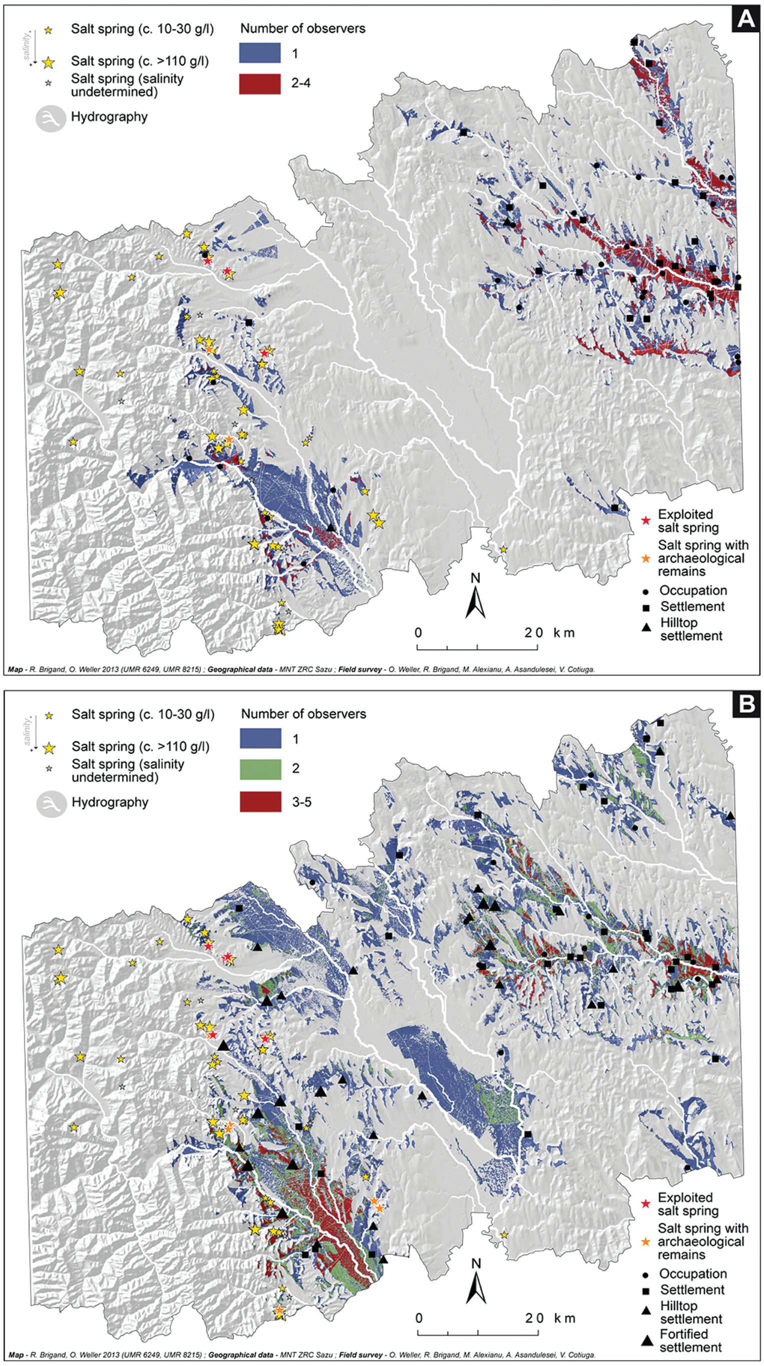

Fig. 8. Cumulative viewshed of the Starčevo-Criş sites (A) and Cucuteni sites stable between 4600 and 3500 (B).

occupied, especially in stream confluence areas, but also on the western Carpathian terraces. On the Moldavian Plain, settlement patterns were strengthened along major rivers (Bahluieţ, Bahlui, Jijia), as if in a refocusing of settlements.

Settlement patterns during the Precucuteni period seem to be strictly integrated into a territorial organisation in which fortified sites are surrounded by secondary occupations, which are probably seasonal and directly visible, as highlighted by the high average of visual links –3.6 (Fig. 6). Settlements are clearly concentrated in several key areas: near stream confluences, river terraces, and salt springs. Incorporated in a well-structured settlement network, exploited salt springs are under the strict supervision of communities, which appear to have specialised to some extent in salt production.

The hilltop settlement of Ţolici-Sipot Mohorâtu, for instance, is located upstream from the confluence of the 'salt' valley – Valea Slatina – and the Ţolici Valley, which leads to the Târpeşti-Râpa lui Bodai fortified settlement, located 4km downstream (Fig. 7, left). Close to the salt spring, this site appears to have served as an intermediate point between the exploited spring and the main settlement of Râpa lui Bodai. Further examples underline the fact that, while salt springs do not need to be clearly visible from settlements, control of their accessibility and the main valley is still more or less ensured.

Always in the northeastern part of Piatra Neamţ – the southeastern part of Targu Neamţ – the central Topoliţa Valley is totally controlled by the Râpa lui Bodai and Dealul Valea Seacă sites, which are mutually visible. This settlement model is not only related to control of the salt springs exploited upstream, but also to those along the main river corridor – for example, in the lower Bistriţa/Cracău Valley. Conversely, several salt rich areas, such as Oglinzi salt springs, are poorly connected to the main settlement pattern.

● Between the Precucuteni and the ***Cucuteni A*** period (4600–4100 BC) some sites in secondary valley sectors were abandoned, but many new sites were created, colonising the entire regional ecosystem, either near salt springs or along major river systems and their tributaries (Fig. 4C). A substantial increase in settlement numbers and above all the spread of new colonies in semi-mountainous areas (such as wetland ecosystems) is noticeable. Cucutenian settlements were generally established on the edges of river terraces, above marshlands and floodplains, for optimal control of fluvial corridors, as evidenced in the high average visibility – 32km^2 (Fig. 6).

The emergence of a new territorial organisation can be observed. It was based on a strong hierarchy, highlighted by a variety of archaeological sites, whether fortified, hilltop or open settlements, and several satellite occupations. Between the Cucuteni A and Cucuteni A–B/B period (Fig. 3, Fig. 4D), a significant decline in the number of settlements suggests, both in the foothill areas and in the Moldavian Plain, a shrinkage and concentration of settlements according to specific choices regarding territorial control and land resources. Numerous sites were indeed deserted, even in areas with several salt springs, yet many new settlements appeared in adjacent sectors, as if the population had moved then resettled elsewhere (Fig. 7, right). High, middle and low terraces are consistently favoured, although a slight reduction in the average viewshed might be observed – 31km^2 (Fig. 5). Nonetheless, the highest average visual link (4.7) would seem to imply that specialisation and complementary sites were continuing and even progressing (Fig. 6).

The distribution of stable settlements over the Cucuteni period underlines that territorial trends between the Cucuteni A and Cucuteni A–B/B period were in accordance with a very well organised territorial network. These new spatial configurations were not the result of new organisational models, but rather of the strengthening of past trends. This is clear from a comparison of settlement patterns during the Early Neolithic (6000–5300 BC) and Chalcolithic (4600–3500 BC), in which the polarities are more or less the same (Fig. 8B). The evolving trends were more precise territorial control in relation to exchange networks and an enhancement of the appropriation of natural resources corresponding to the development of craft specialisations (specific pastoralism, crop production, salt production, *etc.*).

Conclusion

It has been asserted that the penetration and dissemination of early Moldavian agro-pastoral communities followed the general trends observed in Eastern and southeastern Europe (*Ursulescu 1995; Tasić 2002*): a Neolithisation process closely connected with salt springs and rich soils. The distribution of salt resources in the foothills of the Carpathian Mountains marks the western limit of a settlement pattern structured by salt and brine supplies and salt production areas in the upper reaches of secondary valleys. The importance of fortified settlements close to salt resource is explained by the need to control accesses to salt production sites and circulation networks through the main fluvial corridors.

To the west of the Siret Valley, *e.g.,* in areas characterised by fertile, well-drained black soils, agricultural colonisation has been observed, especially during the Cucuteni A period. This region was thus able to support a very dense settlement pattern established around high and fortified settlements. Being located in a dominant position, they controlled both hydrographic networks and a set of secondary settlements.

The increase in settlement numbers during the second part of the 5th millennium was caused by three simultaneous factors: population growth released new agents of settlement; the evolution of agricultural and pastoral practices led to greater mobility and specialisation in farming methods; the intensification of territorial hierarchies led to the emergence of federating centres and formalised trade (*Lichardus, Lichardus-Itten 1985*).

Land use between the Carpathian Mountains and River Prut was highly dependent on two factors: the availability of highly productive soils and the accessibility of easily exploitable salt springs. Forms of human settlement seem to have differed, depending on these resources.

In the Moldavian Plain, groups of different status have been observed. Hilltop or fortified settlements enjoy specific access to land resources that is quite different from that found in open sites close to floodplain river channels. Several seasonal agricultural and/or pastoral occupations gravitate around these two distinct types of settlement. In the foothills area, salt springs were surrounded by many modest occupations, for example in the northern area of the study.

Ethno-archaeological approaches (*Alexianu* et al. *2011*) allow us to reassess this specific settlement organisation. Indeed, an association of agents who specialised in seasonal salt exploitation may be suggested in relation to pastoral activities. This study of the structural process leading to the intensification of environmental uses during the Late Prehistory must be deepened through a global approach aimed at a better understanding of land appropriation processes.

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Interdisciplinary studies of the Cis-Ural Neolithic (Upper Kama basin, Lake Chashkinskoe): palaeoecological aspects

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ABSTRACT – *In this paper we present preliminary results of the first palaeoecological investigations in the Cis-Ural region. This was an area of intensive Neolithic occupation of fluvial landscapes within the basin of the Upper Kama River, the largest river in the area. We selected the area of Lake Chashkinskoe as a key region, where around 10 sites have been found on the remains of the fluvial terraces of the Kama River. We used palaeochannel analysis, radiocarbon dating, and palynology for past landscape reconstruction.*

IZVLEČEK – *V članku predstavljamo preliminarne rezultate prvih paleoekoloških preiskav na območju zahodnega dela Uralskega gorovja. Tukaj je potekala intenzivna neolitska poselitev rečne pokrajine znotraj bazena zgornjega dela reke Kama, ki je hkrati največja reka v regiji. Za ključno območje smo izbrali jezero Chashkinskoe, kjer je bilo na ostankih rečnih teras reke Kama odkritih 10 najdišč. Za rekonstrukcijo pretekle pokrajine smo uporabili analize paleostrug, radiokarbonsko datiranje in palinologijo.*

KEY WORDS – *Upper Kama basin; Mesolithic; Neolithic; radiocarbon dating; palaeochannel analysis; pollen analysis*

Introduction

The Lake Chashkinskoye area has been the subject of archaeological studies for over 20 years (*Lychagina 2008.347*), nevertheless, we concluded that artefact analysis of one culture or another is not adequate in contemporary research. Interdisciplinary research is required to understand the intensive occupation of this territory in Prehistory as well as the reconstruction of the environment (*i.e.* landscape, climate, flora and fauna) in which human societies developed. The methods, such as radiocarbon dating, paleogeomorphology, paleohydrology, palynology, carpology *etc.*, can be used for these purposes (for the Middle Vychegda basin see *Karmanov* et al. *2011; 2012; Zaretskaya* et al. *2012*).

Lake Chashkinskoe

The study area is situated in the Cis-Urals flatlands, in the Kama River basin, after its confluence with the Vishera River (Fig. 1). The Kama and Vishera rivers are the largest rivers in this high plain. Shallow-lying, resistant Pre-Quaternary rocks, outcropping on the sides of the river valley, create specific relief features. The valleys that were cut into these deposits have box-shaped cross-sections: relatively wide bottoms composed of loose alluvium, and steep solid sides, including cliffs of basement terraces. The Kama and Vishera valleys are asymmetrical: the steep right side is bedrock, while the left side is mostly accumulative or formed by a cliff of the second or higher basement terrace. The bottom of the Kama valley reaches

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its greatest width in the study area, within a widened part of the valley, on the large left bank of the floodplain near Lake Chashkinskoe and on the bedrock (and terrace) banks of the river.

Fig. 1. Map of the Lake Chashkinskoye area.

Lake Chashkinskoe is a system of oxbow lakes, interconnected with abandoned channels (Fig. 2). Before the river was dammed, creating the Kama reservoir (Kamskoe Vodokhranilishche), *i.e.* until the mid-20th century, the lake was not a single system: there was only a near-terrace depression of the Chashkinsky floodplain containing an abandoned channel, drying in low-water periods. The rise in water levels on the margin of the backflow zone of the Kama reservoir closed this depression, forming a single oxbow lake and opening its lower part into the Kama reservoir; during flooding, this forms a corridor for the water flow. The right side of the valley, where Lake Chashkinskoe widens, is concave and steep, formed by resistant Pre-Quaternary rocks and cut with hollows. The left bank of the lake is not a floodplain, but formed by an accumulative terrace. The climate of this area is moderately continental. Precipitation is relatively high for this latitude and longitude due to its piedmont position. The peak of the hydrological regime of the rivers is mostly during the spring flood; in winter, the rivers are frozen. The landscapes of the Chashkinsky floodplain consist mostly of willow/poplar forests on sod-fibrous sandy floodplain soils. The high right bank landscape is forest-steppe (grassland); the left bank terrace is covered with secondary pine forest.

On the eastern side of the lake, more then 10 archaeological sites dating to the late Mesolithic/Chalcolithic are located close to each other for some 7km along the bank (Fig. 2). Such density shows that this region was favorable for habitation in the Early Holocene. The initial stage of settlement started after the peak of the Holocene arid period (*i.e.* 7300±50 BP, 6218–6152 calBC (at 1σ), 6250–6051 calBC (at 2σ); GIN-13276) (Fig. 11), which is well defined in the pollen spectra (*Alioshinskaya 2001*). The late Mesolithic sites date to this period: Lake Chashkinskoe V and Zaposelye (Fig. 2.9, 12–13). The construction of small shelters and the use of narrow blades from local pebble flint as the basic blanks for making tools are typical features of these settlements. The need of water led the people to settle either immediately on the bank of today's lake (as seen at sites Lake Chashkinskoe V and Zaposelye), or on the banks of small streams flowing into the lake (such as the Zaposelye site). The present elevation above the water level is 4 – 7m, as compared to 7 – 11m before damming. The presence of small arrowheads and fine pebbles (gastroliths) in construction fills indicate widespread hunting of birds (including waterfowl) (Fig. 3) (*Lychagina 2009a.150*).

The active settlement of the study area coincides with the climatic optimum of the Atlantic period – a gradual increase in rainfall and rise in the river level (6300–5100 BP) (Fig. 11) (*Lychagina 2011a. 28–33; Karmanov* et al. *2012.1–8*). The late Neolithic sites are as follows: Khutorskaya I–II, Chashkinskoe Lake I, IIIa, IV, VI–VIII (Fig. 2.1–2, 4, 6–8, 10– 11).

At present, there are two approaches of defining the Neolithic. In the first case, the presence of farming (agriculture or cattle husbandry) is emphasised. The second approach is based on other signs such as sedentary fishing, wide use of woodworking tools, and beginning of pottery production. The reason for this divergence is that in a number of regions most sites have no signs of farming, but nevertheless have apparent qualitative differences from the preceding Mesolithic. The forest zone of the Cis-Urals is among these regions.

Two archaeological Kamskaya and Volga-Kamskaya cultures were widespread within this area in the Neolithic. It is generally thought that the origin of Kamskaya culture is connected with the further development of local tribes living on the territory of the Perm Province in the Mesolithic. The construction of large rectangular earth-sheltered dwellings, pottery with comb and stamp decoration, and tools made from tabular flint with bifacial treatment are typical elements in this culture (*Bader 1970.157–171*). Artefact assemblages from the Khutorskaya site are the most typical for the Kamskaya culture (Fig. 4).

The origin of the Volga-Kamskaya culture is connected with migration from southern regions of the Middle Volga/Lower Kama (the Middle Volga culture) (*Lychagina 2006.121–124*). Small rectangular dwellings, ceramics with incised ornamentation, and blades with edge retouching are typical element of this culture (Fig. 5). The assemblages of the early stages of the Chashkinskoe Lake VIII and late stages of the Chashkinskoe Lake IV are most typical representations of the Volga-Kamskaya culture (*Lychagina 2009b.154–158*).

High-intensity fishing and hunting were the main household activities of the Kamskaya culture people (*Lychagina, Poplevko 2011.4–10*). A number of researchers (*Denisov, Melnichuk 1986.52*) consider that cattle breeding entering the forest belt is connected to the Volga-Kamskaya cultural traditions, although this was not yet proven. These skills were probably lost during the movement north and this could be the reaseon why this culture relied mostly on hunting and fishing (*Lychagina, Poplevko 2012. 16–30*). It is considered that active settlement of this area in the Late Paleolithic is connected to the development of high-intensity fishing. All Neolithic sites are situated on the first terrace (now at an elevation of 4 – 11m above the water; before the damming, this elevation was 7 – 14m) (Fig. 7). We think that this is connected to higher water levels of the Kama River during the Holocene climatic optimum. The same pattern of occupation is observed in the neighbouring Vychegda basin.

Sites of the Garinskaya culture (*e.g.*, Chashkinskoe Lake II–III, Khutorskaya I) represent the Chalcolithic period (Fig. 2.1, 3, 5). The sites at the Lake Chashkinskoe are still not adequately studied and not radiocarbon dated. The radiocarbon data obtained from other sites allow us to date the Garinskaya culture within the time span between 4500–3500 BP (*Lychagina 2011b.171–172*).

Rectangular earth-sheltered dwellings with passages, ceramics with a high admixture of organic temper and with comb and stamp decorations, and tools with bifacial treatment are typical for the Garinskaya culture (Fig. 6). Judging by the great number of weights and arrowheads at the settlements, the main household activities of this culture had not changed in comparison with the previous Volga-Kamskaya culture. Garinskaya culture settlements, that include permanent dwellings, are located below the Neolithic sites on the Kama floodplain and partially under the lake waters (1 – 4m above the present water level, *i.e.* 4 – 7m before damming) (Fig. 8). We suppose it was connected with a period of low water level in the Kama River and people's preference to be as close to the water as possible.

Paleochannel analysis

The Chashkinskoe Lake is a system of oxbow lakes and abandoned channels remaining from the Kama paleochannel in the rear part of the vast left-bank floodplain. The relief of this floodplain preserves the larger part of traces of the Kama meandering across its valley bottom. The pattern of primary landforms on the Chashkinsky floodplain shows that its mosaic relief consists of many spots created by the Kama river at different times and in different geographical environments. Thus, the position of the Kama riverbed at different stages of its development does not coincide with its present configuration. We conclude that the ancient settlements, which are presently far from the river, could have been situated near the channel at that time.

It is known that the primary relief, *i.e.* floodplain ridges, the hollows between them, and abandoned channels, appears during the formation of the floodplain in the stage of channel deformation, and thus indicates the channel configuration when the relief originated (*Chalov 1970*). The changing of external conditions, including precipitation, volume of water in the river and its annual regime, caused changes in the channel geometry and in primary floodplain relief. The identification of floodplain spots formed at different times, and the analysis of the configuration of ridges, hollows and channels allows us to trace such changes (*Chernov 1983*). The identification of irregular floodplain parts, which can be called *generations*, was made by analysing the pattern of the floodplain landform: the position of ridges indicates the location of the ancient channel; ridges of later date cut in the earlier ridges have different orientations.

According to these principles, we identified seven generations on the Chashkinsky floodplain massif and the adjacent areas (Fig. 9). The youngest generation 1 is currently being formed in the modern channel; it is characterised by the orientation of ridges coinciding with the present channel and is mostly represented by single near-bank islets. Generation 2 is older, but still adjoins the modern channel, indicating only slight changes, which occurred in the river after this generation was formed. These two generations can be considered as contemporary. The remnants of the generations mark the older position of the Kama channel; they were not inherited by the contemporary channel, and lie far from it. These generations can be better analysed starting from the most ancient and moving in time to the youngest. Generation 7; the earliest floodplain generation has not been preserved, except for a small fragment in the lower part of the massif. Nevertheless, even this fragment allows us to conclude that in time of its formation the Kama channel had two meanders in the study area, with the lower meander bearing with its apex and lower wing against the left side of the valley, where the early sites were situated.

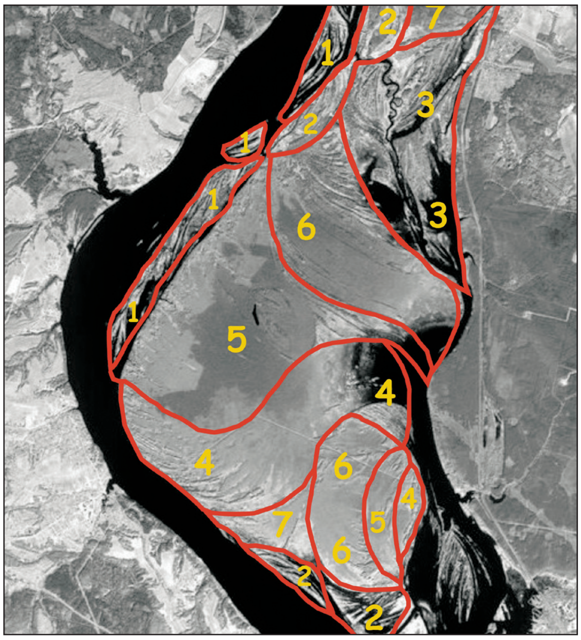


Fig. 9. Geomorphological map of the flood area of Lake Chashkinskoe at different generations of the flood plain.

Further changes in the Kama channel were probably caused by rising of water volumes (the greater the volume, the less the curvature of meanders); sharp meanders were cut off, and the channel approached the left bank much further upstream, at the very beginning of the Chashkinsky floodplain massif, forming a series of three meanders. The traces of these three meanders can be read in the position and relief of flood plain generation 6. The central meander bore against the left bank (the terrace slope), but 1.5km higher up river than in the previous stage of development. The final position of the channel at that stage has been preserved in the form of the contemporary upper part of Lake Chashkinskoe.

In the next two stages, which left traces in the form of floodplain generations 5 and 4, the Kama channel again started to change its outline, gradually approaching a position similar to that of generation 7. In particular, the channel synchronous with floodplain generation 4 – like the riverbed of generation 7 – formed two sharp adjoining meanders, with the lowest bearing against the left of the valley.

By the end of stage 4 of the channel development its curvature had again become too high for the volume of water, which was growing in that period; the series of meanders underwent another cut off and in the period of floodplain generation 3 a bifurcated channel in the place of the Chashkinsky massif existed with a series of transverse channels between the two arms intersecting the Chashkinsky floodplain massif, which was an island at that time. By that time, the main Kama channel had apparently settled already in a position close to the present: under the steep right bedrock valley side. However, under the inhabited left bank – the terrace cliff – a copious arm-channel drawing off at least one third of the total river flow still existed, now inherited by the contemporary Lake Chashkinskoe. Thus, the left-bank sites that existed in the third stage of the river's development were situated on the bank of the wide Kama arm-channel. The beginning of this arm-channel in the upper part of the Chashkinsky massif had dried up by the end of the stage 3: the generation 3 islands appeared, and the downstream part of the channel lost its connection with the river and turned into a series of narrow abandoned channels, stagnant in the low-water season. The river acquired its present-day outlines, and retained this up to the closing of the Kama reservoir.

The dating and duration of the Kama channel development stages, represented in the position and landforms of the floodplain relief generations, can be determined by absolute geochronology methods. The volume of water in the Kama in those stages can be determined by the curvature of the floodplain ridges, indicating the position of the ancient meanders. The environmental conditions of these stages can be reconstructed by palynological analysis of deposits of different floodplain generations.

Pollen analysis

In order to reconstruct the environment during the Chashkinskoe Lake IV site inhabitation, 15 samples were taken for pollen analysis from the western wall of the archaeological excavation in 2012. The total thickness of the analysed strata was 70cm.

Pollen samples were prepared by means of standard chemical methods, with HF and heavy liquid (cadmium iodide) separation and excluded acetolysis (*Faegri, Iversen 1989*). Pollen identification was carried out using an Olympus BX51 microscope at 400x magnification. The pollen sample consisted of terrestrial arboreal (AP, tree and shrubs) and non-arboreal (NAP, herbs) pollen and excluded the pollen of aquatic plants and spores of mosses and ferns. Their representation is expressed as percentages of the pollen-sum. In most instances, a pollen-sum of 482–815 was achieved, except for the four samples with a pollen-sum less than 200. The TILIA and TILIA GRAPH programmes (*Grimm 1991*) were used for calculations and drawing of the diagram. The zoning of the diagram is based on (1) the proportions of tree and herb pollen taxa (pollen zones) and (2) the presence and proportions of local pollen types in AP and NAP groups. These pollen zones were verified with local pollen zones based on the square-root transformation of the percentage data and stratigraphically constrained cluster analysis by means of the incremental sum of squares (*Grimm 1987*). The pollen diagram of the Chashkinskoe Lake IV site is divided into 3 pollen zones (Fig. 10).

Pollen zone 1 (depth 40 – 70cm) represents the period of temperate forests, with pine, spruce and small-leaved linden, before the origin of Lake Chashkinskoe IV site. The pollen spectra predominantly consist of pine (*Pinus sylvestris*; 40–60%) and spruce pollen (*Picea*; up to 20%), and also small-leaved linden (*Tilia cordata*; 10–20%).

The period of the Neolithic site coincides with pollen zone 2 (depth 10 – 40cm), which includes pollen spectra from dark brown humid sandy loam (cultural layer) with the small-leaved linden pollen ratio increasing up to 80%. Pollen from oak (*Quercus robur*) and European hazel (*Corylus avellana*) were also found, although their share is less than 1 – 2%. The content of conifer and birch pollen is less than 5 – 10%. Pollen of herbs is present, but not abundant. According to the radiocarbon dates of 6160±70 BP (GIN–13449) and 5920±80 BP (Ki–14539), obtained from the material found in the 2002 excavations, the deposits of the cultural layer were accumulated in the second half of the Atlantic period of the Holocene (*Khotinskyi 1987*).

The abundance of small-leaved linden pollen observed in the cultural layer reflects the specific local conditions of the pollen zone's formation, since even in the sub-fossil pollen spectra of plant associations of coniferous-broad-leaved and broad-leaved forests of the western slope of South Urals, the small-leaved linden content is only 11% (*Lapteva 2013*). Thus, pollen zone 2 probably represents the stage of development of mixed coniferous forests with broad-lea-

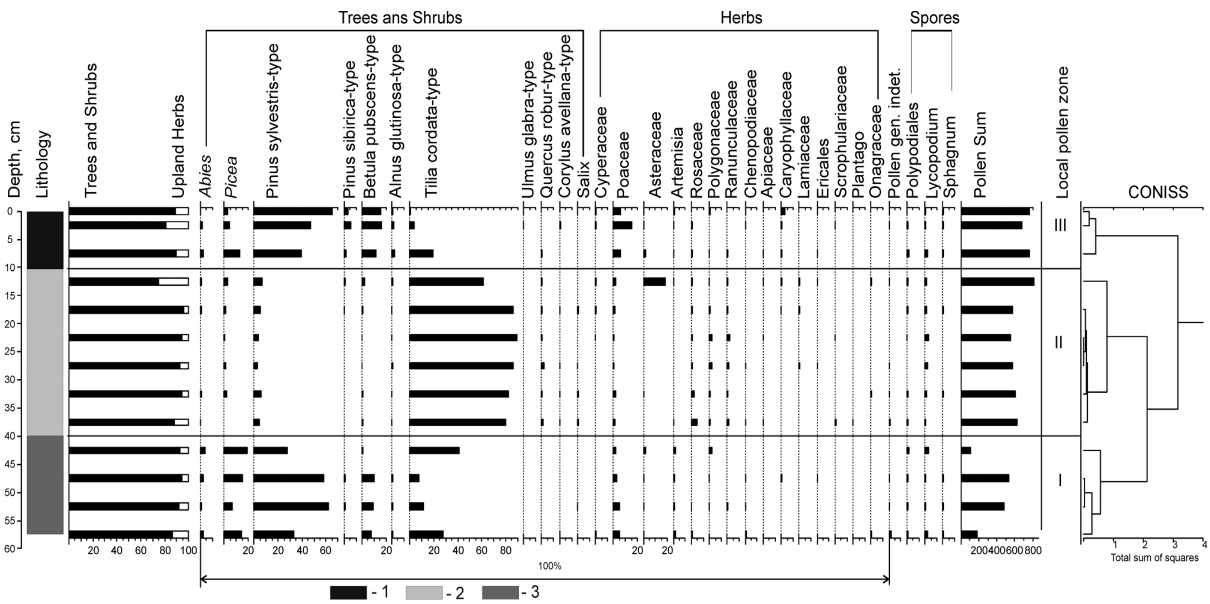
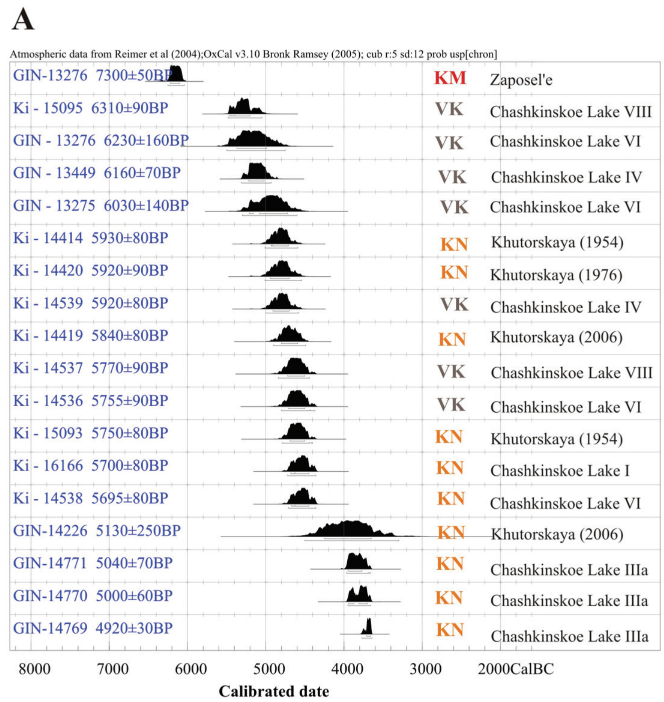


Fig. 10. Pollen diagram for Lake Chashkinskoe IV: 1 sod and grey podzol; 2 dark brown loamy sand,* i.e. *the cultural layer; 3 natural ground.



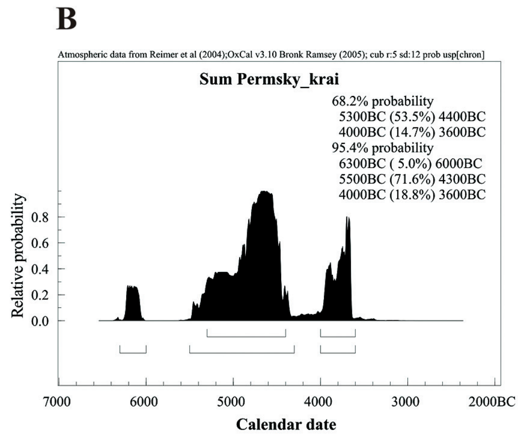


Fig. 11. Radiocarbon dating of archaeological sites in the Lake Chashkinskoe area.

ved species, mostly of small-leaved linden and oak; European hazel occurred in the underwood. According to the pollen data obtained from the Cis-Urals and Vyatka-Kama region sections (*Nemkova 1976; Yelovicheva 1991; Prokashev* et al. *2003*), broad-leaved species were not predominant in the forests of these areas in the Atlantic period. Unfortunately, well-dated reference pollen data still have not been obtained for the study area, so the question of the proportion of small-leaved linden in the Upper Kama forests in the Atlantic period remains open.

Pollen zone 3 (0 – 10cm) represents the stage of occurrence of coniferous forests with some Siberian pine and small-leaved linden, which spread after the Lake Chashkino IV site was abandoned. The pollen spectra show a significant increase in spruce pollen (up to 15%) and pine pollen (*Pinus sylvestris* up to 40–60%; *Pinus sibirica* up to 5%).

Conclusions

To summarise the first stage of our interdisciplinary research in the Lake Chashkinskoe area, we can mention some common factors:

❶ The Chalcolithic sites are located on the river floodplain lower than the Mesolithic and Neolithic sites.
❷ The main activity of people in the Neolithic included hunting, fishing and woodworking; no evidence of productive activities have been found.
❸ In the Holocene climatic optimum, this territory was a zone of mixed coniferous forests with some broad-leaved trees.
❹ The paleochannel analysis identifed the occurrence of seven floodplain generations in the area, which has yet to be radiocarbon-dated.

Further interdisciplinary studies in the Lake Chashkinskoe area will yield interesting new results and help us to understand the environmental conditions in the Mesolithic, Neolithic and Chalcolithic.

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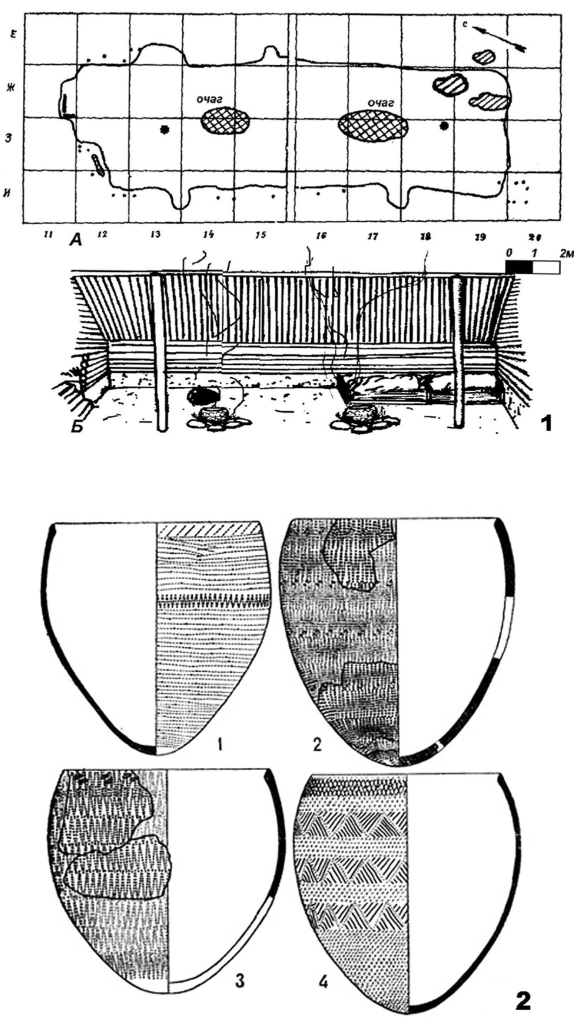
Fig. 2. Locations of middle and late Paleolithic sites on the eastern bank of Chashkinskoe: 1 site Khutorskaya I; 2 site Khutorskaya II; 3 Chashkinskoe II; 4 Chashkinskoe IIIa; 5 Chashkinskoe III; 6 Chashkinskoe Lake IV; 7 Chashkinskoe I; 8 Chashkinskoe VIII; 9 Chashkinskoe V; 10 Chashkinskoe VII; 11 Chashkinskoe Lake VI; 12 Zaposelye settlement; 13 Zaposelye site.



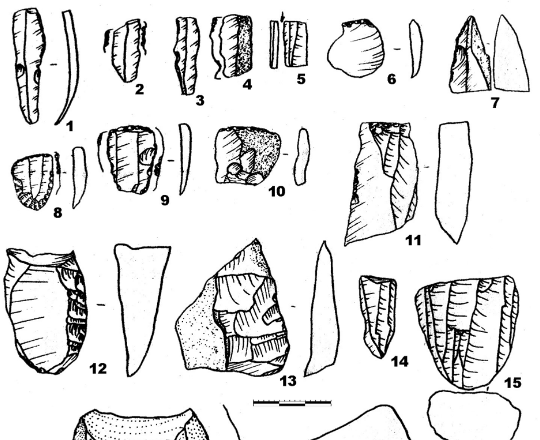


Fig. 3. Stone tools from the Mesolithic site at Lake Chashkinskoe V.

Fig. 4. Khutorskaya I site: 1 reconstruction of dwelling; 2 ceramics; 3 stone implements.

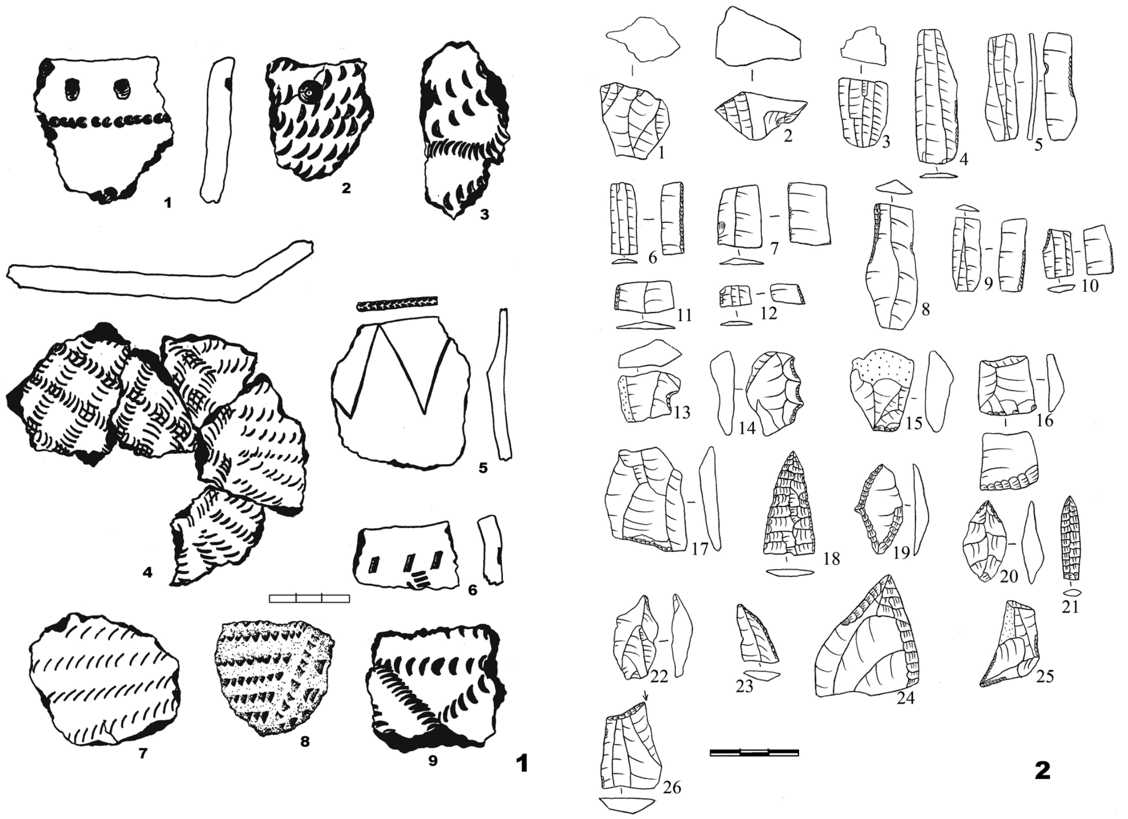


Fig. 5. Lake Chashkinskoe IV site: 1 ceramics; 2 stone implements.

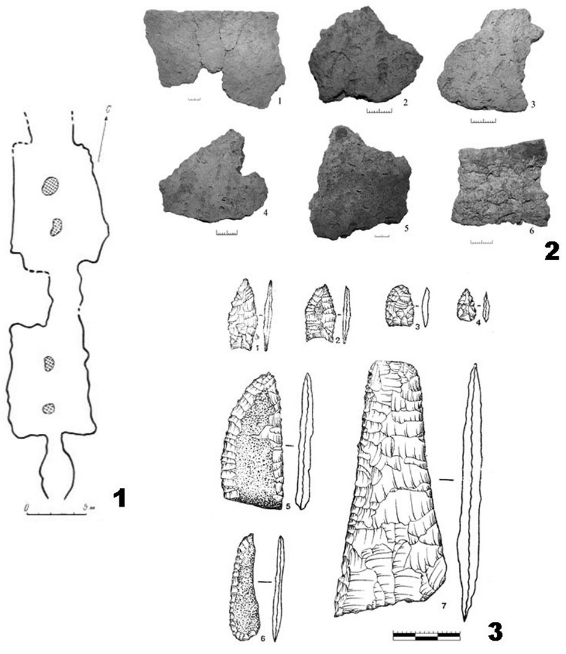


Fig. 6. Garinskaya culture: 1 dwellings; 2 ceramics; 3 stone implements.

Fig. 7. View of the Lake Chashkinskoe VIII site.

Fig. 8. View of the Lake Chashkinskoe III site.

Navigating disciplinary challenges to global sustainability science: an archaeological model

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ABSTRACT – *Current threats posed by anthropogenic climate change, biodiversity loss, the degradation of ecosystem services, and other related impacts of human activity require a concerted response through a global science of sustainability. The threats faced by humanity are so extensive that all academic disciplines are affected in some way and all have a role to play in developing potential responses. Given that few academic disciplines have traditionally focused on issues of ecology or sustainability, however, major challenges remain with respect to how we might build a global science of sustainability that can support concrete policy and interventions. This paper proposes a developmental model with five levels of research and practice required for an effective global sustainability science and examines some of the challenges faced by archaeology in moving up these levels.*

IZVLEČEK – *Trenutne nevarnosti, ki jih povzročajo človeško pogojene klimatske spremembe, izguba biodiverzitete, degradacija ekosistemov in drugi sorodni vplivi človeške dejavnosti, potrebujejo poglobljen odgovor preko svetovne teorije vzdržljivosti. Nevarnosti, s katerimi se sooča človeštvo, so tako obsežne, da vplivajo na vsa akademska področja enako, zato bi morali vsi sodelovati pri iskanju rešitev. Kako zgraditi svetovno znanost o vzdržljivosti, ki bi podpirala konkretne strategije in intervencije, pa ostaja velik izziv, saj se le redke akademske discipline tradicionalno ukvarjajo z vprašanji o ekologiji ali vzdržljivosti. V članku predlagam razvojni model s petimi nivoji raziskovanja in praks, ki so potrebne za učinkovito svetovno znanost o vzdržljivosti, in ki preučujejo nekatere izzive, s katerimi se sooča arheologija, ko se pomika po teh nivojih.*

KEY WORDS – *sustainability; interdisciplinarity; archaeological research*

Introduction

Current threats posed by anthropogenic climate change, loss of biodiversity and wilderness, the degradation of ecosystem services, hyper-consumption of consumer goods and resources, the accumulation of chemical, biological and nuclear wastes, and other related impacts of human activity require a concerted response through a global science of sustainability (*Chapin* et al. *2009*). The global condition of the 21st century will be defined by the disruptions resulting from these problems (*Menely 2012.478*). The threats faced by humanity are so great that all academic disciplines are affected in some way and all have a role to play in developing potential responses. Given that few academic disciplines have traditionally focused on issues of ecology or sustainability, however, major challenges remain with respect to how we might build a global science of sustainability that can support concrete policy and interventions. There seems to be almost universal agreement that our current crisis requires greater interdisciplinarity and that sustainability science is, by definition, a highly interdisciplinary endeavor (*Clark, Dickson 2003*). While, however, there have been numerous calls for such an interdisciplinarity (*Chapin* et al. *2011; Nisbet* et al. *2010*), few studies have examined the implications for particular dis-

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ciplines. Academic disciplines and scientific knowledge will not by themselves be enough to bring about the required social changes for a truly sustainable world. Nevertheless, there is a need to consider trajectories toward sustainability both within the academy in general and within specific disciplines.

Our present condition requires a completely new type of science in order to enhance human well-being and the resilience of social-ecological systems (*Chapin* et al. *2011*). That science must be able to analyse complex networks of interactions between humans and the non-human environment across an increasingly globalised world. Research on the psychology of how people perceive and react to problems must be incorporated in order to involve a broad range of stakeholders. Finally, the 'science' must be proactive enough to actively shape trajectories of social change. Thus, the basic problem of sustainability is: "*How can society transform a trajectory of environmental degradation and disparity in human well-being to a more sustainable trajectory that provides greater opportunity for present and future generations to meet their needs?*" (*Chapin* et al. *2011.46*). This agenda means that academic disciplines are not necessarily central to the ultimate aims of sustainability science; what is required is an interdisciplinary pooling of knowledge and the establishment of common frameworks and meanings (*Bohm 1996; Ostrom 2009; Pickett* et al. *1999*). However, any interdisciplinary project first requires its constituent disciplines to engage with the issues concerned. Furthermore, assumptions that certain disciplines are or are not concerned with questions of sustainability and the environment need to be deconstructed in terms of the history of each discipline.

This paper examines archaeology as a case study in building sustainability science. Archaeology is already very multidisciplinary in the sense that it incorporates various research fields to further its aims of understanding the past. This paper considers how archaeology might also contribute to inter- and transdisciplinary approaches that could develop responses to the global ecological crisis currently faced by humankind. The paper proposes a simple developmental model with five levels of research and practice required for an effective global sustainability science, and examines some of the challenges faced by archaeology in moving up these levels. Although the present paper focuses on the possible use and implications of this model for archaeology, the model itself is designed to encompass all disciplines.

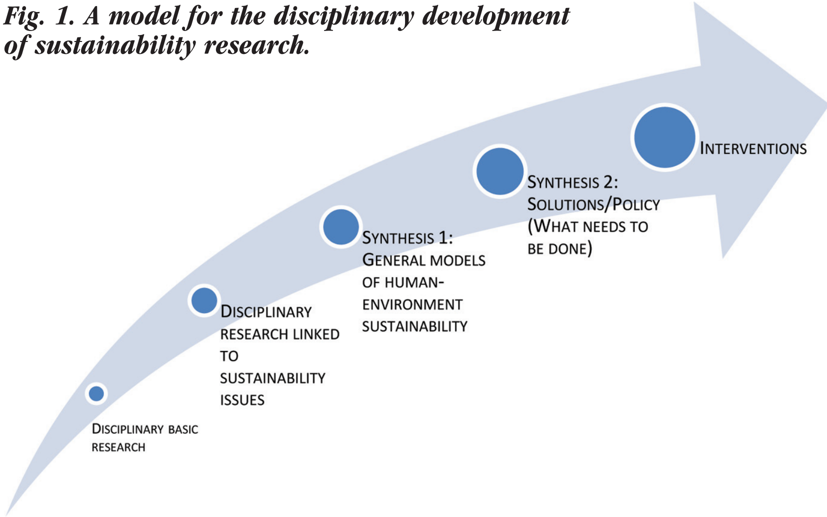
Summary of the model

The model proposed here has five levels (Fig. 1). Level 1 comprises basic research in each discipline. Some disciplines, such as ecology and geography, already include a major focus on human-environment interactions. In other fields, including archaeology, this focus may be present, but more contested. Still other disciplines may define themselves as having little or nothing to do with the natural environment, although closer consideration usually shows that this distance is spurious. Whatever the importance assigned to research on human-environment interactions within each discipline, however, it cannot be assumed that those disciplines will automatically concern themselves with issues of sustainability (Level 2). One example here is a traditional agricultural system in East Asia wherein fish are raised in wet rice paddy fields. This ancient system has long been discussed within archaeology in terms of culture history. Recent ecological research has examined the sustainability of this agricultural heritage (*Xie* et al. *2011*), but unless archaeologists are specifically interested in issues of sustainability, it is unlikely that they will read such literature or develop further analyses related to sustainability. The integration of basic research with questions of sustainability is by no means assured.

In recent years, Level 2 type research has begun to appear in many disciplines where it was previously not present, yet the mainstreaming of such concerns is usually slow. Ecocriticism – the study of ecological and environmentalist issues within literary criticism – is one example where the shift from Level 1 to 2 occurred rather quickly in the 1990s (*Buell* et al. *2011*). Heise (*2006.506*) has emphasised the "*diversity of political and cross-disciplinary influences*" that went into the making of ecocriticism. Such a disciplinary shift to considering sustainability issues requires major transformations in disciplinary goals and perhaps also in power structures. Pathways to this Level 2 transition probably vary significantly, depending on the discipline concerned.

While Levels 1 and 2 are primarily confined to disciplinary research, Levels 3 and 4 require broader syntheses that integrate different disciplinary knowledge. Level 3 comprises theoretical modelling of how humans interact with natural environments and also how they develop sustainability. Anthropology has a long history of research on relations between humans and nature (*Crumley 2001*), but has only recently begun to extend this to explicit modelling of sustainability (*Redman 2005; Hardesty 2007; Fisher* et al. *2009*). Level 4 recommendations for solutions/policy are crucial to transform academic research into practical ideas for change. Level 4 requires the implementation of transdisciplinarity, meaning approaches "*that move beyond the university to engage members of society*" (*Frodeman 2011.106*). All disciplines can develop Level 3 type models, but not all disciplines regularly develop policy recommendations beyond their immediate areas of concern (for example, heritage preservation in the case of archaeology). Level 4 of the present model includes both proposed trajectories of change and suggestions about how to instigate those changes. As discussed in more detail below, the term 'policy' in Level 4 should be understood in a broad sense.

Fig. 1. A model for the disciplinary development of sustainability research.



If the world is to become more sustainable, academic knowledge about sustainability has to be implemented in concrete interventions that comprise Level 5 of the model proposed here. Few disciplines regularly engage in direct interventions with communities or individuals and those with the relevant expertise – such as social work, community development and occupational therapy – are sometimes stigmatised as being less academic than more 'theoretical' disciplines. It is not suggested that all disciplines must eventually develop Level 5 interventions; such work will be best performed by those fields with the relevant experience, especially in terms of the evaluation of interventions. Archaeology, like many other disciplines, does, however, have great potential for participating in multidisciplinary interventions such as those increasingly used with indigenous peoples (*e.g., Frank* et al. *2008*). Furthermore, 'interventions' must be understood in terms of each discipline's culture and goals, and might include museum displays, art exhibitions and poetry readings, as well as more traditional activities in sustainable community development.

Finally, while not shown in the model, there is a crucial role for the humanities in developing critical discourses about how the knowledge summarised in Figure 1 is obtained and utilised. This role should include basic critiques, including the problem of what we actually mean by 'sustainability' (*cf. Alaimo 2012*).

Archaeological implications of the model

Having briefly summarised the outlines of the model, this section will examine how it might be employed within archaeology.

Levels 1–2: basic research and environmentalism

Beginning with 19th century work on shell middens and lakeshore sites, research on the natural environment has always played an important role in archaeology (*e.g., Kristiansen 2002; Habu* et al. *2011*). This research has always been very multidisciplinary and Solli (*2011.49*) argues that C. P. Snow's 'two cultures' have been "*embedded in archaeology since the birth of the discipline.*" Historical explanations linking culture change and the environment have been common since the early 20th century (*e.g., Bruun 1918; Childe 1928*). Since World War Two, basic archaeological research on the environment has been transformed by new techniques of paleoenvironmental reconstruction and by the new science of ecology (*Hassan 2004*). Today, research in environmental archaeology uses a wide range of extremely sophisticated methods.

Despite these technical advances, the role of the natural environment within archaeological theory has often been contested and post-processual archaeology, in particular, has downplayed environmental factors (*Solli 2011; Hudson* et al. *2012a*). This tension over the role of nature is by no means unique to archaeology, and Oestigaard (*2011.70*) argues that since Durkheim "*there has been a dictum in social and human sciences that social facts can be* *explained only by other social facts*" and not by nature and the physical world. It is perhaps for this reason that it is only quite recently that some archaeologists have begun to consider issues of sustainability.

The type of research included here in level 2 might be best summarised as 'environmentalist', *i.e.*, research that shows a social and ethical concern for the state of the natural environment and for human well-being within that environment. Such concerns appear to have developed more or less independently in many archaeological traditions in the 1990s, including the United Kingdom (*Macinnes, Wickham-Jones 1992*), Europe (*van der Leeuw 1998*), the United States (*Redman 1999*), and Japan (*Yasuda 1999*). Nowhere has such research become a recognisable sub-discipline within archaeology along the lines of indigenous or feminist archaeology. There is, however, a growing body of recent work corresponding to Level 2 which suggests that archaeology may have reached some sort of 'tipping point' and research in this area will become increasingly mainstream in the near future. It could also be argued that global environmental problems have become so omnipresent that it is no longer possible to read 'basic research' in environmental archaeology without also considering the implications for sustainability; a good example is a recent paper on rapid climate change in prehistory by Clare and Weninger (*2010*).

Level 3: synthetic models in archaeology

Historical ecology and resilience theory are two examples of the Level 3 type human-environment synthetic models that are used in archaeology. Historical ecology is an interdisciplinary approach that places human history within an ecological framework. Within archaeology, historical ecology has developed research that looks at human-landscape interactions over the long term, often across regional scales (*e.g., Crumley, Marquardt 1987; Balée, Erickson 2006*). Although historical ecology is not a formal explanatory theory (*Crumley 2013*), its broad interdisciplinary perspective has contributed to extensions into sustainability science, particularly through the 'Integrated History of the People of Earth' (IHOPE) network (*Costanza* et al. *2007*).

Resilience theory differs from historical ecology in being a more explicit theory of socio-ecological change. Resilience theory is also a rare example of a paradigm that has grown to incorporate all five of the levels proposed here in Figure 1: basic research in boreal forest ecology (*Holling 1973*) was extended to social-ecological systems (*Berkes, Folke 1998; Folke* et al. *1998*), and then to broad theoretical models of sustainability that include policy recommendations (*Gunderson, Holling 2002*) and some interventions (*Walker, Salt 2006*). The long-term time perspective of archaeology is crucial to resilience theory (*Redman 2005*). So far, only a few archaeologists have attempted to develop formal archaeological analyses using resilience theory (*e.g., Redman* et al. *2009; Butzer 2012; Dunning* et al. *2012; Endfield 2012; Rosen, Rivera-Collazo 2012; Hudson* et al. *2012b*), but there is a growing interest in the broader issues of resilience and vulnerability within archaeology (*e.g., McAnany, Yoffee 2010; Cooper, Sheets 2012*). Although further research is needed on methods of measuring resilience in the archaeological record, archaeological applications of resilience theory are important for sustainability science since they identify factors that promote or reduce resilience in particular contexts, thus enabling the discipline to move up to the next level of solutions and policy.

Level 4: archaeological research and environmental solutions

Although archaeology and other historical sciences have a long tradition of Jeremiadic warnings of social collapse, only quite recently has serious interest been shown in how past societies managed for sustainability in order to avoid collapse. Any programme aimed at fostering sustainability clearly needs to develop suggestions about what needs to be done. Such suggestions can be broadly described as 'solutions' which are instigated through 'policy', but these terms need further explanation in the context of archaeology. Like many other disciplines, archaeology has not traditionally taken a direct role in formulating policy on the management of natural resources, although there are some exceptions, including work on applied zooarchaeology (*Lyman, Cannon 2004*). In order to consider what archaeology might contribute to sustainability policy, we first need to examine what such 'policy' might entail.

Sustainability solutions are not simply polices and regulations enforced by governments, but collaborative frameworks aimed at "*social-ecological governance*", defined as the "*Collective coordination of efforts to define and achieve societal goals related to human-environment interactions*" (*Chapin* et al. *2009. 351; Young* et al. *2008*). A range of collaborative social mechanisms are required to link institutions with social-ecological systems and adaptive learning (*Kofinas 2009*). These mechanisms include fostering innovation and diversity, promoting social capital and social memory, valuing ecosystem services, supporting community belonging and a sense of place, paying greater attention to slow dynamics of change, and planning for surprises (*Folke* et al. *2003, 2009; Walker, Salt 2006; Kofinas 2009; Adger* et al. *2011*). Archaeology has much to contribute here in terms of public engagement in community and conservation, fostering a sense of place, promoting social capital through heritage, and increasing our understanding of the long-term dynamics of social-ecological systems. However, it is as yet unclear quite how such contributions might be implemented. The use of public archaeology in environmental education is one obvious approach, but little such work has so far been conducted (*Hudson* et al. *2012a*).

Level 5: archaeology and interventions

Although it has been suggested that archaeology has great potential to contribute to social-ecological governance for sustainability, this will be an unfamiliar and perhaps uncomfortable role for many archaeologists. Some archaeologists – and no doubt many other scholars in the humanities – may regard policy prescriptions and social interventions as not academic or even utopian. To some extent, such thinking reflects the failure of the academy to reach the public through universities and other institutions where "*The transmission of knowledge to society [is] understood as largely automatic in nature, and commonly devalued as 'dissemination', 'outreach' and 'dumbing down'*" (*Frodeman 2011. 107*). In order to build a science of sustainability we certainly need to become better at communicating our research results. Yet this paper makes no claim that all disciplines must develop policy and interventions in the same way. Recent research in sustainability science stresses the need for multidisciplinary collaborations through which the public is "*(1) empowered to learn about both the scientific and social dimensions of climate change, (2) inspired to take personal responsibility, (3) able to constructively deliberate and meaningfully participate, and (4) emotionally and creatively engaged in personal change and collective action*" (*Nisbet* et al. *2010.329*). Archaeology has the potential to contribute to all of these goals. Like many disciplines in the humanities and social sciences, archaeology has often adopted committed positions of social advocacy and praxis (*e.g., McGuire 2008*), and by their very nature such disciplinary commitments can contribute to shaping social trajectories toward sustainability.

Conclusions

This paper has proposed a model for the disciplinary development of sustainability research (Fig. 1) and discussed some applications of the model to archaeology. The discussion suggested a number of preliminary conclusions. Firstly, although the current crisis in global sustainability may tend to favour research associated with the higher levels in Figure 1, the continuing importance of basic research should be emphasised, since that research forms the foundations for the other levels in the model. Secondly, the move from Level 1 to 2 is often influenced by idiosyncratic historical factors within each discipline, yet the broad cultural context is crucial, and many disciplines seem to experience a 'take-off' when issues of sustainability become widely debated. Opportunities for communication between disciplines are probably important here. However, fields – like archaeology – where the role of the natural environment in Level 1 research is contested may be much slower in this respect. A third conclusion is that, while Level 5 type interventions are ultimately crucial, disciplines such as archaeology need to consider further what such interventions might comprise for their particular areas of expertise and public interest.

Different disciplines bring different strengths and expertise to the model proposed here, and a truly sustainable future will be best supported by a diversity of approaches and the synergies between them. At the same time, academic disciplines form the primary organisational units within which research and outreach is conducted. Although the boundaries between disciplines are currently changing, due to both increasing specialisation within disciplines and integration between different fields (*Pohl* et al. *2008*), the existing disciplines are a realistic start-line for building sustainability science.

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Social change at the end of the Middle Jōmon: a perspective from resilience theory

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ABSTRACT – *It is widely known that social change occurred in the end of the Middle Jōmon, which can be seen in archaeological evidence such as settlements, pottery types, and so on. Most archaeologists have recognised this change as a result of climate change. It is said that a cooling trend in this period had a great influence on food acquisition and caused low chestnut harvests, which was a staple. However, the notion that climate was the critical factor is not sufficient to explain the social change that occurred at the end of the Middle Jōmon, because similar types of society existed after this cooling trend, although the population numbers decreased. It is also important to consider human adaptation to the environment, especially in the case of hunter-gatherer societies. In this paper, I will describe the outline of the arguments supporting the environment theory among Japanese archaeologists, and explore how Jōmon people overcame this period and constructed a new society, based on resilience theory.*

IZVLEČEK – *Znano je, da se je družbena sprememba zgodila na koncu razvoja srednje Jōmon kulture, kar lahko prepoznamo v arheoloških podatkih kot so naselja, tipi posod, itd. Večina arheologov je prepoznala to spremembo kot posledico klimatskih sprememb. Ohladitve v tem obdobju so imele velik vpliv na pridobivanje hrane in so povzročile slabše letine kostanja, ki je bil osnovno živilo v tej kulturi. Vendar pogled, da je sprememba klime predstavljala ključni dejavnik, ni zadosten za razlago o tem, kako je prišlo do družbenih sprememb na koncu srednjega Jōmona, saj so se podobni tipi družbene ureditve obdržali tudi po ohladitvi kljub zmanjšanju števila prebivalcev. Upoštevati je potrebno tudi človeško prilagodljivost na okolje, sploh pri lovsko-nabiralniških družbah. V članku opisujem okvirne razprave, ki so v prid okoljskim teorijam med japonskimi arheologi, in s pomočjo teorije prožnosti raziskujem, kako so ljudje v kulturi Jōmon obvladali to obdobje in zgradili novo družbo.*

KEY WORDS – *Jōmon; social change; resilience theory; hunter-gatherers; prehistory*

Social change at the end of the Middle Jōmon

It is widely known that social change occurred at the end of the Middle Jōmon. Many archaeologists (*Yamamoto 1980; Yasuda 1981; Suzuki 1986; 1991; Teshigawara 1992; Abiko 2011; Abe 2008*) describe how large settlements disappeared and the size of settlements decreased, while settlements in the middle Middle Jōmon had large numbers of pit houses. Most archaeologists believe that climate change caused this social change. It is said that a cooling trend in this period had great influence on food acquisition, and caused low chestnut harvests, which was a staple food in the Middle Jōmon. They reason that the Jōmon economy could not have sustained such large-scale settlements, and that Jōmon people were forced to change their subsistence and settlement system in order to adapt to climate change, which is thought to have been a cooling trend.

This kind of interpretation has been dominant since the 1980s. However, the notion that climate was the critical factor is not sufficient to explain the social change which occurred at the end of the Middle Jōmon, because similar types of society existed after the cooling trend although the number of houses decreased. It is also important to consider human adaptation to the environment, especially in the case of hunter-gatherer societies. Only a few archaeologists (*Kobayashi 1985; Imamura 1997*) proposed alternative view, which focuses on the environmental adaptability of hunter-gatherers. They assert that Jōmon society could have adapted to climate change, since their subsistence was based on hunting, gathering and fishing.

However, no theory has explained this social change so far, except climate change which is based on pollen analysis (*Yasuda 1981; 1997*). According to the pollen analysis, increasing amounts of horse chestnuts (*Aesculus hippocastanum*) from Late Jōmon sites are inferred, relating to climate change (*Sasaki 2007*). Although the main construction material for houses (and other structures) after the Late Jōmon remained chestnut wood. Therefore, it is not sufficient to explain the increasing quantity of horse chestnuts merely as a result of climate change (*Kawashima 2009*).

Resilience theory and archaeology

According to Walker and colleagues, a *resilient system* is defined as a system that can absorb disturbance and undergo some degree of change while still retaining the same general functions and structure (*Walker* et al. *2004*). Resilience is also explained as the ability of a system to undergo change and keep the same functions, structure and feedbacks (*Gunderson, Holling 2002; Walker, Salt 2006*).

Resilience theory suggests four stages: exploitation, conservation, release and reorganisation. These stages are highly theoretical, but suggest important concepts for understanding processes of reformation or reorganisation in cultures. Previous archaeological research in Japan focused mainly on the exploitation and conservation stages. However, resilience theory can be also applied to understanding prehistoric societies.

In this paper, I will examine the process of changing material culture in the Jōmon, using the methodology proposed by Hegmon and colleagues (*2008*), which aims to measure degrees of rigidity. Rigidity is thought to be among the factors that reduce resilience. Jōmon society must have been much simpler than the societies which are examined in the following examples, but I will test the method for the analysis of hunter-gatherer societies.

Case studies from the Southwest of the US

Hegmon *et al.* (*2008*) investigated some parameters of three societies in the southwest region of the United States: Mimbres, Mesa Verde and Hohokam. They chose the periods of transformation: the Mimbres Classic (AD 1000–1130) ended with changes in material culture and settlement reorganisation, which can be related to change in the natural environment (*Schollmeyer 2011*); Late Pueblo III (AD 1200–1300) ended with large-scale emigration and depopulation; and the Hohokam Classic (AD 1150–1450) ended with population decline.

They assessed 20 archaeological measurable variables (Tab. 1), using data from three regions for almost the same period. A key concept here for explaining the difference in changes in various societies is 'rigidity trap'. They conclude that such parameters support their proposition that an association existed between the degree of rigidity and the severity of transformations. As a result of their comparison of three cases, they concluded that the Mimbres transformation was the least rigid case, which led to the moderate reorganisation of their settlements and change in their material culture. I will try to evaluate the rigidity of Middle Jōmon societies in the same way.

Resilience of Jōmon society: comparison with societies in the Southwest of the US

The subsistence and social organisation of the Jōmon differs from those of the three cultures of the US Southwest. We cannot apply the same variables. For example, there were no clear public structures in the Middle Jōmon in the Kanto region. So, we cannot measure the degree of 'restricted access to public architecture', 'people per public structure', or 'average number of public structures per aggregated site'.

It is well known that the Middle Jōmon was characterised by many large-scale settlements. Settlement plans were usually circular, and sometimes areas were divided for storage, graves, and pit houses. Although the area is different, the Nishida site in Iwate prefecture is well known. This kind of large settlement appears in the middle period of the Middle Jōmon, and disappears after the Kasori E3 phase.

For example, at the Teranohigashi site, which is known as a site with a ring-shaped earth mound, Middle Jōmon pit houses were excavated in the southern part of the site (*Ehara 2001*). The Middle Jōmon settlement at Teranohigashi could have been

	Variables Area (km^2) of core and region	Mimbres 2000/19 000	Ranking	Mesa Verde 1817/22 000	Ranking	Hohokam 4000/50 000		Jōmon
Severity of Transformations: Scale and Displacement.	1. # of people core/region	2700/5600	1	15 000-19 500/30 000	2	20 000-30 000/40 000	3	?
	2. What happened to the people?	Some emigration, some reorganization	1	Complete depopulation, some emigration, and probably some mortality	3	Large but not complete population decline, probably both emigration and mortality	2	Depopulation? less and smaller settlements
	3. Abruptness of transformation	Period of change, then abrupt depopulation	2,5	Period of change then abrupt depopulation	2,5	Gradual	1	period of change and abrupt depopulation
	4. Eventual resettlement?	Yes; repopulated after ± 50 years	1	No	2,5	No	2,5	No
	5. Ceramic style and technology	Fades away	1,5	Fades away	1,5	Disappears	3	Fades away
Severity of Transformations: Degree of Change.	6. Household organization	Changes in organization and mobility	1,5	Changes from unit pueblo to modular	1,5	N/A		mobility
	7. Ritual architecture and organization	Changes in architecture	1	New organization and religion	2	N/A		No
	8. Village layout/organization	Major change	1,5	major change	1,5	N/A		Major change
Severity of Transformations: Physical Suffering.	9. Health problems	Sporadic	1,5	Sporadic	1,5	Endemic	3	No
	10. Violence	Slight	1	Yes, massacre	3	Threat	2	No
Measures of Rigidity: Integration (Calculated for the Core Areas).	11. % of population in aggregated sites	~50	2	~30	1	~90+	3	up to 70
	12. Average # of people per aggregated site	80	1	130	2	250	3	up to 130
	13. people per public structure	N/A	1	250	2	450+	3	No (in Kanto region)
	14. Average # public structures per aggregated site	N/A	1	~1.6	2	~0.5	3	No (in Kanto region)
Measures of Rigidity: Social Power.	15. Household differences	Possible differential access to ceremonial spaces	1	Differential access to special structures/stores	2	Clear differences in form and placement	3	No
	16. Restricted access to public architecture	N/A	1	Yes, new more restricted forms in last few decades	2	Yes, surrounded by walls	3	N/A
	17. Differential burial treatment	No	1,5	No evidence	1,5	Yes, goods and treatment	3	No
Measures of Rigidity: Conformity.	18a. # of locally made decorated ceramic wares	1 (Mimbres B/W)	2	1 (Mesa Verde White Ware)	2	1 (Salado Polychrome)	2	Kasori E pottery type
	18b. # of locally made decorated ceramic types	1 or 2 closely related (Style II and III)	2,5	2 closely related (Mesa Verde and McElmo B/W)	2,5	3 closely related (Pinto, Tonto, Gila Polychrome)	1	2 (Closely related Sori and Daigi pottery type)
	19. % of locally made types in decorated assemblages	0,97	2	0,99	2	0,95	2	app. 90%
	20. Household architecture	Many forms and configurations	1	Redundant unit pueblos	3	Redundant courtyard groups, some variability at larger scale	2	Some types and configurations

Tab. 1. Parameters of rigidity (after* Hegmon *et al.* 2008.Tabs. 1–6*).

a circular settlement. Like other Middle Jōmon sites, scarce archaeological evidence of residence such as pit houses and pits from the end of the Middle Jōmon to the beginning of the Late Jōmon was found, while in the northern part of the site, a ring-shaped earth mound and most pit houses were built after the Horinouchi phase (Fig. 1).

Using variables presented by Hegmon *et al.* (*2008*), I try to examine the degree of rigidity of Middle Jōmon society.

Scale and displacement: demographic and settlement data

The size of the regional population in the Jōmon prior to the transformation is difficult to estimate. Some archaeologists assume that in the Middle Jōmon, large settlements were formed, but in a very long time period, which means the so-called large settlements could be the result of accumulation of pit houses over time. The minimum size of a settlement is about five contemporary pit houses grouped together. On the other hand, settlements could have a maximum of 12 houses. It is difficult to identify the phase to which each settlement belongs. If the assumption of population increase is correct, rapid population decline after the Middle Jōmon presents another problem. The issue of Jōmon population needs further research. While we should consider this problem, it is notable that houses were built repeatedly on the same sites in the Middle Jōmon, even if they were mobile. This can be related to the rigidity of the society.

After the Kasori E3 phase, these large settlements disappeared. At such sites thereafter, only a small number of archaeological remains are found. But, there is no clear archaeological evidence of emigration. People probably dispersed and created small-scale and short- term settlements.

Degree of change: ceramic and architectural data

Stylistic and organisational changes in the material culture can be seen in the Middle Jōmon period. The ceramic styles gradually faded away, and regional differences are less recognisable. Mobility probably increased, although the basic style of a pit house remained unchanged, so change in household organisation could have been minimal.

Physical suffering

There is almost no trace of physical suffering in the Jōmon, such as health problems and violence. We should study decayed teeth, which can be related to amounts of carbohydrates consumed.

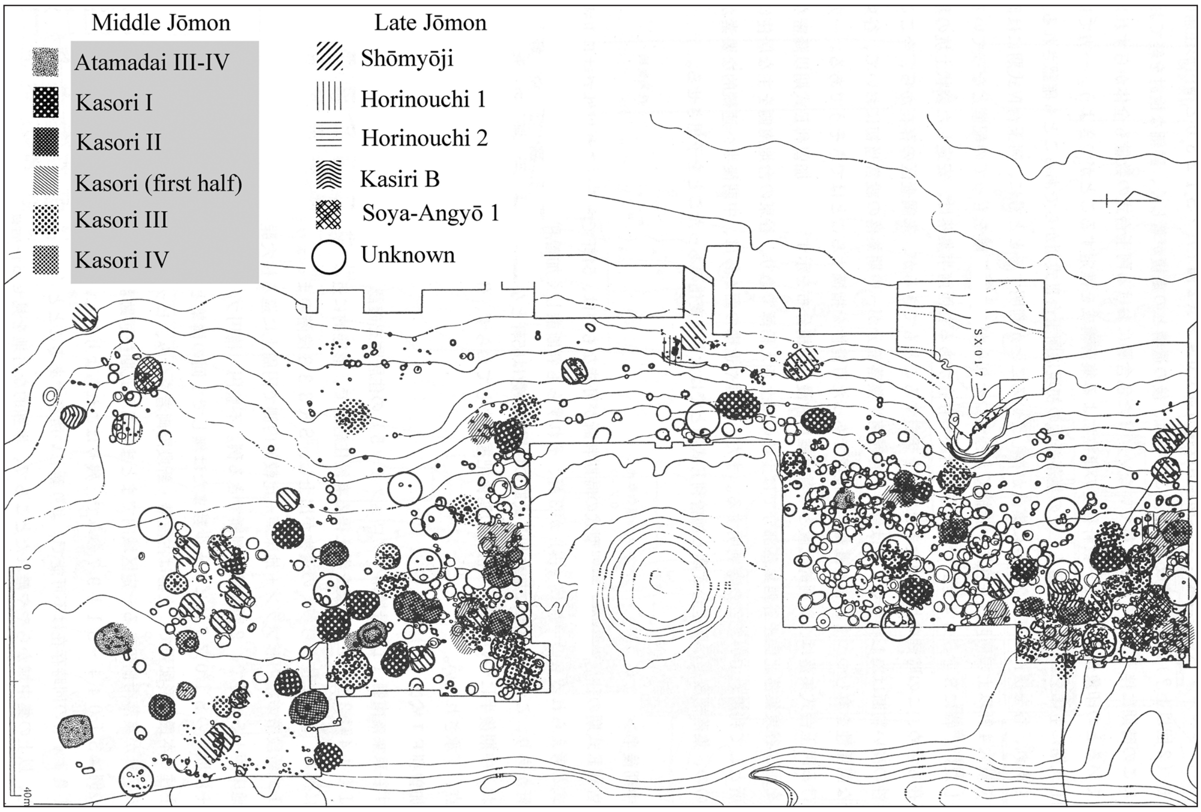

Fig. 1. Distribution of pit houses in the southern part of Teranohigashi (after* Ehara 2001.Fig. 856*).

Measures of rigidity: integration

Again, it is difficult to define the population of aggregated sites. These range from a few houses to more than 10 houses, according to the previous references. Medium-size settlements could consist of up to 130 people. The percentage of population in aggregated sites would have been approximately 70% in terms of the number of houses.

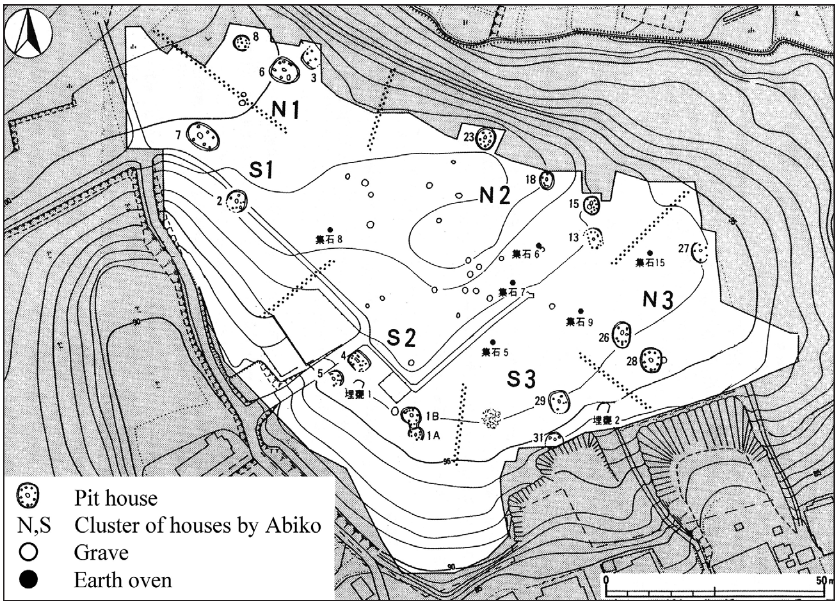

Fig. 2. Pit houses at TNT no. 446 (from **Abiko 2011.Fig. 1***).*

Measures of rigidity: hierarchy

Household difference is not clearly observable, although hierarchy or social complexity after the Late Jōmon is a subject for discussion. Public architecture does not appear in the Kanto region in the Middle Jōmon. Differences in burial treatment are not apparent. There were various types of burial, such as pit burial and burial in abandoned houses. At the TNT no. 446 site, it is assumed that household heads were buried in pit graves which are located at the centre of the settlement, because this fits the number of houses from the same site (Fig. 2) (*Abiko 2011.33*). This calculation seems to be based on the idea that people stayed at the settlement throughout the year.

Measures of rigidity: conformity

Conformity can be assessed by material homogeneity. Pottery has similar forms, but with many variations in decoration. In the Kanto region, Kasori E pottery type is dominant. At least two pottery types have been found in the Tohoku region in the north, and the Chubu region in the west. A certain amount of such pottery has been found in neighboring regions. In the Middle Jōmon, household architecture remained homogeneous, and no critical differences in the structure and size of pit houses appear.

Conclusion

I used the variables in the study of Hegmon *et al.* (*2008*). Not every variable is useful for calculating the degree of rigidity in the Middle Jōmon, but they can be useful when comparing its rigidity with other periods. In this paper, I chose the Middle Jōmon period as a whole, although regional diversity and temporal differences are present even in the Kanto region. For further research, we should explore more detailed data to clarify certain features of social change, such as the process of reorganisation and depopulation at the end of the Middle Jōmon.

Compared with the Late-Final Jōmon, the Middle Jōmon seems to have been less rigid and therefore more resilient. In the case of the US Southwest, Mimbres is thought to have experienced the least severe transformation of these regions. In contrast, Hohokam shows high rigidity. This could be related to the irrigation system, which limits population mobility. The depopulation of the Middle Jōmon society seems to have been more rapid than in the Late-Final Jōmon, so we should consider what happened at the end of the Middle Jōmon and whether the Middle Jōmon society was resilient and able to reorganise.

The variables used to examine rigidity can be also applied to simple hunter-gatherers. So, for a more detailed examination, we need to improve and create more variables to understand rigidity among such societies.

While Middle Jōmon society exhibits a certain degree of rigidity, the Middle Jōmon should be compared with other Jōmon societies, or other periods in the same region in order to clarify the degree of rigidity. We can then consider whether Middle Jōmon society merely disappeared or underwent reformation.

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Will the real specialist please stand up? Characterising early craft specialisation, a comparative approach for Neolithic Anatolia

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ABSTRACT – *The Neolithic period saw changes in production practices and the roles of individuals that were important in the development of increasing social differentiation. Although there is evidence of specialised manufacturing in Neolithic Anatolia, the dynamics of changing production and accompanying social effects have not been characterised. This article looks at how specialisation might be defined and identified in the Neolithic period in Anatolia using the results of recent theoretical debates as a starting point. It addresses the possibility of comparing the various forms taken by early non-institutionalised specialisations and argues the importance of considering this subject as a major element in emerging social complexities.*

IZVLEČEK – *V obdobju neolitika so se spremenile proizvodne prakse in vloge posameznikov v družbi, ki so bile pomembne pri oblikovanju vedno večje družbene razslojenosti. Dinamika spreminjajoče se produkcije in družbenih učinkov, ki jo spremljajo, še niso bili opisani, kljub dokazom o obstoju specializirane proizvodnje v neolitiku v Anatoliji. V članku predstavljam, na kakšen način bi lahko definirali in prepoznali specializacijo v neolitskem obdobju v Anatoliji, pri čemer se opiram na rezultate sodobnih teoretskih razprav. Poleg tega poskušam primerjati različne oblike proizvodnje, ki so obstajale v zgodnjih ne-institucionaliziranih specializacijah, in dokazujem, zakaj je pomembno, da upoštevamo te različne oblike proizvodnje kot glavni element v razvijajočih se družbenih kompleksnostih.*

KEY WORDS – *craft specialisation; Anatolia; Neolithic; beads; chipped stone; social structure*

Introduction

Archaeologists have traditionally conceptualised and explained the emergence of craft specialisation in the context of various linear evolutionary models of socio-economic development originally proposed by Gordon V. Childe (*1925; 1944*) in the 1920s. Conceptualisations of the Eurasian Neolithic have been fitted into an ethnographically derived developmental framework, which typifies hunter-gatherer and small-scale agriculturalist communities as non-hierarchical, egalitarian societies (*Perlès 2001.200; Wiessner 2002*). Within these models the first manifestation of craft specialists has been associated with the appearance of metal working in the archaeological record of the Chalcolithic and Early Bronze Age (*Rosen 1997.112; David, Kramer 2001.304*). It is during these periods, in the 5th – 3rd millennia BC, that emergent hierarchies and large-scale settlements, that might be termed chiefdoms, and early states in social evolutionary models are believed to appear. In contrast, Pre-Pottery Neolithic and Pottery Neolithic social organisation has been perceived as much simpler, with egalitarian household based production as the modus operandi (*Perlès 2001.200; Wiessner 2002*). Definitions of craft specialisation have frequently been included in artefact studies by scholars across the globe, some are very region- and period-specific (*e.g., Arnold, Munns 1994.497; Kenoyer* et al. *1991.45*), and many do not give enough detail to address seriously the issues associated with specialisation (*e.g., Tosi 1984.23; Stein 1996.25;*

Rice 1981.220). Cathy L. Costin (*1991*) produced the most comprehensive survey of the possible combinations of circumstances that would allow craft specialisation to take place and the publication by Rowan K. Flad and Zachary X. Hruby (*2007*) has made further significant contributions. John E. Clark (*2007. 20*) has recently criticised the stagnation of work on craft specialisation in theories developed from systems thinking, neo-evolutionism and holistic views of social change.

Archaeological evidence of the past few decades has made it increasingly clear that the roots of complex stratified societies and their accompanying economic and social conditions lie farther back in prehistory than had previously been acknowledged. Catherine Perlès (*2001.226*) shows conviction that craft specialisation already existed in the Early Neolithic of Greece, "*…what cannot be doubted is that … the organisation of craft production in the early Neolithic was already differentiated, and that, in some cases, it rested on complex strategies of raw material exploitation*". She suggests that in order to further understand this, we should, "*…consider all commodities in circulation and systematically compare the parameters that characterise, in each case, the procurement of raw materials, commodity production, site consumption and regional distribution.*" (*Perlès 1992.119*). There are now also undisputed examples of Neolithic workshops in Central Anatolia that carried out large-scale manufacture of obsidian products which were then transported long distances to their place of use (*Binder 2002. 80; Binder, Balkan-Atlı 2001*), a phenomenon to which I will return later. There are also signs of differentiation in other aspects of society, such as the building of communal structures that may not have been intended for everyday habitation (*Christensen, Warburton 2002; Beyer-Honça 1995*). Much of the work on craft specialisation has focussed on its structural form, the time consumed in its practice and whether the practitioners were under the direct control of others. Although part-time and full-time work are concepts familiar to us in the modern world, and usefully considered by authors such as Costin (*1991*), they are not generally traceable in the Neolithic record and are also not necessarily relevant to the presence or absence of specialisation. Perlès's (*1992*) positive approach to the possibility of specialisation in the Neolithic sets aside previous preconceptions and provides a starting point from which to form a definition of craft specialisation and methods by which it can be identified. The ethno-archaeological examples discussed by Nicholas David and Carol Kramer (*2001.316 onwards*) show that there are endless social and economic permutations to specialisation that cannot all be adequately codified in a simple textual format. Such variations are even less visible in the archaeological record; therefore, although it is necessary to acknowledge the fact of variation, it is important to understand the limitations of archaeological data.

Archaeological evidence has increasingly pointed to the coexistence of a variety of different specialisations during the Anatolian Neolithic varying from whole communities (*Binder, Balkan-Atlı 2001*) to single individuals (*Wright, Bains 2007*). A method that encompasses all of these concurrently existing types of specialisation, categorises them and assesses and records their variations is essential in order to usefully discuss their dynamic change and inter- and intra-site variation. In the very specific context of the Neolithic, it is also essential to have a framework within which to situate incipient specialisations. An understanding of the nature of the archaeological evidence available from prehistoric societies is vital to the development of this methodology; the method presented here was developed for application to the Anatolian Neolithic, however, it is designed to be widely applicable and therefore also comparable. The parameters that are suggested are relevant to the Neolithic period and archaeologically identifiable, but not context-specific; terminology such as 'part-time' and 'full-time', which cannot be corroborated, has been avoided. The ideal is that the consistent use of a methodology for characterising specialisation will allow a considered approach to some major questions such as 'where and when are the origins of specialisation?', 'how is a workshop area defined?' and 'where are the origins of social differentiation?'. The detailed methodology of current excavation projects lends itself to the identification of the fine-scale in production practices; micro-debitage scatters can be traced, as can small artefacts such as beads, which have an excellent recovery rate through flotation and wet-sieving (*Twigger 2009*). Indications are that rather than being a bi-product of social complexity, specialisation formed an integral part of its development.

Social structure and craft specialisation

The assumption of the inherently egalitarian nature of Neolithic society has often been an integral part of interpretations produced in archaeological research (*e.g.*, at Çatalhöyük; *Düring 2006*). Egalitarianism can be defined as, "*…societies that maintain* *equal access of individuals, within age-sex categories, to resources and status positions...*" (*Wiessner 2002.235*), or as many prestige positions in society as there are people to fill them (*Fried 1960*). Flanagan (*1989.248*) highlights that there is a difference between equality of opportunity and equality of outcome, and suggests that it may be clearer to use the word autonomy to imply that people were not answerable to anyone else. The association of craft specialisation with a cultural paradigm that includes a specific level of socio-economic 'complexity' (*Cross 1993.61; Kenoyer* et al. *1991.45*) is argued below to preclude discussion of specialisation for certain periods due to the serious underestimation of societies' capabilities. Stateless societies became largely defined by the absence of indicators of modern social complexity (*Flanagan 1989.245*) and the terms that were used to describe them were not defined in their own right, but only in opposition to complexity and inequality (*Chapman 2003.72*), "*...simple societies are believed to demonstrate their egalitarian nature simply by displaying evidence of a lack of differentiation, and complex societies the inverse.*" (*Rowlands 1989.29*).

These ideas came to be described in almost evolutionary terms, implying both natural selection and that human agency and decision-making played a small or non-existent role in this evolutionary process (*Boone, Smith 1998.141*). The emphasis on hierarchy and accumulation of wealth that has been created by the association of specialisation with complex societies, as opposed to a broader view of other social positions related to community organisation or redistribution of wealth (*Bender 1978.212*) has only helped to exacerbate the diversion of attention from Neolithic evidence. Salzman (*1999.31*) advocates the view that there is a continuum between equality and inequality, effectively a sliding scale with no single point at which one can be separated from the other. Michael Rowlands (*1989.35*) also highlights the fragility of the reach of many early states, suggesting that stateless sub-groups of different structure may have lived under the umbrella of a highly hierarchical society while not participating in its mechanisms.

Institutionalised inequality is seen as the crucial milestone on the road to political development, almost an obstacle on the way to the goal of complexity (*Wiessner 2002.233*). Partly because of the application of social-anthropological terminology and an approach, which sees social hierarchy and social complexity as being one and the same (*Chapman 2003.10*), it has been assumed that egalitarian societies were therefore basic and unvarying in every sense. Polly Wiessner's (*1995.234*) counter argument to this paradigm is that a certain level of differentiation is inherent in every society, because every society, no matter what form it takes, has 'aggrandisers' who take advantage of opportunities. The importance of differentiated social structure in 'egalitarian' societies has only recently come to light. Although it has long been accepted that there are universal divides on the basis of age, sex and kinship (*Costin 1986.328; Wiessner 2002.235; Kuijt 1995. 12, 62; Giddens 1984.396*), it is only relatively recently that the more complex institutions of 'egalitarian' societies are beginning to be explored in the archaeological literature (*e.g., Byrd 2005; Kuijt 1995*). John Clark and William J. Parry (*1990.320*) concur, saying that part-time independent craft specialisation can be found in almost all societies. This is not to imply that there is any inherited inequality or that it necessarily takes any institutionalised form, but it is nonetheless important to acknowledge the possibility and discuss the Neolithic accordingly.

What is craft specialisation?

An array of attempts has been made to define craft specialisation in specific archaeological examples, as well as in a purely theoretical setting. The latest of these is the collected work published by the American Anthropological Association (*2007*), which criticises the inconsiderate or inadequate definition or explanation of specialisation in the context in which the term is being used, alluded to by Costin (*2007. 147*). A selection of the definitions previously used by others quickly highlights their lack of detail:

- "*...variability in output per capita for a given product within the population sampled.*" (*Tosi 1984.23*);
- "*...the regular, repeated provision of some commodity or service in exchange for some other.*" (*Costin 1986.328*);
- "*...regular production for supplying people or groups beyond the household or near kin unit.*" (*Rosen 1989.107*);
- "*...the production of goods and services for a broad consumer population, on a (usually) full-time basis, in order to earn a livelihood.*" (*Stark 1991.64*).

Elizabeth M. Brumfiel and Timothy K. Earle (*1987.5*) describe it as a continuum, with the domestic mode of production at one end and modern industrial economy at the other:

- "*...craft specialisation is production of material objects through modification of raw materials – a creative act of reorganisation that invests the material with information by means of human labour*" (*Clark, Parry 1990.225*), and

- "*...fashioning items at volumes above and beyond the needs of the producing individual or group for exchange with those engaged in complementary economic pursuits*" (*Schortman, Urban 2004.187*).

Even the seminal work of Costin which defined specialisation as, "*...a differentiated, regularised, permanent, and perhaps institutionalised production system in which producers depend on extra-household exchange relationships at least in part for their livelihood, and consumers depend on them for the acquisition of goods they do not produce themselves.*" (*Costin 1991.4*) has recently been criticised by the author herself for focussing on the dominance of elites (*Costin 2007.145*).

Overall the areas covered by the definitions of specialisation that have previously been used can be summarised in a number of points:

- the amount of time spent on an activity,
- the proportion of subsistence that might be obtained from an activity,
- the attribution of a name or title for the activity and the person doing it,
- payment in money (where applicable) or in kind for the products or exchange of products,
- production beyond the needs of the household or relative volume of production,
- level of knowledge/skill, and
- proportion of households or individuals involved in production.

As Costin (*2007.145*) succinctly describes, there have been games of 'lexical semantics' and 'phenomenological classification' with regard to how these various aspects are described. While discussing these different facets of specialisation, authors have used the same terms to mean different things; *e.g.*, 'household-based production' and 'independent production' can be interpreted variously or used to characterise a single example. This highlights the need for a careful definition of what is meant by craft specialisation if understanding of the subject is to be improved (*Costin 1991.6*). This problem is largely the result of approaches generated to apply to individual case studies where authors have concentrated on specific sites or forms of material culture and focussed their definitions accordingly. Examples include work by Prudence M. Rice (*1981*), Miriam T. Stark (*1991*) and David Peacock (*1982*) on pottery manufacture and Leslie A. Quintero and Philip J. Wilke (*1995*) on lithics.

The recent debate on specialised production published by the American Anthropological Association (*2007*) gathered a variety of views about the development of specialisation studies over the past decades. Flad and Hruby (*2007*) and Costin (*2007.145*) concur in their overviews of the subject that there have been issues in the consistent use and understanding of terminology. Although Flad and Hruby (*2007.3*) go on to suggest their own definition of specialised production, I concur with Costin (*2007.147*) in finding the result to be both confusing and complicated, as well as falling largely outside the scope of the archaeological record of the Neolithic period.

The issue of Neolithic specialisation was raised by Perlès (*1992.150*) in her consideration of Greek examples, from which she concluded that there was 'technically specialised production' which went beyond the need of the community, using know-how that was not shared by all, and provided for the needs of exchange, in the form of village craft specialisation or inter-village household specialisation: the beginnings of social hierarchy. This can almost certainly be characterised as part-time for the Neolithic period; she concludes, "*...it is those crafts which demand the longest apprenticeship followed by regular production 'to keep in practice', but which then result in an output far beyond domestic needs, that are characteristically organised into specialized crafts.*" (*Perlès 1992.135*).

Despite Perlès' accepting attitude to the idea of incipient specialisations during the Neolithic, craft specialisation has been inextricably linked to a stage of socio-economic development deemed appropriately complex for its viability, as discussed earlier. The implication of an economic impetus for specialist production was that a certain level of 'development' had to be reached and economic elite had to be present in order to pay for goods (*Childe 1942.87*). Although such an approach is not incompatible with later periods when full time specialists were attached to elite sponsors in the 4th – 3rd millennia calBC, the problem with this approach is that it "*drastically limits what we can know about the past*" (*Pyburn 2004.xi*, cited in *Patterson 2005.330*) because the discussion of the emergence of craft specialization has been couched largely in terms of a 'cost-benefit' economic framework. Childe recognised that specialisation could take a number of different forms: part-time specialisation, household and village specialisation and full-time professional specialisation (*Childe 1958.13*). He regarded small-scale specialisation as being essentially a magnification of common skills, whereas professional specialisation entailed special training (and by implication, restricted knowledge) (*Childe 1925; 1944*).

This implies that there are widely varying levels of commitment to the risk of economic commitment, on a sliding scale, and a 'part-time' or seasonal specialist may have taken only the most minimal risk, or indeed no risk at all, because other members of their household might have continued to produce the food requisite for subsistence. In a non-market economy, everyone is protected in times of need by the communal nature of the arrangement and the loose commitment to production (*Wiessner 2002. 235*). The question of competition has played an important role in much discussion (see *Rice 1981; Tosi 1984*) with the general assumption that something more closely resembling the modern western view of the market economy would have rapidly developed and that competition would have been the norm.

The long-standing association of specialisation with the presence of elites has created an inextricable link between specialisation and the terms 'attached' and 'independent'. In her recent article, Costin (*2007. 155*) makes assertions about the significance of these terms that are not only irrelevant in the context of the Neolithic period, but are actually fundamentally opposed to much of the available evidence. In fact, some of Costin's assertions seem to act as self-fulfilling prophecy, "*...by definition, the products of attached specialists serve to up-hold institutionalized sociopolitical differentiation, but the products of independent specialists do not.*" (*Costin 2005. 1072–1073*). As neither of the terms is applicable in societies without an institutionalised hierarchy in the Childean sense, they will not be applied here in reference to the Neolithic. Likewise Clark's (*2007*) suggestion that specialisation should only be treated as a part of technology rather than as a separate phenomenon is useful when specialisation is a known and accepted aspect of the social milieu being discussed. However, in the case of the Neolithic, the identification and characterisation of specialisation are not well defined, especially in its incipient stages, where a more nuanced approach to its definition is essential.

Having established which aspects of specialisation cannot be identified from the archaeological record of the Neolithic period, it is necessary to structure an approach based on the materials and evidence available. Standardisation in 'craft' products may be one of the most fruitful avenues for further research, as it is archaeologically traceable. Fewer producers should mean that there is, by default, less variation in artefacts, and also the repeated production of identical items will economise on time and allow standardisation of the treatment of the raw material (*Costin 1991.33*). This is one of the only criteria for specialisation that has already been recognised in the Neolithic and has been suggested as indicative of the earliest specialisation (*e.g., Conolly 1999; Quintero, Wilke 1995*). Increasingly high definition methods of recovering and recording archaeological data mean that it is possible to identify activities at a household level (*e.g., Hodder 1996; 2005*). François Sigaut (*1994.436*) has suggested a pragmatic approach to technology in the archaeological record, whereby an artefact should be studied from three different perspectives: the form and construction of the object, how it works and its function. There is an obvious drawback in that the function of an object is often not clear; given that the processes used in the past are now lost to us, analogy with known artefacts may or may not be possible on a case by case basis (*Sigaut 1994.436*). There are also issues relating to the function as perceived by the manufacturer/user of the artefact as opposed to those understood by the archaeologist.

At the (generally low) levels of production for which there is evidence in the Neolithic, it is possible, contra David and Kramer (*2001.305*) and Costin (*1991. 33*), that there was little efficiency to be gained from expending more time on a task. It is possible to argue that efficiency should be seen as the best use of available time, whether for agricultural, pastoral or craft activity. It is possible that particular ways of doing things should be seen as socially significant, "*...at its heart, specialisation is ... a cultural activity that is actively created and manipulated.*" (*Conolly 1999.105*); market economy conceptions of efficiency are not necessarily relevant in this scenario. James Conolly (*1999.104*) concluded that craft specialisation becomes so culturally and temporally specific that it can never fully be defined.

Although the situation-specific nature of specialisation is clear from the above discussion, some common strands offer promise in undertaking its systematic characterisation. To summarise, previous theoretical approaches to and discussions of specialisation indicate that a wide variety of parameters for specialisation are not applicable in the context of Neolithic archaeology; they also indicate, however, that there are potential avenues for consideration. The refining of parameters to assess the presence and degree of specialisation to fit the available evidence, and the disregard for aspects such as the proportion of time devoted to an activity, which in most cases is an abstract concept, allows the construction of a framework within which specialisation can be discussed.

Parameters for Anatolian Neolithic specialisation

Clark's (*2007.20*) use of the concept "*things, persons, action, value and surplus*" is a realistic point from which to begin a consideration of Neolithic craft specialisation. However, his contention that craft specialisation should not be considered as an entity in its own right, but only as a facet of production is, as mentioned above, less helpful in a situation where the identification of incipient specialisations has important social and economic connotations. I begin then, from the premise that "*Agents made, exchanged, and used a variety of objects in daily practice, and these had different meanings and values that affected social relationships, personhood, and social reproduction.*" (*ibid.*).

The criteria for characterising specialisation that I propose are divided into three groups. It is suggested that there were only basic social prerequisites for the development of specialisation and that it had the potential to occur in one form or another in almost any place at any time (characterised by Rosen (*1989.111*) as, "*...incipient and sporadic specialization, not yet institutionalized nor widespread*". Dichotomies have previously been a popular method of contrasting different circumstances: for example, full-time/part-time; attached/independent; exotic/utilitarian; and there has been a reliance on questions of presence and absence (of hierarchies, exotic materials, workshop areas, among others). The criteria presented are designed to be viewed as part of a more nuanced sliding scale; skill level, for example, is not necessarily crucial, as production may be based on volume manufacture of products requiring low skill levels. The criteria that have been produced can be used to assess the likelihood of specialisation, given a specific set of archaeologically identified circumstances. The focus is therefore on the scale, significance and plausibility of the various parameters of craft specialisation outlined below; assessment is based on the strength of a range of evidence and is explored below through two case studies. The use of a consistent set of parameters in assessing potential cases of craft specialisation is designed to produce discursive results that are broadly comparable. The system provides for reinterpretation on the basis of new evidence and also allows criticism in an environment of comparability.

Outlined below are the suggested parameters for assessing Neolithic specialisation arranged under three headings: the first refers to conditions that are assumed to have been present for the potential of specialization; the second group refers to the technical aspects of manufacture, and the third to the social conditions that would have motivated and allowed specialised production. These are followed by some example case studies to demonstrate how this system might indicate relative likelihoods and degrees of specialised activity during the Neolithic period.

The system in use

In order to demonstrate the potential of this approach to characterising craft specialisation, I apply it here to two examples, both taken from Neolithic Anatolia, which are at either end of the 'specialisation scale'. The first is the production of obsidian items at Kaletepe, where the naviform technique was used to produce very specific blades for export to southeast Anatolia and the Levant; the second is the early Neolithic manufacture of stone beads within small communities, using the example of Boncuklu Höyük in central Anatolia (Fig. 1). These examples are broadly contemporary, dating from the late ninth millennium onwards.

Chipped stone – the naviform strategy

The naviform strategy has long been regarded as one of the best candidates for evidence of early craft specialisation and was suggested by Quintero and Wilke (*1995.18*) as one of a key set of indicators of socio-economic change that includes the phenomena of sedentism, and domestication of plants and animals. Because of the dominance of blade-based technologies in the Levantine PPNB, largely produced by naviform cores, this technology became a type fossil for the period (*Quintero, Wilke 1995.19*). Naviform technology was suitable to produce the typical suite of products utilised by PPN communities, sickles with long blades, projectile points, burins, borers, cutting and scraping tools (*Quintero, Wilke 1995.20*). The

Prerequisites for Neolithic specialisation:
Surplus: In order to participate in this economic activity, a potential consumer must possess, or have the ability to provide, a surplus of some item/good/service with which they are willing to part.
Value: Whether by locality or social factors, variable by place, season or demand, there must be some form of equivalency in order for exchange (even in gift systems or cases of delayed reciprocity as described by Layton (*1997.76*) which "…*binds the giver and receiver in a continuing social relationship.*") to be agreed on. Value in the case of the Neolithic social milieu was perceived and subjective in a way that is not the case in a market economy (*Clark 2007.27*). The attribution of value does not need to be consistent or non-negotiable as is often the case in modern economies, and could largely have been determined by the supply/demand/abundance of materials and time and could be non-material, such as the attribution of status/kudos to the producer.
Payment: Some form of reciprocity is integral to specialisation. The question of the exchange of gifts as a part of social and economic interactions, and the use of 'high value' or 'luxury' goods is difficult to identify archaeologically, but must be acknowledged as a possibility.
Technology and production
Modification of materials: Fundamental to any production for exchange is the modification of a material by one individual in order to produce an item demanded by another. This is the most basic level and may be complicated by the involvement of further stages in procurement and production and the involvement of more individuals. The modification will generally add to the value attributed to the material.
Knowledge/know-how: Those conducting the production task would use specific knowledge sets/know-how. This does not imply that others in the community would be excluded from knowledge of these skills and would necessarily be unable to produce similar items themselves.
Repeated production: The household (whatever form it may take) must have the capacity to produce more of certain items than it can consume. This necessitates an appropriate length of time being spent on the task and implies that there is enough time available to do so, whether because certain members of the household carry out different economic tasks, or because of seasonal variation in subsistence-related tasks, or because a certain amount of subsistence-related tasks could be substituted by the specialised activities. This could be seasonal/daily/or any combination thereof.
Production based on demand: There must be a need for the products in order to create a viable economic situation. This is fundamental to the specialisation question – the desire for the products creates the demand.
Social aspects
Number of producers fewer than consumers: Although obvious it is important to highlight that as specialisation of production becomes more prevalent, the proportion of individuals carrying out any particular production task decreases.
Product function: This is key to the concept of demand: a perceived need for an item is required, whether for utilitarian or social reasons – items would be ascribed value (as described above) according to their desirability.
Cultural congruency: A product will be recognisable to its producer and consumer for reasons of style, form, function or choice of material. This may contribute to a sense of identity through reinforcing community cohesion or by imbuing an item with added value by virtue of its 'exotic' nature, rarity or association with a distant area/community/source. This can be true for purely utilitarian as well as decorative or adornment related items.
Culturally specific typology: The consumer will be discerning about the products that they acquire. This would be dependent upon quality, function, style and even fashion. In order for a new technology to spread, it must have been seen to be desirable, whether or not it provided a significant technological or functional advancement.

Tab. 1. Criteria for the characterisation of Neolithic craft specialisation.

key to the success of this technology was the ability to produce many very consistent and predictable blades from a core without much wastage, although materials such as tabular flint are most suitable to the quick production of a useable core, they were also commonly made from obsidian (such as at Aşıklı Höyük) and other stones (*Quintero, Wilke 1995.20*). Quintero and Wilke (*1995.26*) suggest that, "*Many villages comprised population clusters that were substantial in size, large enough to provide an appropriate social and economic setting for a beginning stage of craft specialization. We believe that the villagers in turn required a degree of craft specialization to meet their economic needs.*"

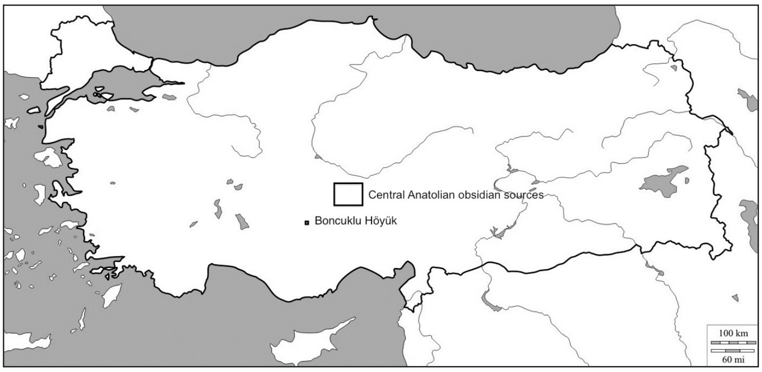

Fig. 1. Location of the sites discussed in the case studies, the obsidian sources of central Anatolia and the site of Boncuklu Höyük.

Few Neolithic specialists would disagree with the first of the above sentences given the current state of evidence; however, it is the second that remains contentious. Quintero and Wilke are absolutely clear in pointing out that one specialised lithic industry does not mean that all lithic production was specialised; indeed, they say that most day-to-day needs could have been met by almost all individuals, and specialisation was only in blades (*Quintero, Wilke 1995.27*). They also suggest that blade production would not have been the only specialised activity; others may have been burnt lime technology for plastering and the production of white-ware and plaster statuary (*Quintero, Wilke 1995.28*). They end by arguing that lithic specialisation of this sort was lost in the Pottery Neolithic. The crux of Quintero and Wilkes' (*1995.27*) argument for specialised production lies in the standardisation of the technique being used and the skill of the manufacturers. Douglas Baird (*2001.329*) has argued, on the basis of evidence from Jilat, that the Naviform reduction strategy was not inherently specialised on the basis of skill or know-how, but that it may have been specialised in terms of the number of practitioners at some but not all sites – *e.g.*, not among desert communities. The example of central Anatolian naviform production using obsidian indicates the possible isolation of a single, highly specialised manufactory in an otherwise less complex production paradigm.

Anatolia has some of the richest sources of obsidian and served a wide area during the Neolithic. The obsidian sources are located on a group of volcanoes, Acıgöl, Göllü Dağ, Nenezi Dağ, Hasan Dağ and Erciyes Dağ (*Balkan-Atlı* et al. *1999.135*). Kömürcü is the most studied of the sources and has the best known of the workshop areas, Kaletepe, which is a large plateau with obsidian in the form of elongated blocks. It is on the northern slope of Göllüdağ at 1600m elevation and is about 4ha in area (*Binder, Balkan-Atlı 2001.1*). Kaletepe is the only workshop to have been excavated and has revealed deposits more than 6m deep (*Balkan-Atlı* et al. *1999.140; Binder, Balkan-Atlı 2001.3; Balkan-Atlı 2001; Balkan-Atlı, Binder 2000; 2001; 2003; Balkan-Atlı* et al. *1999; 2000; 2003; Balkan-Atlı, Binder and Kuzucuoğlu 1999a; 1999b; Balkan-Atlı, Binder and Cauvin 1999*). Two soundings found workshop waste in situ, and care was taken to try and understand the production sequences of the unipolar, bipolar and bifacial cores. In some layers there appear to be pieces of obsidian which come from sources other than the one at which they were found; the excavators regard these as evidence of the domestic use of the site, as well as its use as a production area (*Balkan-Atlı* et al. *1999.142*). A variety of production sequences is represented at the site, but a 'spectacular' 64.7% of the cores found at the workshop were standardised naviform cores (known as Kaletepe naviform), which were used for the production of long pointed blades which were exported to other sites (*Balkan-Atlı* et al. *1999.138; Binder, Balkan-Atlı 2001.1; Balkan-Atlı* et al. *2001. 41*). Balkan-Atlı *et al.* conclude that, "*Kaletepe can be considered as a specialists' workshop where an intensive production of regular long pointed blades designated to exportation took place.*" (*2001.41*).

The typical products of the workshop were long blades of about 15cm, all of which were exported, even some of the by-product upsilon blades and lateral blades were also exported. These products are characteristic of the PPNB of the Levant and sites such as Çayönü Tepesi, Cafer Höyük and Nevalı Çori; they are rarely used in Central Anatolia (*Balkan-Atlı* et al.

1999.142). This example provides the single convincing case of production for long-distance export in the Neolithic period in Anatolia. The scale of production was unquestionably considerable, and thanks to chemical identification there is no doubt of the provenance of the raw material. The organisation of production and transportation of the products are matters open to debate. The possibilities are numerous in terms of the way that the different geographical areas were in contact; contact may have been directly with envoys moving from one region to another to collect materials, or it may have been via a system of down-the-line trade. The producers themselves may have originated elsewhere and controlled the obsidian sources to their own advantage. It may never be possible to answer the question of how these processes came about, but they certainly involved a level of sophistication with which Neolithic society has rarely been credited.

As a potential example of specialised production, the naviform technique employed at Kaletepe produces robustly positive results in response to the proposed criteria (Tab. 2). The modification of the raw materials is consistent and on a large scale; there is a specific set of technical knowledge associated with the manufacturing process that is not only restricted, but also external to the region as a whole. The production is on a scale that is (according to current archaeological data) unprecedented in Anatolia and the demand, if it was fuelled by external populations, as has been suggested (*Balkan-Atlı* et al. *2001*) was both specific in nature and large in scale. There is no doubt that there was a limited number of producers relative to those who, over a wide geographical area, were in receipt of the products, and although it is not clear that the product fulfils a unique function that could not be achieved by other, similar techniques, it was clearly perceived as the most desirable way to achieve this specific functionality at this time. Perhaps the most specific matches with the criteria are in cultural congruency and specific typology, in which form, material, function and style were consistent, and the steps that were taken to achieve the end result were of extraordinary complexity. The type of product that was produced and procured was specific, without any obvious functional benefits when compared to other similar and more locally available technologies. Overall, the naviform production at Kaletepe was overwhelmingly specialised, which is perhaps not a surprising result given the unprecedented organisation and scale of the enterprise. The following example is designed to show the scope of simple criteria to articulate the nuances of a less definite situation in which production was on a very small scale.

Beads

As an example of potential craft specialisation, beads provide an unusual case study in that their role was probably not directly functional, but rather related to the representation of the individual or the community within wider society. In some instances, beads may have been 'inalienable' goods, attributed a value that was outside of the usual production economy, that would have belonged to a particular individual and been inalienable in ownership and meaning (*Clark 2007.29*). Examples of these would include the beads that were repaired when broken, such as those seen in the case study used here, beads from the site of Boncuklu Höyük in the Konya Plain (Fig. 1).

Boncuklu Höyük is an early sedentary Neolithic settlement on the Anatolian Plateau, first settled in the late 9th millennium BC and about 9.5km from Çatalhöyük (*Baird 2009*). On-going excavations have produced evidence of all stages of stone bead manufacture from the procurement of raw material from sources in the surrounding landscape to the manufacture, use and discard of the beads, despite the relatively small size of the assemblage (*Baysal 2013; Baysal forthcoming a*). The detailed contextual information from the excavation in conjunction with the varied nature of the assemblage renders this an ideal testing ground for craft specialisation theory. Contextual evidence tells a story of production that may have moved dynamically around the site by season; houses would have been preferred in the cold winter months, while the large open areas between the buildings were heavily utilised when the weather permitted. Bead production did not always go according to plan: sometimes a rock or pebble was chosen which was too hard for the available drilling technology. Sometimes a bead blank was abandoned in sheer frustration at the difficulty of piercing it, after several unsuccessful attempts (*Baysal 2013*). Some manufacturers worked efficiently on a string of bead blanks, which were simultaneously shaped by abrasion, indicating that in at least some cases production probably constituted more than just a hobby. This too could fail; some beads were dropped on the floor and never retrieved, possibly slipping under the dense reed matting that covered almost every surface. Beads were valued at the site; they were rarely included in burials, and even then only in small numbers (Fig. 2). When a bead broke, it was usually mended, the sharp edges were rounded off and a new piercing was made so that the bead continued in use. It is not clear how they were worn; there is a single example of three stone beads strung together, although whether as an item of jewellery or decoration on clothing remains unknown. Some beads appear to have had a secondary use as tools; they were grooved from repeated use, perhaps as a cutting surface on which to use an obsidian blade (*Baysal 2013*) (Fig. 3). Perhaps they were fastened about the body for convenient portability.

When considered in the framework of the parameters for specialisation suggested here (Tab. 2), this assemblage tells us that raw materials were heavily modified – the most basic disc bead of limestone would have taken at least half an hour to produce; the most complex of the beads would have taken hours of work. At least some knowledge of drilling technology would have to have been applied, in conjunction with an understanding of the raw material. This knowledge was not universal; some of those attempting to manufacture beads did not always succeed, so perhaps the knowledge was restricted within the community. Some households show clear evidence of repeated bead manufacture, including concurrent manufacture of a number of beads. There is not enough evidence of the way that the beads were consumed to establish whether this was production within or beyond the household sphere. The fact that beads were curated, mended and re-used as tools and that they were rarely deposited in burials indicates that once manufactured they were regarded as items of either practical, personal or social value. The current evidence from the excavation of Boncuklu Höyük indicates that bead production probably was restricted to certain households within the community, or that perhaps some of the activity took place in communal outdoor areas. The variable levels of skill among those producing the beads also suggest that those who were more proficient carried out the majority of production. Some of the stone beads have clear evidence of a practical purpose and can be interpreted as tools that were worn on the body rather than items purely of personal ornamentation. The recycling of broken beads also indicates that they may have been perceived to have a purpose or value beyond their purely aesthetic quality. The stone disc bead can be seen as the basic unit of Neolithic social identity. It is found at every Neolithic site (*e.g.*, Körtik Tepe, Çatalhöyük, Pınarbaşı; *Özkaya, Coşkun 2011; Hamilton 2005; Baysal 2013*) with little variation except in the stone material used. Other bead forms can be identified as having a more localized significance; for example, the stone plaques seen at Boncuklu are not paralleled in other central Anatolian sites, including contemporary Pınarbaşı (*Baysal forthcoming b*). Through these characterisations it is possible to see a layered identity, which may have extended, consciously or unconsciously, across much of Anatolia. The beads of Boncuklu have a variety of forms and quality. Those that conform to the wider Neolithic typology (*e.g.*, discs and lozenge shapes; *Hamilton 2005; Erim-Özdoğan 2011*) would have been recognised and accepted over a wide area, whether in terms of trade, exchange or an affinity with the person wearing them. Those that were manufactured for recognition and use within a site such as Boncuklu probably carried more specific messages or practical purposes, the plaque pendants currently being the prime example. Those beads that do not typologically conform are also typically those that are least well formed, technologically poorly executed or not completed.

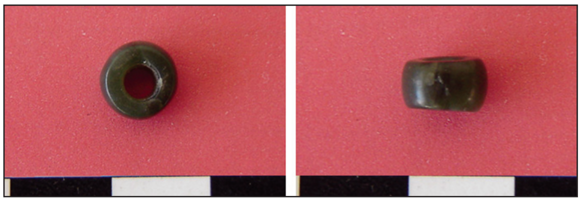

Fig. 2. A high-quality stone disc bead from a burial at Boncuklu Höyük.

Fig. 3. A stone plaque bead from Boncuklu Höyük, Turkey, showing indications of re-use.

Overall, the Boncuklu bead assemblage does not currently show conclusive proof of specialisation (Tab. 2), although in some respects the specialisation criteria are fulfilled, and indeed further 'high definition' excavation may reveal that there were some individual specialists operating within the community. There is clear evidence of different levels of cultural congruency, suggesting that individuals may have recognised themselves in terms of varying interaction spheres relating to their material environment, the largest of which may have extended over much of Anatolia. There are also clear indications that knowledge and know-how may have been restricted to certain individuals within the community, whether this related to those individuals who also owned the necessary toolkits is not yet clear.

Discussion

Although the parameters for the identification of early craft specialisation that are presented here are (of necessity) relatively basic, they form a system which can be applied regardless of the chronological or geographical setting of an archaeological assemblage and will produce a result which is consistent and comparable. Where previously there has been an implicit difference in the interpretation of archaeological evidence, this methodology requires an author to articulate the reasoning behind their conclusions in a systematic and consistent form and thereby allows others to offer variant interpretations. The discursive system is, inevitably, subjective, but the transparency of the system lies in its basis in archaeological data. Reinterpretation on the basis of new and increasing sources of evidence is important to the success of the scheme. In producing specialisation criteria appropriate to the Neolithic period, it is inevitable that some of the detail that may be desirable in historical or anthropological situations will be lost. However, stripping away the history of archaeological discourse that has led to the overlooking of early craft specialisation reveals the potential utility of a wealth of evidence that can be used to begin a new narrative.

The importance of identifying incipient craft specialisations, and being able to distinguish them from production in general, is inestimable for our understanding of changing social identities and the differentiations that that led to hierarchy. Clark's (*2007*) contention that "*studies of craft specialisation rarely justify their attention to the phenomenon*" therefore does not hold true in the case of the Neolithic context presented here. The boundaries between non-specialised and specialised production in its incipient stages are often, although not always, blurred; that there were "*transformational process involving skill, aesthetics and cultural meaning*" (*Costin 2007.146*), however, is not in doubt. The methodology highlights the importance of Rosen's (*1989.107*) assertion that, "*...explaining the origins and development of craft specialization as a natural consequence of increasing social complexity ignores the active role that specialization plays in that complexity*". Reintegrating the specialist within wider issues of social structure is the next step towards a better understanding of the changing role of the individual in society and the early indicators of social differentiation.

	Naviform technology	Bead manufacture
Prerequisites (assumed to be positive)		
Surplus	✓	✓
Value	✓	✓
Payment	✓	✓
Technology and production		
Modification	✓	✓
Knowledge	✓	✓
Repeated production	✓	✓
Demand	✓	X
Social aspects		
Producers/consumers	✓	X
Function	X	X
Cultural congruency	✓	✓
Cultural specificity	✓	✓
Overall results	Positive 7/11	Indeterminate 5/11

Tab. 2. The degree to which the examples used in this article meet the proposed criteria for craft specialisation.

If questions of social evolution have little relevance to the development of incipient specialisations, the significance of the study of the phenomenon must be re-evaluated. However, I believe that the emergence of different roles in society, or a stage at which they become archaeologically visible for the first time, has an important bearing on the way that we view Neolithic society and would also have affected the way that Neolithic populations viewed each other. Specialisation entails the attribution of value (economic or social) to each item and indicates agreements made between those participating in a transaction or social relationship. The production of goods for exchange also provides some of the earliest evidence for long-distance contacts and an insight into the way that Neolithic populations interacted with each other. The knowledge that Neolithic people had of raw materials and the way that procurement and the use of these materials was handled can give clues both to spheres of interaction and to decision making processes. An approach that can integrate all types of specialised craft activity within a wider understanding of society helps archaeological interpretation processes from the level of individual to regional interaction.

The case studies presented here are, of necessity, fairly perfunctory; however, they serve to contrast the description of an accepted case of craft specialisation with much more ephemeral evidence from a small community with equivocal indications of social structure in the archaeological record. Does the use of criteria to describe craft specialisation add anything to our understanding? It is perhaps best to view criteria as a way to frame a debate and to ask consistent questions of each data set rather than judging first and describing evidence that fits the judgement. Clark's (*2007.21*) suggestion to include all production rather than separating and considering specialisation in isolation is indeed valid, given that specialisation must be understood and discussed in the context of that-which-is-not-specialisation.

Craft specialists, ephemeral, individual, talented or exceptionally productive were an important part of Neolithic societies and complex social interactions. The formality of their production areas and the quantity of products should not be assumed. Their strengths may have been in their flexibility, the portability of their skills and their strengths as individuals. The nature of the available evidence may mean that in many instances it will never be possible to determine the exact nature of the specialised activity of a particular community at a particular time. Is there such a thing as a real beginning to craft specialisation or was it an organic process involving thousands of years of work by talented and hardworking individuals? Who is a 'real' specialist? There may be a multitude of opinions about the question, provided there is a framework within which those viewpoints can be compared and contrasted by using a set of parameters which fit the nature of the evidence.

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Deciphering Later Neolithic stamp seal imagery of Northern Mesopotamia

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ABSTRACT – *Stamps, pendants and related image bearing objects of the Near Eastern Neolithic are commonly treated as markers of property control and as precursors of writing. Through a basic stylistic analysis of image and shape relations, this study focuses on material from later 7th and the 6th millennium BC Northern Mesopotamian sites in an attempt to understand the symbolic role of stamps within the wider context of social practice. I suggest that the stamps and pendants may have been objects that elaborated on their user's identity in various spheres of social membership. More significantly, these objects may have introduced a new discursive field through which personal identities and community structures began to be redefined with reference to male sexuality. This interpretation is demonstrated by the dominance of phallic imagery within the stamp assemblages of the time period and the links built between these phallic images and the remaining stamp corpus which is composed of powerful imagery surviving from the earlier Neolithic of the region.*

IZVLEČEK – *Pečatniki, obeski in drugi podobni predmeti iz obdobja neolitika na Bližnjem vzhodu predstavljajo znake nadzora nad lastnino in veljajo za predhodnike pisave. Ta študija je usmerjena na material iz poznega 7. in iz 6. tisočletja BC v severni Mezopotamiji. Z osnovno stilistično analizo podob in odnosov med oblikami poskušam razumeti simbolično vlogo pečatnikov v širšem kontekstu družbenih praks. Sklepam, da so bili pečatniki in obeski predmeti, ki so dodelali identiteto tistega, ki jih je uporabljal, v različnih sferah družbene pripadnosti. Še bolj pomembno pa je, da bi lahko takšni predmeti predstavljali novo diskurzivno področje, preko katerega so bile osebne identitete in strukture skupnosti ponovno definirane v zvezi z moško seksualnostjo. Ta interpretacija se kaže tako v prevladi faličnih podob znotraj zbirov pečatnikov v tem obdobju kot v povezavah med temi podobami in preostalim korpusom pečatnikov, ki je sestavljen iz močnih prispodob, ki so navzoče v tej regiji od zgodnjega neolitika naprej.*

KEY WORDS – *Neolithic; stamp seals; symbolism*

Introduction

Small, image-bearing items usually produced from available local stone, sometimes together with items made from clay, bone or exotic materials, are traditionally called stamp seals. These items are regularly encountered at later 7th and 6th millennium BC sites of Northern Mesopotamia (Fig. 1). A remarkable unity can be observed in the selection of seal images across this region, which strengthens the impression that these objects were part of a common symbolic world. Various styles of cross-hatching, concentric circles, zigzags or a combination of parallel and perpendicular lines were often incised on carefully shaped geometric surfaces (Fig. 2). More naturalistic images of animals, such as caprines, snakes and scorpions along with humanoid and house imagery are also consistently observed. The great majority of these objects have pendant- or bead-style perforations or raised suspension loops that indicate attachment to another medium, such as a rope or textile (*von Wickede 1990; Charvat 1991*). Evidence from the mid-7th millennium BC cemetery at Tell Ain el-Kerkh indicates that they were worn on the hip or

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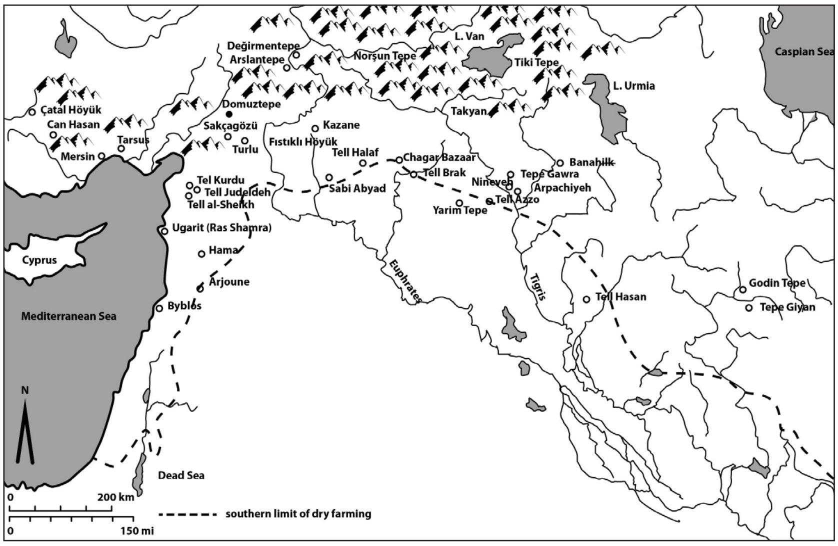

Fig. 1. Map of the later 7th and 6th millennium BC sites mentioned in the text (adapted from* Carter 2010*).

hand area as body adornments by individuals of both sexes and of various ages, including juveniles and children (*Tsuneki 2011*).

The role of stamps and pendants in Mesopotamia is often considered within an evolutionary framework that led to the emergence of writing (*Dittman 1986; Nissen* et al. *1993; Pittman 1994; Frangipane 1994; 2000; Schmandt-Besserat 1996; Postgate 2005; Algaze 2008*). In this framework, the construction of a universal Mesopotamian ideology is narrated as a progressive development of increasingly rational solutions to administrative problems over the course of development of a sedentary agricultural lifestyle. The most overt crystallisation of this idea is found in the work of Denise Schmandt-Besserat (*1992; 1994; 1996; 2007; 2009*), who, by focusing on the geometry of image-bearing objects from various prehistoric and proto-historic contexts, postulated that stamps with particular geometric shapes symbolised counting of particular types of goods that, when used as sealing, secured a record of those goods in exchange transactions.

Many scholars agree that the objects studied by Schmandt-Besserat may have served as antecedents to the proto-cuneiform writing system. The evidence for the earliest writing comes from clay tablets found at Uruk dated to *c.* 3200 BC, the majority of which are understood to be records of material transactions taking place within the economy of a densely populated temple-state in which trade and labour was centrally controlled through powerful political institutions and religious rituals enacted within the context of monumental architecture (*Algaze 2008*). According to Robert Englund (*1998; 2004*), in the period just prior to the development of writing, geometrically shaped objects began to be used as tokens that were impressed on clay envelopes, which then became the basis of numerical tablets and ultimately proto-cuneiform, or pictographic and ideographic writing.

The discovery, in Sabi Abyad, of approx. 300 sealings (impressed clay used to seal goods and commodities) was a prominent factor in the identification of stamps and pendants as types of administrative

Time period	Associated cultural development
The Early Neolithic (Aceramic or Pre-pottery Neolithic) *c.* 10000–7000 BC	Emergence of early forms of sedentary life and ritual, with the first domesticated grasses appearing during the initial stages, followed by the development of an increasing reliance on domesticated legumes and herd animals which was accompanied by increasing architectural elaboration and ritual intensification.
The Late Neolithic (Ceramic Neolithic) *c.* 7000–5500 BC	Appearance of wide scale colonization of the Northern Mesopotamian landscape by small communities of extended households who subsisted on mixed farming and herding strategies. Introduction of portable items, such as pottery and stamp seals, laden with symbolism which gradually created an impression of a culturally unified horizon, commonly referred to as the Halaf, over Northern Mesopotamia.

Tab. 1. Generalized chronology for the Early and the Late Neolithic periods of the Near East.

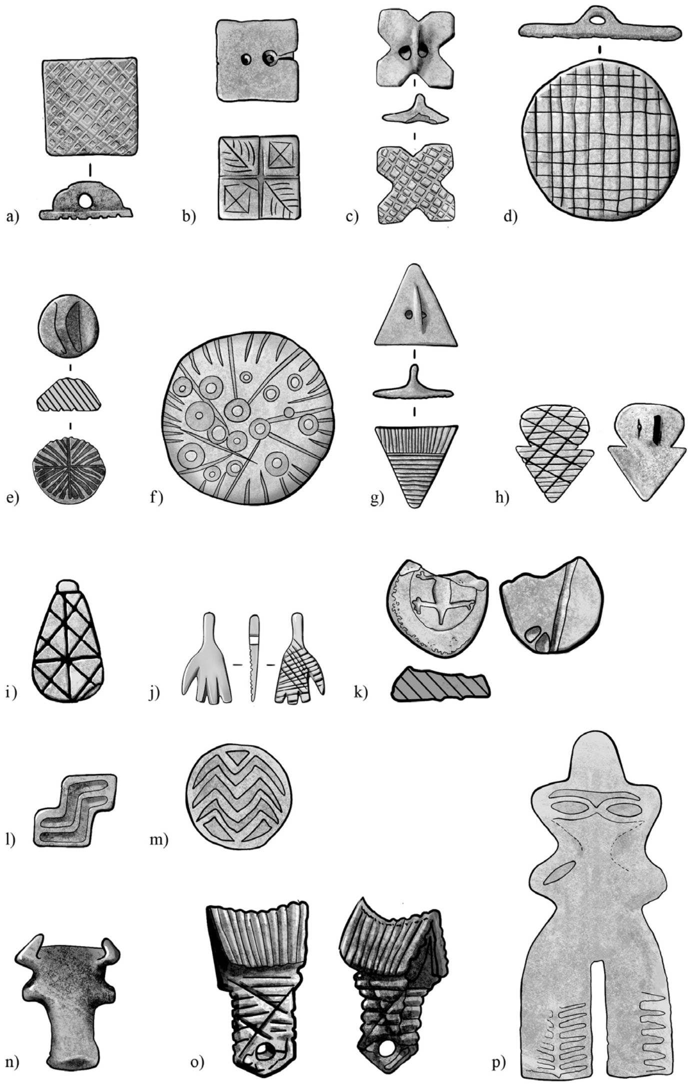

Fig. 2. Various stamp seals, pendants and related images bearing objects from the 6th millennium BC contexts in Northern Mesopotamia: a) Domuztepe Dt 2804, serpentinite (from* Carter 2010.168, Fig. 5.2*); b) Ras Shamra, carnelian (from* von Wickede 1990.Pl. no. 186*); c) Domuztepe Dt 3, serpentinite (from* Carter 2010.168, Fig. 5.17*); d) Arpachiyah A 18, steatite (from* Mallowan, Rose 1935.93, Fig. 50.15*; drawing adapted from* von Wickede 1990*); e) Domuztepe Dt 492, dark red clayey slate (from* Carter 2010.170; Fig. 5.24*); f) Tell Halaf, Limestone (from* von Wickede 1990. Pl. no. 207*); g) Domuztepe Dt 140, serpentinite (from* Carter 2010.170, Fig. 5.33*); h) Arpachiyah A 583, steatite (from* Mallowan, Rose 1935.583, Pl. VIIa*; drawing adapted from* von Wickede 1990*); i) Arpachiyah A 13, limestone (from* Mallowan, Rose 1935. 94, Fig 51.10*; drawing adapted from* von Wickede 1990.Pl. no. 133*); j) Domuztepe Dt 171, serpentinite (from* Carter 2010.172, Fig. 6.1*); k) Sabi Abyad sealing impression (from* Akkermans, Duistermaat 2004.7, Fig. 4.19*); l) Sabi Abyad sealing impression (from* Duistermaat 1996. 359, Fig. 5.3, C 1.1*); m) Sabi Abyad sealing impression (from* Duistermaat 1996. 359, Fig. 5.3, B 2.1*); n) Arpachiyah A 895 (B), limestone (from* Mallowan, Rose 1935.Pl. 6. A*; drawing adapted from* von Wickede 1990*); o) Arpachiyah, steatite (from* Mallowan, Rose 1935.93, Fig 51.4, Pl. VI a.11*); p) Sabi Abyad, sealing impression (from* Duistermaat 1996.362, Fig. 5.6, T1.1*).

tools. Together with a concentration of miniature vessels, tokens, discs and figurines, the sealings came from the Level 6 settlement known as the 'Burnt Village', a well-established community with large, closely spaced rectangular buildings and many small *tholoi* that were largely destroyed by fire around 6000 BC (*Akkermans, Verhoeven 1995; Akkermans, Duistermaat 1997*). The sealings were concentrated within particular rooms of extensive architectural complexes, where they appear to have been placed after having been removed from the sealed objects (*Duistermaat 1996*). Actual stamps have also been recovered from other contexts at Sabi Abyad, and 15 of these stamps have been published (*Duistermaat 1996; Akkermans, Duistermaat 2004*).

The sealings were apparently used to mark food or other commodities that may have been kept in straw baskets or stone or clay containers (*Akkermans, Duistermaat 1997*). Often, the same surface was covered with multiple impressions of the same seal. Considerable variation was observed among motifs, which comprised a total of 67 separate types of imagery, most frequent among caprines (17%), 'S'-shaped motifs possibly representing snakes (10%) and zig-zag motifs possibly representing scorpions (5%). Through a complex set of arguments, the excavators concluded that the Burnt Village served the storage needs of pastoralists travelling in the Balikh Valley, and that the practice of sealing was used to keep a record of the commodities secured by sedentary groups at the site (*Akkermans, Duistermaat 1997; Verhoeven 1999*).

Alwo von Wickede (*1990*) recorded 43 sealings and 130 stamps from various 6th millennium BC contexts, mostly from Arpachiyah, with smaller numbers from Chagar Bazar, Tell Hassan, Gird Banahilk, Tepe Gawra and Yarım Tepe. Some of the best-crafted artefacts from Arpachiyah were found at the Burnt House, the rich archaeological context of Tt 6, which is believed to have been a communal storage area for valuable objects such as figurines, finely made pottery and stamps before it was intentionally burnt during the abandonment of the site (*Mallowan, Rose 1935; Campbell 2000*). At the Burnt House, 41 sealing impressions, apparently created from 26 stamps, were recovered along with other valuable objects.

Evidence of sealing and stamping practices varies substantially among sites. At the 20ha site of Domuztepe in Kahramanmaraş, Turkey, for example, approx. 150 stamps, pendants and related objects were collected, whereas very few sealings were encountered (*Denham on-line*). At Domuztepe, stamps and pendants were not found within a discrete building; rather, nearly one-third of the stamps and pendants found at Domuztepe were encountered during the surface survey of the site, and the rest were found within archaeological deposits from the late 7th through the early 6th millennium BC. In particular, the 'Death Pit', a communal burial context, was a rich find context for stamps and pendants (*Campbell* et al. *1999; Carter* et al. *2003*). Most of the stamps were carved from serpentinite, a local stone, although jasper, alabaster, steatite, limestone, quartzite and sandstone were also used.

Various attempts have been made to reveal the social function of the late 7th and 6th millennium BC period stamp seals. For example, Frangipane's argument draws attention to their use as identity markers, albeit the term 'identity' begs the fundamental question of how personhood was constructed in social contexts in the 7th and 6th millennium BC (*Fowler 2002; 2004; 2010*). Frangipane (*2007.159*) argues that, "*the similarity between the different groups of seal design comprising very specific iconographic sets, each of which was characterized by the repetition of a particular motif, indicates that the seal-holders withdrawing the goods must have been members and representatives of different households or clans, each one symbolized by a dominant motif, perhaps a kind of identity symbol.*" In a critical light, however, the similarity between images carved on the stamp surfaces would probably make for a very inefficient form of individualised or group marker to be used in property control on any scale. Nevertheless, it is certainly possible that such signs of 'membership' were shared beyond individual households to clans or tribal groups, and linked together numerous communities within a cultural system of integration.

In an attempt at a more holistic interpretation, Sarah K. Costello (*2000; 2011*) argued that tokens, seals and even writing should not be viewed as functional solutions to the administrative needs of the first states. Rather, she postulated that stamp images carry meaning, in many cases religious, and that the earliest context of writing was intertwined with a long visual and symbolic tradition rooted in religious belief and practice. Yet, by referencing one particular shaft straightener from the PPNA site of Jerf el-Ahmar, Costello traced the history of a quadruped-snake-raptor image trilogy to the detriment of other rich and often much more significant imagery of the 7th and 6th millennium BC, such as the crosshatching design commonly found on the geometrically shaped seals of the period.

It is possible that the previous approaches to the Late Neolithic stamps and related image-bearing objects have assumed that if a certain set of imagery appeared in 'writing', then these imagery and or similar looking objects could be selectively sought out in prehistory and assembled as a backdrop to a progressively evolving administrative and religious system within which writing became practically perceivable. However, the success of any approach linking early imagery to the emergence of writing or to the development of central authority requires an understanding of the processes and practices through which selected elements of prehistoric imagery survived and were reproduced within the administrative record system of temple-states. With this framework, this study aims not to solve the riddle of the emergence of writing, but to understand the role played by stamps and pendants in the symbolic construction of communities in later Neolithic Northern Mesopotamia.

Theoretical concepts

From a material culture perspective, humans have no pre-discursive existence; rather they become themselves through experience, interaction and discourse. Identity and self are constructs that must be perpetually constituted through social action. Within this context, objects operate as important active agents of symbolic construction of community and of an ever-unfolding process of social change within which a continuous categorisation, communication and negotiation of the conceptual world take place. Human beings manipulate objects to express ideas. However, meaning in symbolic communication is always contextual and fluid; thus, symbolic objects are best approached as attention-capturing devices that attract and divert attention to concepts in need of evaluation (*Donald 1991*). Situated within a complex set of social affiliations ranging from family to progressively more encompassing levels of community, individuals are able to negotiate and elaborate on their position at the intersection of social boundaries through the continuous manipulation of material culture. Objectification, abstraction, portability and alienation should be viewed as manipulative technologies that emerge through the dialogue between the person and the collective (*Dobres, Hoffman 1994; Dobres 1995; 2000; Tilley 2006*).

For example, the contexts through which objects are attained and distributed can be appropriated or controlled through ritualised acts in such a way that the objects are ultimately alienated from their original contexts of production. Symbolically-laden objects may be distributed after painful body manipulations or competitive displays of skill during initiation ceremonies in which the body would have been appropriated for different stages of personhood. At large events, social power and hierarchy may be demonstrated through taboos regarding the body, place and food preparation. In order to attain, produce, carry and display objects of social membership, individuals may be increasingly required to demonstrate that they possess the skills, knowledge and responsibility expected of them in order to engage in increasingly hierarchical spheres of the social world.

Often, the body becomes a negotiable space through the symbolic agency of objects, which aids in the enchainment of the self within a world of other beings (*Chapman 2000*). A person is who s/he is because s/he uses certain objects, lives in certain places, eats in certain ways and practices certain acts. Those who wish to join or remain part of a social group must display his or her capacity to be part of any social sphere by responsibly engaging in social relations with all the encountered entities of daily existence – observing taboos, behaving and speaking appropriately and remaining conscious of the fact that every thought and action has wider implications. Failure to honour the obligations of personhood can be dangerous, as one who does not follow certain rules and practices may be made into an 'other'. Within this context, persons may be either forbidden or permitted to prepare their body with special haircuts, tattoos, *etc.* and to produce and consume certain foods in relation to their identities. Food preparation taboos are a particularly important subject for those who come from different cultural backgrounds. Through such symbolic displays, an environment of trust and cooperation can be created to allow social exchanges to take place.

In this context, style can be perceived as a product of the intersection of the person and the structuring principles of community that s/he manipulates to re-produce social boundaries (*Wobst 1977; Kopytoff 1986; Carr, Neitzel 1995; Gosden, Marshall 1999*). Therefore, in seeking to recover the relations between objects and their social context, any stylistic analysis requires an exploration of how a given form is determined by its position in a sequence of changing forms, what an image depicts as its subject matter and how an image expresses or even constitutes social relations (*Lesure 2011.51, Fig. 17*). Also within this context, an important part of the 'message' may be embedded within an object's specific material qualities such as durability, redundancy, transferability and expression of investment (*Donald 1991; Prijatelj 2007; Gamble 2008*) that expand the symbolic performance characteristics of

Material attributes of affiliation	***Material attributes of status and social differentiation***
Similarity in shape, size, decoration, craftsmanship	Differentiation and variation in shape, size, decoration and craftsmanship
High numbers	Low numbers
High visibility (through monumentality or portability)	Management of social boundaries through manipulation of image abstraction
Distribution over wide spatial ranges, with emphasis on social integration	Different materials (*e.g.*, stone, clay) carrying different messages
Spatial variations	***Chronological changes***
Variation in the frequency of occurrence of different styles within a specific class of items should be evaluated within the context of other material media at a specific site in order to assess variant social strategies within a cultural horizon.	Change in the frequency of occurrence of different styles within a specific class of items should be evaluated over time and within the context of other material media at a specific site in order to assess the introduction of new strategies of manipulation.

Fig. 3. Suggested material attributes of social affiliation.

the raw material by opening up new possibilities of communication between different scales of audience.

Within a given class of objects, variations in material, craftsmanship and levels of abstraction may signal membership of different social spheres within and between groups (Fig. 3). Different degrees of craftsmanship may be an indication of different degrees of skill, and in social terms, one may expect that a person carrying a highly crafted object aims to be distinguished from others. This status may be achieved over a lifetime, as an individual moves through consecutive stages of personhood and demonstrates the capacity to carry out increasingly more complex social performances. Like craftsmanship, abstraction is another strategy for manipulating social boundaries. Abstract items are often ambiguous and require exegesis by those who can understand and interpret their symbolism. Therefore, one may expect that the bearers of abstract items understand the significance and meaning of the objects with which they are associated. The frequency with which one encounters abstract and/or highly crafted objects may be another indicator of access to knowledge and power domains. For example, high numbers of a particular class of items may indicate an emphasis on social inclusion, whereas low numbers of a specific set of imagery may indicate segregated power domains controlled by a limited number of individuals.

I suggest that the prolific use of highly abstract, elaborately crafted portable objects such as stamp seals may reflect a need to expand, as well as limit the boundaries of social identity. The objects under consideration may be viewed as a field of symbolic technology that empowered individuals to strategically negotiate their position within an existing social grid. That is to say, seals and sealing practices may not necessarily reflect capitalistic exchange and ownership relations during the 6th millennium BC; instead, this period may be perceived as one in which social positions were negotiated by material practices, which allowed for the symbolic constitution of personhood and community in new ways.

The evidence

Within the framework of this analysis, stamps and related image bearing objects were reviewed from the sites of Arpachiyah, Domuztepe, Tell Ain el-Kerkh, Sabi Abyad, Tell Halaf, Yarım Tepe, Chagar Bazaar and Ras Shamra. While not all of the items are presented here, examples of most of the representative types are shown in the text figures, and regional differences in style preferences are duly noted. Whereas the frequency of occurrence and the degree of abstraction and craftsmanship of the different types may have changed over time, such an analysis would require more accurate chronological and spatial data than what is available; therefore, this analysis is by necessity limited to the reconstruction of discursive relations between the items of the analysed sets as a whole. Such an analysis is more capable of revealing image-shape relations and a very general level of chronological and spatial variation than it is of performing a comprehensive chronological and spatial evaluation at the site level.

The stamps and seals assessed here may be classified into three categories and sub-categories as follows:

A. Irregular geometric forms:
   A.1. Deltoid; A.2. Bulbous ovoid; A.3. Ovoid with tip-marking or tip-denticulation; A.4. ‘Sickle’ and ‘foot’; A.5. Trapezoid and pyramid.

B. Regular geometric forms:
   B.1. Rectangular; B.2. Circular; B.3. Polypartite rosette; B.4. Quatrefoil rosette; B.5. Triangle and axe.

C. Naturalistic forms:
   C.1. Bird; C.2. Caprine; C.3. Snake; C.4. Scorpion; C.5. Unidentified animal (Varanus lizard?); C.6. Humanoid; C.7. Bucranium; C.8. House; C.9. Angels; C.10. Double-axes.

A. Irregular geometric forms

These types are found both in pendant and back-loop handle forms and occur in relatively high numbers. Within the irregular forms, five different types can be recognised:

A.1. Deltoids (Fig. 4): The deltoid objects are essentially comprised of two parts: a smooth, bulbous part and a long pointed part. Although there may be

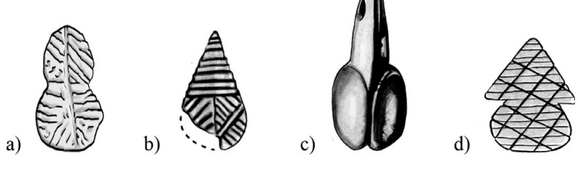

Fig. 4. Type A.1. Deltoids: a) Tell Ain el-Kerkh (from* Tsuneki 2011.95, Fig. 21*); b) Domuztepe Dt 137, serpentinite (from* Carter 2010.170, Fig. 5.32*); c) Arpachiyah A 17, brown limestone (from* Mallowan, Rose 1935.94, Fig. 51.6*); d) Arpachiyah A 583, steatite (from* Mallowan, Rose 1935.Pl. VIIa*).

highly abstract items within this range, many of them appear to be phallic.

A.2. Bulbous ovoids (Fig. 5): These are usually in pendant form and are encountered at most sites in moderate numbers. The imagery and shape may connect some of these forms to the bulbous part of the deltoids (compare Figs. 4.a and 5.e, f.). At Arpachiyah, bulbous ovoids comprise the majority of all the pendant-shaped stamps encountered.

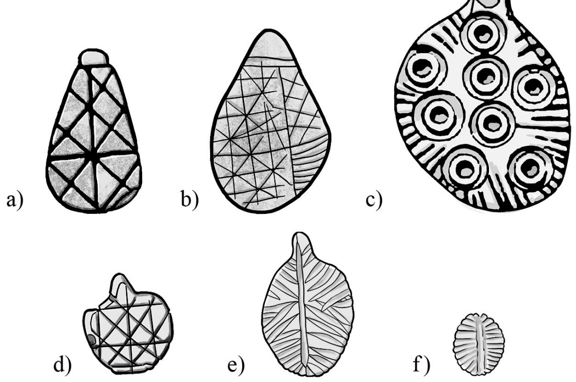

Fig. 5. Type A.2. Bulbous ovoids: a) Arpachiyah A 13, grey stone (from* Mallowan, Rose 1935.94, Fig. 51.10*); b) Arpachiyah, A 1, steatite (from* Mallowan, Rose 1935.93, Fig. 50.7*); c) Tepe Gawra, marble (from* Tobler 1950.31, Pl. 172*); d) Arpachiyah A 10, steatite (from* Mallowan, Rose 1935.93, Fig. 50.4*); e) Yarimtepe II (from* von Wickede 1990.Pl. no. 126*); f) Tell Ain el-Kerkh (from* Tsuneki 2011. 95, Fig. 21*).

A.3. Ovoids with tip-marking or tip-denticulation (Fig. 6). This group includes items with various forms of tip denticulation. The so-called 'hands' (Fig 6.b, c), which are encountered rarely, but consistently, at many sites, may be considered within this set.

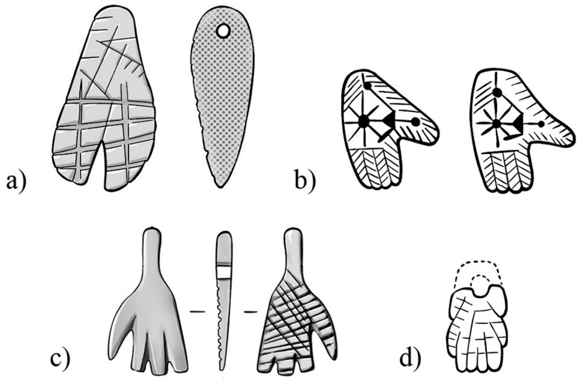

Fig. 6. Type A.3. Ovoids with tip-marking or tip-denticulation: a) Yarım Tepe II, steatite (from* von Wickede 1990.Pls. no 162*); b) sealing impression from Arpachiyah A 619 (from* Mallowan, Rose 1935. Pl. 9b*); c) Domuztepe Dt 171, serpentinite (from* Carter 2010.172, Fig. 6.1*); d) Arpachiyah A 9, steatite, from* Mallowan, Rose 1935.94, Fig. 51.1*).

A.4. 'Sickles' and 'feet' (Fig. 7): The so-called sickles and feet may be stylistic variations on deltoids and ovoids (Figs. 4, 5, 6). The high frequency with which they are encountered at Arpachiyah suggests some specific social significance for this site.

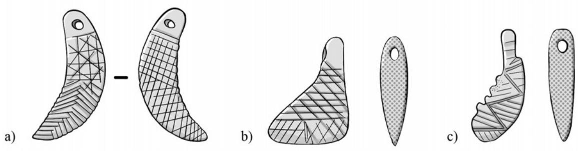

Fig. 7. Type A.4. 'Sickles' and 'feet': a) Arpachiyah A 16, steatite (from* Mallowan, Rose 1935.93, Fig. 50.25*); b) Arpachiyah A 557, quartzite (from* Mallowan, Rose 1935.Pl. 8a*); c) Arpachiyah, A 882, steatite (from* Mallowan, Rose 1935.93, Fig. 50.27*).

A.5. Trapezoids and pyramids (Fig. 8): These types are regularly encountered at many sites. The form may be a variation of the deltoids (Fig. 4) and/or humanoid forms (Fig. 19).

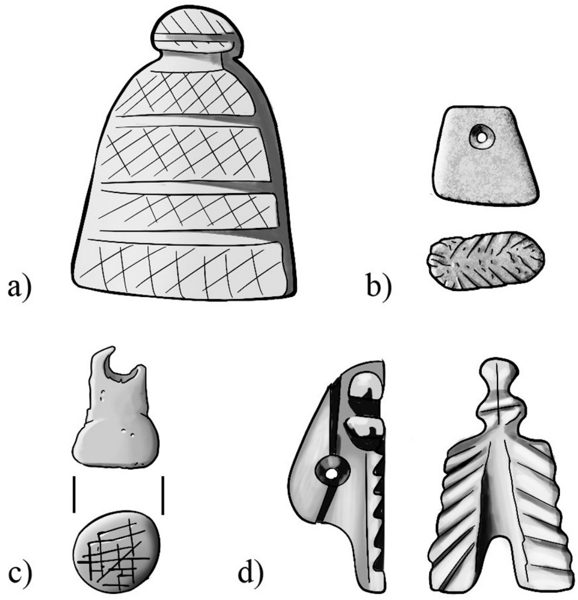

Fig. 8. Type A.5. Trapezoids and pyramids: a) Arpachiyah A 58l, limestone (from* Mallowan, Rose 1935.93, Fig. 50.10*); b) Domuztepe Dt 303, turquoise-coloured stone, possibly serpentinite (from* Carter 2010.172, Fig. 6.2*); c) Domuztepe Dt 4748, quartz (courtesy of Stuart Campbell, Domuztepe excavations); d) Sabi Abyad (from* Akkermans, Duistermaat 2004.4, Fig. 2.3*).

B. Regular geometric forms

These include rectangular, circular, triangular and rosette forms that occur in relatively high numbers. Well-made pieces and loop-handle stamp forms are encountered most frequently, although smaller and less well-made items may also be encountered. Regular geometric forms frequently bear abstract imagery of crosshatching, eyeholes, or a composition of parallel and perpendicular lines. Also, the surfaces were sometimes divided into four sections in a manner very similar to that of the quatrefoil rosette forms (Fig. 12). Otherwise, the surface may sometimes be divided into two sections in a manner similar to the bulbous ovoids (Fig. 5.e, f) and double-axe forms (Fig. 23). Rarely encountered relatively larger and heavier block styles and highly crafted polyfoil rosettes are also included within this category of items.

B.1. Rectangulars (Fig. 9): Rectangular stamps are by far the most commonly encountered objects at many sites of the period. The surfaces are usually decorated with crosshatching, eyeholes, or a distinct composition of parallel and perpendicular lines. Four partite versions, such as Figures 9.d and 9.e, may be variations of the proper quatrefoil rosette forms (Fig. 12). Figure 9.g may be a variation of Figure 10.b, both of which appear to be related to the bulbous ovoids (Fig. 5.e,f) as well as the lower portion of the deltoids (Fig. 4.a–c). The objects with 'eyeholes' (Fig. 9.f, h) may be a variation that referred to the eyeholes on such objects as demonstrated in Figures 11.a and 19.

B.2. Circulars (Fig. 10): Circulars are also among the most commonly encountered types, along with the rectangular forms. Like rectangulars, they can

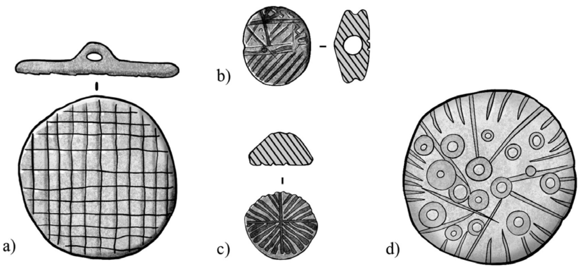

Fig. 10. Type B.2. Circulars: a) Arpachiyah A 18, steatite (from* Mallowan, Rose 1935.93, Fig. 50.15*); b) Domuztepe Dt 133, serpentinite (from* Carter 2010.167, Fig. 4.2*); c) Domuztepe Dt 492, dark red clayey slate (from* Carter 2010.170, Fig. 5.24*); Tell Halaf, limestone (from* von Wickede 1990.Pl. no. 207*).

have crosshatched surfaces, sometimes with eyeholes. Alternatively, some object surfaces may be two partitioned, or the surface may be four partite in a similar way to the rosettes. Four partite versions, such as Figure 10.c, may be a variation of the proper quatre-

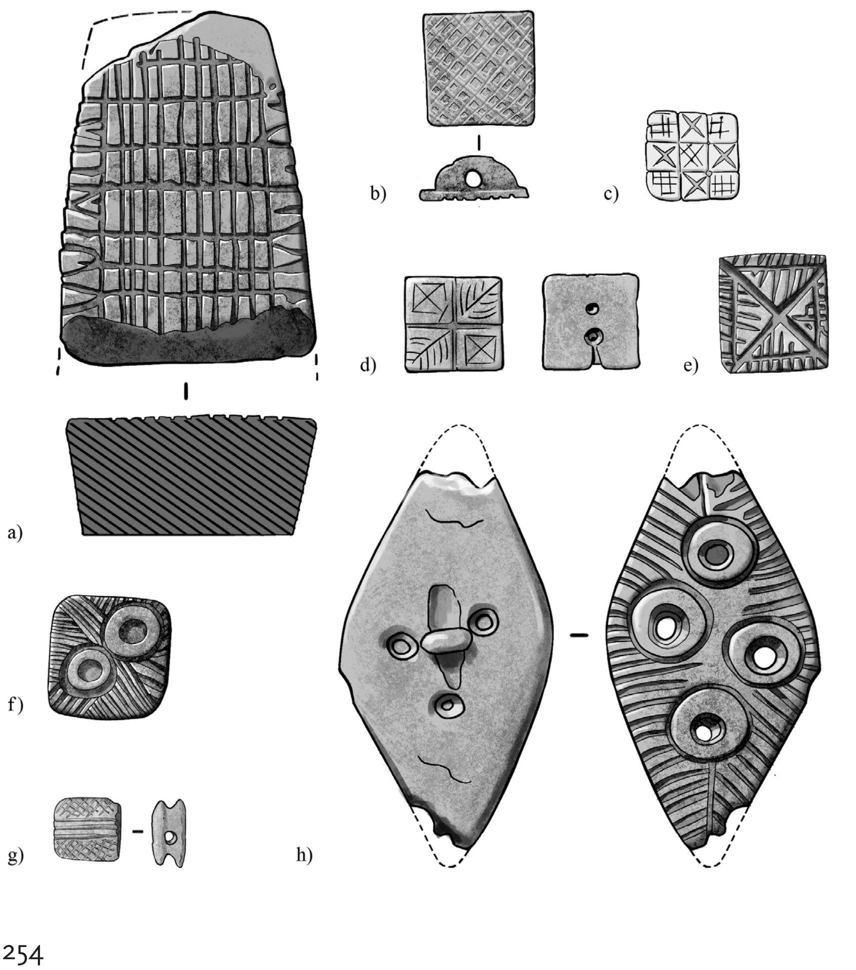

Fig. 9. Type B.1. Rectangulars: a) Domuztepe Dt. 717, gypsum block style (from* Carter 2010.172, Fig. 8.1*); b) Domuztepe Dt 2804, serpentinite (from* Carter 2010.168, Fig. 5.2*); c) Arpachiyah A 574, limestone (from* Mallowan, Rose 1935.Pl. 7a*); d) Ras Shamra, carnelian (from* von Wickede 1990.Pl. no. 186*); e) Domuztepe, Dt 1683, serpentinite (from* Carter 2010.168, Fig. 5.12*); f) Domuztepe Dt, serpentinite (from* Carter 2010.168, Fig. 5.10*); g) Domuztepe Dt 1787, quartz (?) (from* Carter 2010.167, Fig. 4.1*); h) Domuztepe Dt 180, serpentinite (from* Carter 2010.170, Fig. 5.23*).

foil rosette forms (Fig. 12). Figure 10.b may be a variation of Figure 9.g, both of which appear to be related to the bulbous ovoids (Fig. 5.e, f), as well as the lower portion of the deltoids (Fig. 4.a–c). The objects with 'eyeholes' (Fig. 10.d) may be a variation that referred to the eyeholes on such objects as demonstrated in Figures 11.a and 19.

B.3. Polypartite rosettes (Fig. 11): Examples of polypartite rosette forms have been recovered at many Northern Levantine sites, as well as at Domuztepe. Along with small and less skilfully made examples (Fig. 11.b, c), some highly crafted objects (Fig. 11.a) can be found within this range of objects. The polypartite rosette imagery frequently appear on some of the most remarkable painted pottery known from Arpachiyah, and are usually symmetrically placed at the inner centre of the pottery in association with surrounding quatrefoil rosette imagery. In the stamp corpus, this centre may take the shape of an eyehole. Apparently, the depiction of this central hole added potency and meaning to the whole image.

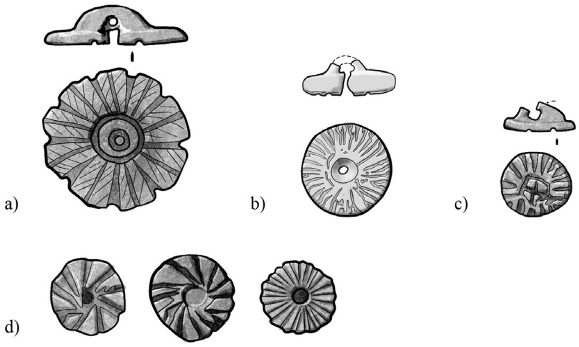

Fig. 11. Type B.3. Polypartite rosettes: a) Domuztepe Dt 168, serpentinite (from* Carter 2010.170, Fig. 5.31*); b) Domuztepe Dt 1113, serpentinite (from* Carter 2010.170, Fig. 5.26*); c) Domuztepe Dt 1684, coral-coloured quartz (from* Carter 2010.170, Fig. 5.25*); d) Tell Ain el-Kerkh (from* Tsuneki 2011.95, Fig. 21*).

B.4. Quatrefoil rosettes (Fig. 12): Quatrefoil rosette forms are also among the most commonly encountered types. The foils may be shaped as pointed tips (Fig. 12.a–c) or may have wide edges (Fig. 12.d–f). Quatrefoil rosette forms with pointed foils appear to be associated with either full crosshatching designs (Fig. 12.a) or a simple cross at the tip (Fig. 12.c). Quatrefoil rosettes with wide-edged foils are commonly decorated with multiple parallel and perpendicular lines, sometimes accompanied by a deeply incised line running perpendicular to the outer edge of the foils. In terms of both their shape and decoration, the quatrefoil rosette forms may be considered a close relative of the rectangular and circular forms (Figs. 9 and 10). Some of the triangular objects (which may be related to the deltoid forms) are crafted in a manner similar to the rosette foils (compare Figs. 12.f and 13.a).

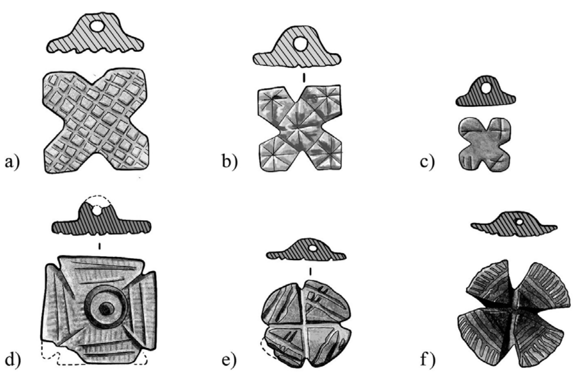

Fig. 12. Type B.4. Quatrefoil Rosettes: a) Domuztepe Dt 3, serpentinite (from* Carter 2010.168, Fig. 5.17*); b) Domuztepe Dt 48, flint (from* Carter 2010.168, Fig. 5.16*); c) Domuztepe Dt 2, serpentinite (from* Carter 2010.168, Fig. 5.15*); d) Domuztepe Dt 244, sandstone (from* Carter 2010.168, Fig. 5.19*); e) Domuztepe Dt 353, serpentinite or flint(?) (from* Carter 2010.170, Fig. 5.30*); f) Domuztepe Dt 1687, serpentinite (from* Carter 2010.170, Fig. 5.29*).

B.5. Triangles and axes (Fig. 13): Triangular objects are also commonly encountered, although not as frequently as the rectangular, circular or rosette forms. They appear to be highly stylised versions of some of the deltoid (compare Figs. 13.a-upside down and 4.b) and ovoid types (compare Figs. 5.a and 13.b). The shape and imagery suggest that some of these objects are crafted in a manner similar to rosette foils (compare Fig. 12.f and 13.a). The cattle/bull horns in Figure 20.b have striking similarities to Figure 13.c.

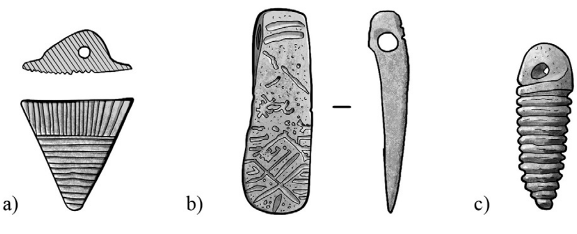

Fig. 13. Type B.5. Triangles and axes: a) Domuztepe Dt 140, serpentinite (from* Carter 2010.170, Fig. 5.33*); b) Domuztepe Dt 3601, serpentine (courtesy of Stuart Campbell, Domuztepe excavations); c) Domuztepe Dt 242, serpentinite(?) (courtesy of Stuart Campbell, Domuztepe excavations).

C. Naturalistic types

These are highly expressive types encountered rarely, but consistently. Various animal and humanoid and house forms were particularly popular in the Northern Mesopotamian context.

C.1. Birds (Fig. 14): Birds, together with houses, are often encountered as pottery decoration.

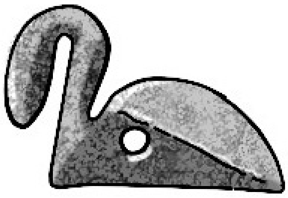

Fig. 14. Arpachiyah A 870 (B), steatite (from* Mallowan, Rose 1935.94, Fig. 51.7*).

C.2. Caprines (Fig. 15): Caprines are frequently encountered in the later 7th millennium BC contexts of Sabi Abyad.

Fig. 15. Sabi Abyad sealing impression (from* Duistermaat 1996.359, Fig. 5.3, A1.1*).

C.3. Snakes (Fig. 16): Snakes are understood to be one of the earliest symbolically depicted animals in Northern Mesopotamia. They were frequently encountered at the pillars of the late PPNA contexts of Göbekli Tepe. In the stamp corpus, the snake imagery was most commonly observed in late 7th millennium BC contexts of Sabi Abyad. Snakes also appear on decorated pottery of the 6th millennium, although rarely.

a) b)

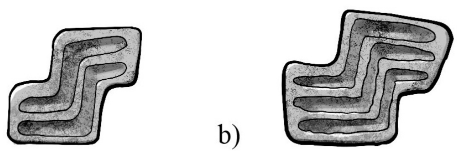

Fig. 16. a) Sabi Abyad sealing impression (from* Duistermaat 1996.359, Fig. 5.3, C1.1*); b) Sabi Abyad sealing impression (from* Duistermaat 1996. 359, Fig. 5.3, C3.1*).

C.4. Scorpions (Fig. 17): Scorpions were also among the most commonly depicted animals at the PPNA site of Göbekli Tepe. Like the snake imagery, scorpion images are highly stylised versions of the real thing.

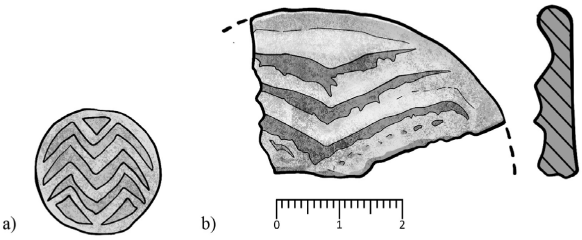

Fig. 17. Sealing impression: a) Sabi Abyad sealing impression (from* Duistermaat 1996.359, Fig. 5.3, B 2.1*); b) Domuztepe block stamp Dt. 444, serpentinite (from* Carter 2010.17, Fig. 8.3*).

C.5. Unidentified animals (Fig. 18): The image of a quadruped with spread legs is a common motif in many Early Neolithic contexts. A relief image of a Varanus lizard, a dangerous species that lives in the desert and camouflages itself in the sand, was depicted on one of the pillars at Göbekli Tepe. However, it is difficult to identify the animals depicted on the later 7th and 6th millennium stamps of Northern Mesopotamia.

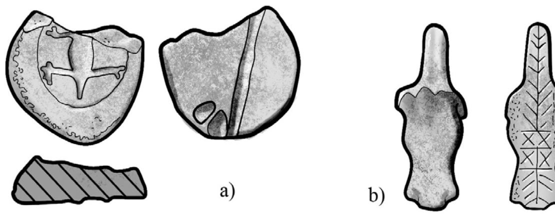

Fig. 18. Type C.5. Unidentified animals: a) Sabi Abyad sealing impression (from* Akkermans, Duistermaat 2004.7, Fig. 4.19*); b) Gogjali near Arpachiyah A 887, steatite (from* Mallowan, Rose 1935. 94, Fig 51.9*).

C.6. Humanoids (Fig. 19): In PPNA and PPNB contexts the pillars encountered at Göbekli Tepe, Yenimahalle and Nevalı Çori were considered anthropomorphic and were strongly associated with maleness. The eyes on Figure 19.a and 19.b may be linked with the eyeholes depicted on items in Figures 9.f–h and 10.d. Figure 19.c may be a variation of a so-called angel form at Figure 22.b.

C.7. Bucrania (Fig. 20): Bucrania are considered among the most significant imagery of the later Neolithic. The stamp or pendant forms are encountered at many sites, albeit in very small numbers. They bear stylistic resemblances to some deltoid forms (*e.g.*, Fig. 4.c upside down) as well as the house form in Figure 21. Also, note the similarity between the possibly phallic drill in Figure 13.c and the bucrania in Figure 20.b.

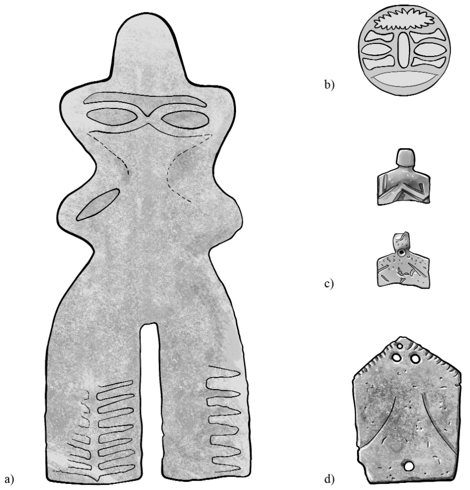

Fig. 19. Type C.6. Humanoids: a) Sabi Abyad sealing impression (from* Duistermaat 1996.362, Fig. 5.6, T1.1*); b) Sabi Abyad sealing impression (from* Duistermaat 1996.360, Fig. 5.4, G1.1*); c) Domuztepe pendant (courtesy of Domuztepe excavations); d) Domuztepe Dt 352, serpentinite (courtesy of Domuztepe excavations).

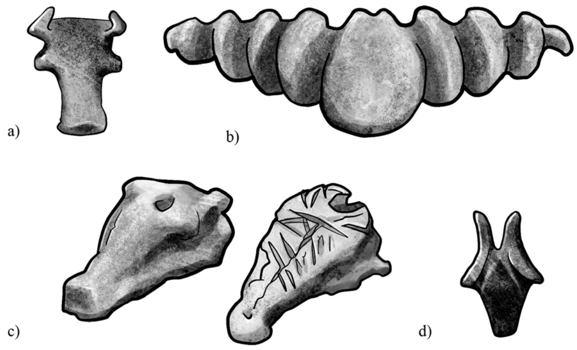

Fig. 20. Type C.7. Bucrania: a) Arpachiyah A 895 (B), limestone (from* Mallowan, Rose 1935.Pl. 6.a*); b) Domuztepe (courtesy of Stuart Campbell, Domuztepe excavations); c) Chagar Bazaar, marble (from* Mallowan 1936.Pl. 7.33*); d) Domuztepe (courtesy of Stuart Campbell, Domuztepe excavations).

C.8. House (Fig. 21): House depictions are sometimes encountered on the painted pottery of the period. One rare example in stamp form, which is shown in Figure 21, comes from Arpachiyah, and the stylistic links between this object and some of the bucrania forms (Fig. 20.a upside down) as well as deltoid forms (Fig. 4) is worth mentioning.

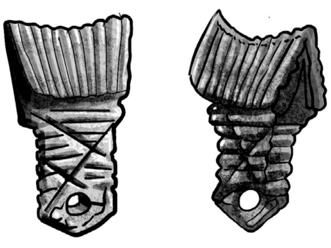

Fig. 21. Arpachiyah, steatite (from* Mallowan, Rose 1935.93, Pl. VI a.11, Fig. 51.4*).

C.9. 'Angels' (Fig. 22): The so-called angels may be associated with more abstract forms such as the phallic deltoids (Fig. 4) or some rosette styles (Fig. 12.d). It is also possible to note the connection of the imagery between the triangular forms (*e.g.*, Figs. 13.a and 22.a). In some ways, Figure 22.b can also be associated with the humanoid form in Figure 19.c.

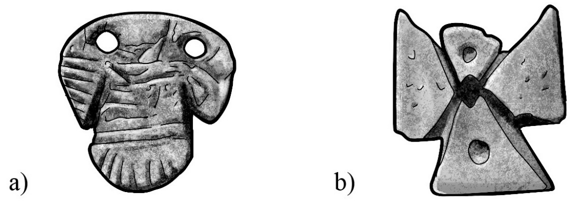

Fig. 22. Type C.9. Angels: a) Domuztepe Dt 6560 (courtesy of Stuart Campbell, Domuztepe excavations); b) Arpachiyah A 860, steatite (from* Mallowan, Rose 1935.Pl. VI.b*).

C.10. Double axe (Fig. 23): What has been termed a double axe at Arpachiyah by Max Mallowan, is a specific design which resembles a two-foiled rosette (Figs. 9.g and 10.b). Also, the bulbous portion of the arguably phallic deltoid forms may be linked with this image (Fig. 4.a–c).

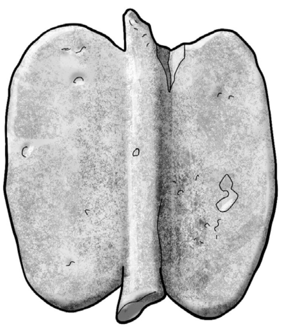

Fig. 23. Arpachiyah A 865 (B), steatite (from* Mallowan, Rose 1935.Pl. VI.b*).

The discourse of stamp seals

The comparative relationships mentioned in the presentation of evidence is summarised in Figure 24. Within this context, both the quatrefoil and polypartite rosette forms may be understood as highly stylised composite depictions of male genitalia. If at least some of the deltoids and ovoids are variant depictions of the male sexual organ, the sickles and so-called feet may represent a special body wrapping or manipulation technique which may have been emphasised at Arpachiyah.

Some stylistic similarities between the broken figurines of Sabi Abyad (Fig. 25) and the stamp seals may strengthen the view that the objects under consideration refer to various parts of the male sexual organ. In the case of the circular objects with central eyeholes, it is possible that a particular emphasis may have been placed on the potency of either the upper tip or the lower root of the phallus. The phallic imagery is also noteworthy in the context of the house and bucrania pendants; the stylistic similarities between the house (Fig. 21), bucrania (Fig. 20) and the relatively more overt phallic objects (*e.g.*, Figs. 22.a and 4.c) within the same material corpus may indicate that concepts of male fertility and house-based social continuity were manipulated and linked in very special circumstances, as the bucrania or house shaped objects are rare and were probably used by ritual specialists.

In terms of the overall image and shape relations, no one stamp or pendant is precisely the same as another, and some very distinctive styles were achieved. However, the majority of objects can be classified into a limited repertoire of geometric shapes that appear to have been produced by a technique whereby the raw material was reduced to a sequence of rectangles, circles, quatrefoil or polyfoil rosettes, triangles and ovoids. The suggested chain of reduction also appears to be related to a particular discursive relationship between the objects (Fig. 26). The regular geometric forms are often associated with the crosshatch decoration. The rosette forms provide a transitional link between regular and irregular forms, whereas the naturalistic forms fall into an entirely different category and include various wild animals, bucrania, houses and human shapes.

In terms of decoration, the following three general categories emerge, all of which can be combined through the division of the surface into two or more sections:
❶ crosshatching,
❷ a set of parallel and perpendicular lines,
❸ eyeholes.

Overall, the objects appear to form a discursive field that links irregular phallic shapes with more complex forms within relatively more abstract and frequently encountered regular types and relatively more expressive but rarely encountered naturalistic types (Figs. 27 and 28).

In further interpretive terms, objects exhibiting a higher degree of stylistic concern, such as the rosettes or crosshatched rectangles, are likely to have been associated with people who understood their performative and narrative power (Figs. 29 and 30). While the level of abstraction may have been associ-

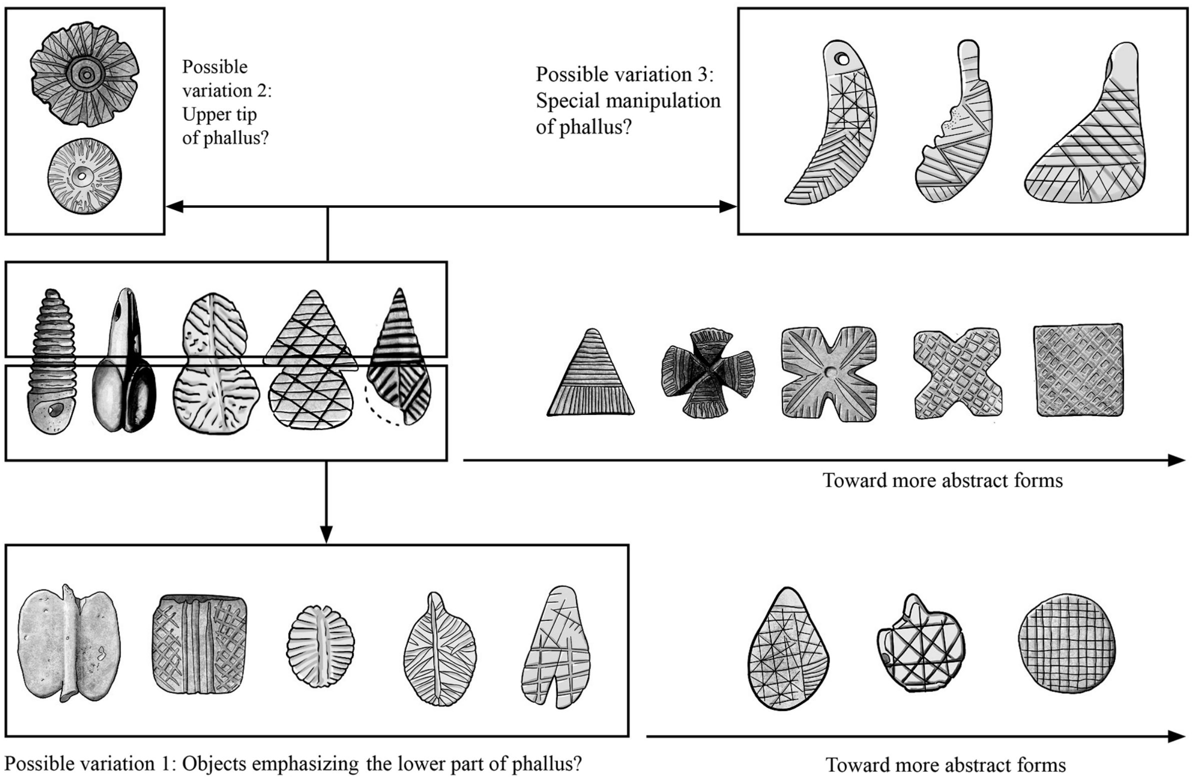

Fig. 24. Links between various stamp forms.

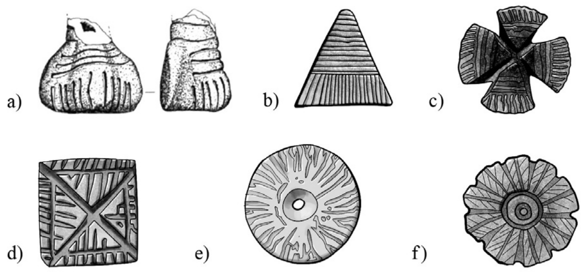

Fig. 25. Clay figurines and stamp seals: a) clay figurine from Sabi Abyad (from* Collet 1996.410, Fig. 6.2*); b) Domuztepe Dt 140, serpentinite (from* Carter 2010.170, Fig. 5.33*); c) Domuztepe Dt 1687, serpentinite (from* Carter 2010.170, Fig. 5.29*); d) Domuztepe, Dt 1683, serpentinite (from* Carter 2010.168, Fig. 5.12*); e) Domuztepe Dt 1113, serpentinite (from* Carter 2010.170, Fig. 5.26*); f) Domuztepe Dt 168, serpentinite (from* Carter 2010. 170. Fig. 5.31*).

ated with enhanced stages of personhood and community membership, the relatively high numbers of items with crosshatching may indicate that their distribution was not as limited as the naturalistic items, which were probably used by a few people only and on very special occasions at which powerful concepts were invoked in order to manipulate existing narratives of the social landscape. It is important to note that some of these images are associated with earlier Neolithic contexts, suggesting that they may have been connected to highly specialised knowledge and persons who were capable of consulting and manipulating the past and present.

At a different level, recognisable regional and/or chronological differences exist in terms of the frequency in which different types have been found. For example, in the late 7th millennium BC context of Sabi Abyad, a high frequency of animal images such as snakes, scorpions and anthropomorphic shapes were encountered. These images are reminiscent of the PPNA and PPNB imagery known from Göbekli Tepe (*Schmidt 2000; 2010*). On the other hand, large numbers of irregular ovoid pendant forms were found at the 6th millennium BC sites at Arpachiyah, whereas at the roughly contemporary site of Domuztepe, rectangular and quatrefoil rosettes were encountered more frequently.

Site-based differences may actually reflect regional differences. In Von Wickede's work on stamps and pendants of the 7th and 6th millennium BC (*von Wickede 1990*), ovoid pendants appear with noticeably greater frequency in Northern Iraq at sites such as Yarım Tepe and Arpachiyah. In the Levant, both regular and irregular geometric shapes were in use, although the regular shapes are encountered more often. Nevertheless, within a local community of stamp-seal users, individuals appear to have had a degree of freedom to choose from an iconographic set, perhaps to add to it creatively, within a permissible range, and thus personalise these items. This practice indicates a relatively less conservative mind set, which may in turn indicate the absence of an institutionalised authority that controlled both economic and ritual activities. In this respect, the basic socio-economic unit of the societies of the period would appear to have been the household (possibly comprised of extended families), who frequently gathered with nearby households and communities for routine social events, such as feasts, initiation ceremonies and other social exchanges. These groups may have consulted ritual specialists on very specific occasions, such as death, birth, marriage, place abandonment, which must have had a direct impact on the social continuity of the community and the social position of individuals within it.

Concluding remarks

Douglas Bailey (*2000*) suggested that a new 'politics of the human body' emerged during the transition to settled life and the development of the 'built environment' of the tell settlements in the Balkan Neolithic (*c.* 6500 BC). At these densely populated settlements, the negotiation of personal identity and household composition as a way of resolving disputes between persons and groups was a major preoccupation. By representing the body in miniature, it

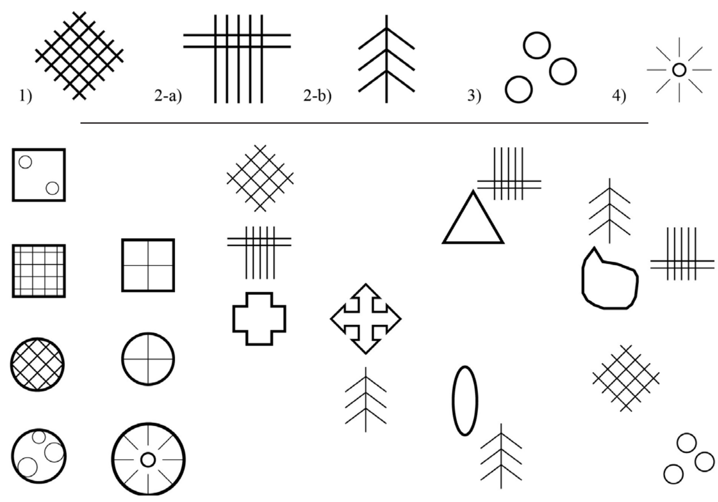

Fig. 26. Diagnostic image and shape relations.

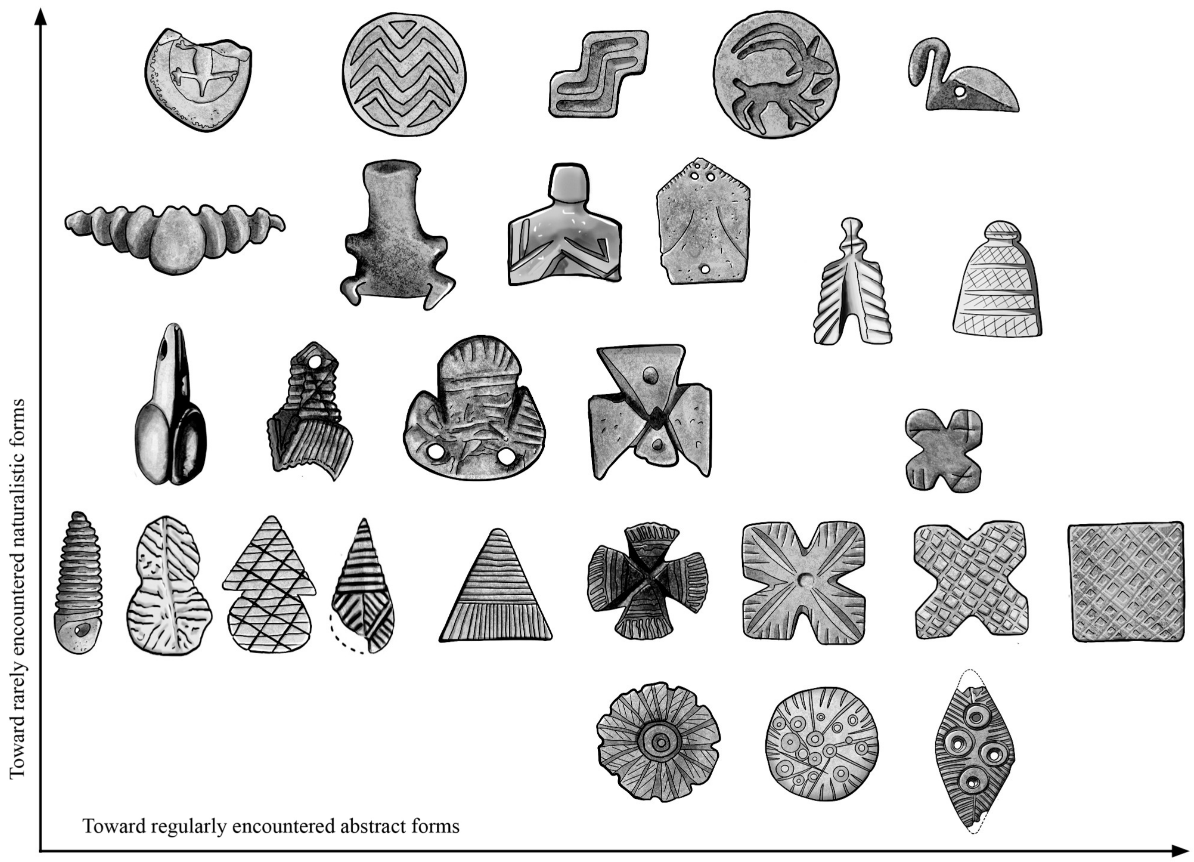

Fig. 27. Discursive relations between various types in terms of abstraction and frequency.

was possible to invoke different aspects of person and its relation to the collective, when necessary. Given all the other evidence pertaining to the use of space and burial during the 7th and 6th millennium BC in Northern Mesopotamia (see *Pollock 2011*), it would also be appropriate to place sealings within a social context still dominated by processes of enchainment. Stamps and related image-bearing objects may have been used as a transformative medium of discourse that constructed specific narrative links within a specific set of concepts pertaining to ideas about sex, place, past and the personhood. I suggest that the stamps and pendants may have been objects that elaborated on their users' identity in various spheres of social membership. More significantly, these objects may have introduced a new discursive field through which personal identities and community structures began to be redefined with reference to male sexuality. This interpretation has been demonstrated by the dominance of phallic imagery within stamp assemblages of the period and the links built between these phallic images and the remaining stamp corpus comprised of the powerful imagery surviving from the earlier Neolithic of the region. Nevertheless, this suggestion does not mean that stamps and pendants would have been used only by males (in fact, evidence indicates that they were probably used by both men and women of all ages). Instead, it may mean all kinds of personhood were being redefined with reference to the perceived significance of male sexuality.

The introduction and increasing complexity of pottery production during the 7th and 6th millennium BC indicate that the formal context of food preparation and consumption had become a significant medium for constructing social divisions when diverse communities with different social and economic practices began to exchange commodities, people and food with greater frequency (*Nieuwenhuyse 2007*). Through food, people shared memories and exchanged materials, as well as partners, thus forging alliances (*Hayden 1990*). In fact, by recognising hierarchical distinctions based on perceptions of food production, consumption and settlement practices within and between communities, a certain set of rules and taboos may have been activated in an attempt to enhance social inclusion within specific grids of social power. Personhood and its relation to the communal were possibly constituted within this context, which resulted in a rich symbolism that elaborated on the fluid boundaries between individuals

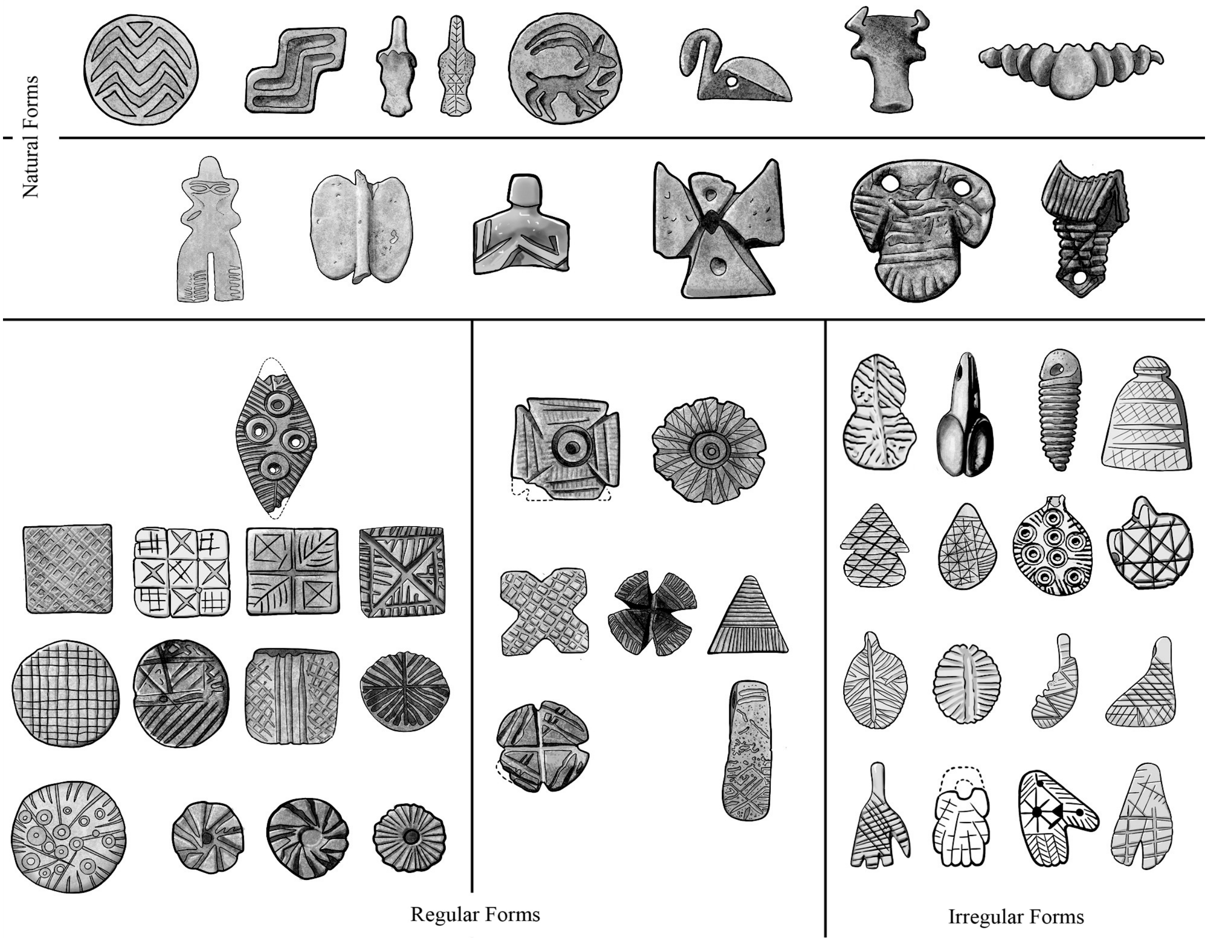

Fig. 28. Relations between regular, irregular and naturalistic forms.

and groups (*Budja 2003; 2004*). In such a context, stamps would have created an immediate environment of trust by demonstrating that participants understood what was socially acceptable.

Within this framework, the stamps of the later 7th and 6th millennium BC in Northern Mesopotamia may have connected their users to social spheres ranging from intimate to wider networks. In effect, those who claimed to be ready to take on certain social responsibilities may have been required to demonstrate their strict observation of rules regarding the preparation of the social body, and stamp use may have been part of this display. In return, the sealing and stamping practices would have demonstrated an appropriation of food, commodities and social relationships within cultural expectations pertaining to the preparation and consumption of food and other items. It is possible that in some places such as Sabi Abyad or Arpachiyah, sealed objects were stored or buried in particular rooms in order to maintain the memory of social exchange events through which certain persons and groups were enchained, and in the processes were indebted to each other in more significant ways than they were to others.

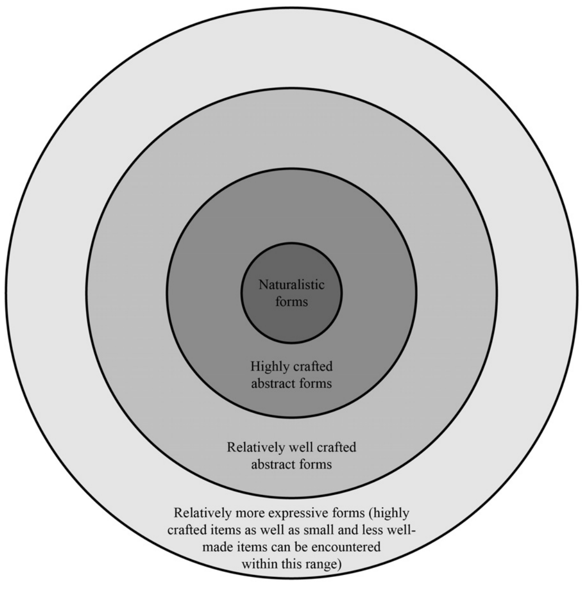

Fig. 29. Suggested spheres of social inclusion for stamp seals, in relation to abstraction, craftsmanship and find frequency.

Form	Characteristics	Possible social context
Irregular geometric types	● occur in relatively high numbers ● usually in pendant styles ● some highly crafted items ● some overtly phallic objects	Passage to adulthood and demonstration of readiness to assume particular responsibilities within society.
Regular geometric types	● occur in relatively high numbers ● usually in back loop handle stamp styles ● abstract imagery ● linked to powerful concepts of male fertility, house success and social continuity	Users may have gone through a particular stage in personhood, perhaps akin to marriage and household leadership.
Naturalistic types	● rarely but consistently found ● images are reminiscent of the early Neolithic anthropomorphic and zoomorphic imagery	These were probably used by a few, who were capable of consulting and manipulating the past on very special occasions during which powerful narratives were invoked and manipulated.

Fig. 30. Different stamp seal types and possible social context.

As a final word, the objectification and abstraction of important concepts may facilitate the rapid migration of ideas into vastly remote and sometimes fundamentally different social contexts; however, abstract objects are ambiguous and can be interpreted in multiple ways. Therefore, in order to understand the specific function of stamps and pendants, one must inevitably focus on site-specific evidence and contextualise the use of stamps within the wider material culture of figurines, pottery and stone bowls, before producing generalising theses about the construction of personhood and community during the 7th and 6th millennium BC.

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The necklace from the Strážnice site in the Hodonín district (Czech Republic). A contribution on the subject of *Spondylus* jewellery in the Neolithic

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ABSTRACT – *The study refers to the issue of shell artefacts in the Early Neolithic and highlights the importance of identifying the correct genus and species of the raw material used. The subject of the study is an older find of a necklace, which had not been subjected to any analysis of species identification in the past. The shell material of the necklace was examined by 'microstructural analysis'. This article also questions the age of the necklace and the possibilities of it having been reconstructed.*

IZVLEČEK – *Študija je usmerjena v artefakte iz školjčnih lupin v zgodnjem neolitiku in poudarja pomen prepoznavanja pravilnega roda in vrste uporabljenih naravnih materialov. Predmet te študije je ogrlica, starejša najdba, ki ji do sedaj še niso določili vrste uporabljene školjke. Lastnosti školjke sva prepoznala s pomočjo 'mikrostrukturne analize'. V članku tudi podvomiva o starosti ogrlice in preučujeva načine njene rekonstrukcije.*

KEY WORDS – Spondylus*; Neolithic in the Czech Republic; shell artefacts; LBK; bivalves shell microstructure*

Introduction

People have always had a need for adornment; we know of decorations from Palaeolithic and Mesolithic graves. While in the Palaeolithic, pierced teeth and bones prevail, in the Mesolithic, shell artefacts made from snail shells occur in abundance (*Grünberg 2000*). The first evidence of the use of shell for jewellery production is from the Middle Paleolithic period (*Arrizabalaga* et al. *2011.11*).

Neolithic necklaces can be made from three types of mollusc shell: *Spondylus*, *Glycymeris* or *Charonia* (Lampas) (*Micheli 2010.24*). Together with the advent of the Neolithic and Linear Pottery culture in our study area, a new species of mollusc, *i.e. Spondylus*, comes to the fore.

Species of the genus *Spondylus* live worldwide and, today approx. 65 species have been identified (*Huber 2010.214*). *Spondylus* shells are cemented to the substrate in the same way as oysters. *Spondylus gaederopus*, which is the main source of raw material for Central European jewellery, lives in warm seas at depths from 2 to 30m as somewhat isolated individuals (*Sériades 2010.178*). Their colours vary from violet to crimson or red-violet, and only exceptionally white. The lower part of the shell is white and the inner surface is reminiscent of white porcelain. This species can grow to a height of 15cm (*Borello, Michelli 2005.71*) and the lower (right) valve, with which the bivalve is attached to the substrate, can reach a thickness of up to 5.5cm, while the upper (left) valve is planar to slightly convex, with a thickness of up to approximately 2cm (*Titschack* et al. *2009.335*).

The subject of this study is Neolithic jewellery found in the suburb of Strážnice in the South Moravian district of Hodonín town, which was previously de-

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scribed by Jan Pavelčík as a necklace from the Moravian Painted Pottery culture (*Pavelčík 1955.50*). In 1959, Slawomil Vencl published a study of spondylid jewellery in Danubian Neolithic culture. The study contains *inter alia* an enumeration of sites where *Spondylus* jewellery had been found, although some doubts were expressed about the Strážnice necklace being made of this type of shells (*Vencl 1959.706*). The necklace was kept in a cabinet in a secondary school in Strážnice. Although a record of the circumstances of the find and accurate data on its location are not available, the author of the article does assert that it was found either in Strážnice or its immediate vicinity (*Pavelčík 1955.50*).

A number of questions emerge about this rediscovered find: (1) whether the genus identification (*Spondylus*) is correct; (2) whether we can agree with Pavelčík's dating to the period of Moravian Painted Pottery culture, and (3) what was its purpose?

An accurate identification of the bivalve genus from which the Strážnice necklace was made was essential for this article. Apart from the genus *Spondylus*, we could also consider *Glycymeris*, which was also found at Vinča, where it was falsely identified as *Spondylus* (*Dimitrijević, Tripković 2006.247; Siklosi, Csengery 2011.54*).

However, the greater occurrence of these bivalves is evident in the Carpathian Basin until late into the Lengyel or Tisza grave culture (*Siklosi, Csengery 2011.54*). As Maria A. Borrello rightly pointed out (*2005.28*), we have to take the *Glycymeris* shells into account in Central European Neolithic necropolises. At the same time, Borello (*2005.33*) names some other species that could have been used by prehistoric people in jewellery production[1]. In the past, not much attention has been paid to *Glycymeris* shells as opposed to *Spondylus*. The finds from the Levant have proved that it was no less important; this species was used there, for example, in highlighting the eyes of statuettes found at Ur (*Bar-Yosef 1991; Dimitrijević, Tripković 2006.238*).

Since all the beads were made from the same raw material, one cylinder[2] was examined by means of microstructural analysis by M. Golej. One large bead, off white to white colour, with a macroscopically visible slightly yellowish V-shaped area was selected for the microstructure analysis (Fig. 1.1). Yellowish parts were present practically on almost all small and large beads, but predominantly on large beads, so the question was whether this macroscopically distinctive area was part of the original shell or recrystallized shell.

Description of the large bead microstructure

The terminology used to describe the microstructure in this paper follows Benjamin P. Carter (in *Rhoads, Lutz 1980.79*) and Jay A. Schneider and Carter (*2001.609*). The large bead was first cut transversally. One half with a yellowish area was embedded in epoxy resin. When the resin hardened, the bead was cut again transversally and longitudinally (Fig. 1.1), then hand ground and polished on a glass plate to obtain a smooth, flat surface. Finally, the polished surface was etched for 40 seconds in 0.5% HCl, washed with tap water and dried; acetate peel replicas with acetate foil 0.2mm thick were then produced. The replicas were mounted between two glasses and studied under a light microscope. Three types of very well preserved microstructures were observed: (1) Dominates aragonitic crossed lamellar (CL) structure (Fig. 1.8) alternating with (2) complex crossed lamellar (CCL) aragonite (Fig. 1.4). The yellowish part is composed of (3) simple prismatic (SP) aragonite alternating with CCL aragonite (Fig. 1.7, 1.9). Small dark dots (originally pores) and tubes are present in all the observed layers (Fig. 1.8).

No recrystallisation was observed; hence, based on the preservation, we conclude that the shell is not a fossil and the macroscopically visible yellowish layer is not recrystallised shell or calcite, but an area with a composition different from the surrounding material. This SP layer is produced within the palial area and corresponds to the palial line and one muscle scar found in spondylids and the two muscle scars in glycymerids. No calcitic parts were found in any of the whole range of large and small beads available from the site at Strážnice; and all yellowish parts were assigned to SP aragonite. In contrast, Bernadett Bajnóczi *et al.* (*2013.880*) reported calcitic parts on three beads, but in Figure 4.f we do not agree with the statement that the irregular surface of the bead, not the sawtooth shape between the calcitic and aragonitic layers, indicates dissolution and recrystallisation. The shape of the contact of the outer calcitic and inner aragonite layers is not

1 She names these shell raw materials: *Cypraea*, *Conus*, *Cardium*, *Dentalium* shell (*Borello 2005.33*).

2 A bead marked with the letter 'C'.

sawtooth in the entire shell (for comparison see Fig. 2.3, 3.6) and the continuous run of the growth lines from the inner to the outer layer is natural, as is the shell's irregular surface. And finally, in Figure 4.f , below the opening, there are visible SP lines within the CL aragonite that can be present not far from the outer calcitic foliated (CF) shell layer, and the orange colour is the same as in Figure 4.e.

As documented in Figures 2.2, 3.6, 4.3, 4.6, the shell colour occurs only within the outer calcitic layer and is absent in the aragonitic middle and inner shell layers. Therefore, it can be stated that if coloured parts are present in Neolithic beads, this is the outer calcitic layer. In the material from the site at Strážnice, no coloured or calcitic parts were recognised, so we can conclude that all the beads were originally white and all CF layers had been removed as the beads were produced. The SP layer has become slightly yellowish after a few thousend years and is probably the result of deposition, accumulation or the incorporation of various minerals in low stable prismatic aragonite. This is much more visible in young tertiary fossils. Only one half of the bead surface was clearly weathered, with the regular growth lines being more visible compared to that on the smooth, polished and fresh surface. As can be seen in Figures 1.5 and 1.7 no recrystallisation from aragonite to more stable calcite is present, but only dissolution with the preserved, originally aragonitic, microstructure.

Is the bead made of *Spondylus* shell? Comparison with other bivalve shells

Although the shell microstructure of species *Spondylus gaederopus* (Linnaeus, 1758) is known (*Titschack* et al. *2009; Maier, Titschack 2010*) various thick-shelled bivalves can be considered as candidates for the production of large and thick beads. To answer this question, we studied the shell microstructure of two other species of this genus, especially *S. spinosus* (Schreibers 1793) (unknown locality) (Figs. 2.1–2.7, 3.1–3.7), *S. lamarcki* (Chenu, 1845) (Camotes Islands, Phillipines) (Fig. 4.1–6), then *Tridacna crocea* (Lamarck, 1819) (Palawan, Phillipines), a recent specimen of *Glycymeris (G.) glycymeris* (Linnaeus, 1758) from Brittany, France (Fig. 4.10, 4.11) and one fossil of *Glycymeris (G.) pilosa deshayesi* (Mayer, 1868) from Miocene-Badenian deposits in Slovakia (Borský Mikuláš town) (Fig. 4.7–4.9).

In the spondylids, we observed a uniform shell structure with variable shell thickness. Shells of the same length of two different species may have different shell thickness. The outer shell layer of spondylids is composed of foliate calcite (CF), with relatively uniform thickness across species. The middle shell layer is composed of crossed lamellar (CL) aragonite, which can vary dramatically from one species to another. The last identified inner layer is composed of complex crossed lamellar (CCL) aragonite and simple prismatic (SP) aragonite that irregularly alternates near the center of the discus with the CL and CCL lines. The prismatic layer is visible as a dark line/lines that separate the CL and CCL layers (Figs. 2.3–2.4, 2.6; 3.1–3.3). This layer is thinner in sections perpendicular to the shell surface near the central axis (Fig. 2.4) and becomes thicker in various inclined sections and distances from the umbo (Fig. 3.2). the prismatic layer is produced by the mantle as a palial line and within the muscle scar (myostracum). The contact between the outer calcitic and middle aragonitic layer is sharp, or these two layers interfinger together (Figs. 2.7; 3.2, 3.5, 3.6; 4.5). Small dark pores and tubules are present in all the layers within the whole shell.

The glycymerid shells are composed entirely from aragonite, with an outer aragonitic CL layer, an inner layer of cone complex-crossed lamellar (cCCL) aragonite and an SP aragonitic layer (myostracum of muscle scars) (Fig. 4.7–4.9) as also described Tschudin (*2001.659*). The dark pores and tubes are present from the umbonal part to the ventral margin, but are absent on the ventral margin and in the teeth. In cross section, in comparison with spondylids, the structure of the glycymerids is completly different. The outer shell layer is irregular, 'ribbed' (Fig. 4.9). The last studied shell microstructure of tridacnids (giant clams) has been described by various authors (*Schneider, Carter 2001.626; Aubert* et al. *2009.991*). The sigificant factor is of the absence of calcite and of pores and tubes. Based on our microstructural study of possible thick shelled bivalve candidates, we can conclude, that the Neolithic beads from Strážnice were produced from spondylid shells and the only one possible species in the vicinty of the appropriate thickness is *Spondylus gaederopus*.

Some earlier studies have already been devoted to the manufacture of similar beads. Here, I would like to mention Vladimir Podborský (*2002a.237*), Vladimir Ondruš (*1975–76.136–137*), Vencl (*1959.734–735*) or the recently-published study of Siklosi and Csengery (*2011.50–51*), where the authors deal inter alia with the quantity of *Spondylus* used for the production of beads. According to this study, to create one large cylindrical bead, it would be necessary to use one shell, more precisely the right valve, which has the necessary thickness (*Siklosi, Csengery 2011. 51*). One shell bracelet manufacturing centre has been discovered in Italy (in the Ligurie cave Arene Candide), where the researchers agree and indicate that a workshop for these bracelets was located on the shore, in front of the cave (*Micheli 2010.30*).

Dating

It is known that during the period of the Moravian Painted Pottery culture in our region, spondylid jewellery is present only sporadically (see *Podborský 2002a.224*). Although this jewellery was worn, with various caveats, throughout the Neolithic and even later, the main period when this precious jewellery occurred (according to Henrieta Todorova) is from 5400/5300 to 4200[3] BC (*Todorova 2000.415*). In Central Europe, its greatest expansion was contemporary with the Linear Pottery culture (*Nieszery 1995; Podborský* et al. *2002b.236*). Some years earlier, Slavomil Vencl (*1959*), who summarised the spondylid jewellery finds, made a similar observation. The finds of oval beads are chronologically classified into the Linear Pottery period (see *Vencl 1959. 727*).

In their study, Zsuzsanna Z. Siklosi and Piroska Csengery (*2011*) reconsider the use of Middle and Late Neolithic spondylid jewellery in the Carpathian Basin. Based on analyses of selected graves, they came to the conclusion that large, cylindrical, barrel-shaped beads, together with medium-sized, cylindrical, irregular- and barrel-shaped beads dominate the Middle Neolithic in this region[4]. By contrast, in the Late Neolithic small, flat, disc-shaped beads and thin bracelets are more characteristic (*Siklosi, Csengery 2011.49–50*).

Therefore we can state (with a certain amount of confidence) that the Strážnice necklace derives from the Linear Pottery culture in the Early Neolithic. This can be supported by the few traces[5] of the presence of Linear Pottery culture found in the vicinity of Strážnice town, particularly Hroznová Lhota village, at the location, '*U vodojemu*' ('near water-tower'), where a few objects were retrieved from a Linear Pottery settlement (*Parma 2005.220*). At the same site, at a location called 'Kozojídky', a collection of flint blades was salvaged and documented (*Vaškových 2007.134*). The Tasov village lays not far from Hroznová Lhota village, where Linear Pottery culture finds were recorded (*Vaškových 2007.154*). Furthermore, in nearby Tvarožná Lhota village and Vnorovy town, several random objects of Linear Pottery culture (especially pierced stone hoes) were discovered (*Vaškových 2007.156, 161*). In a residential area of Strážnice itself, cullet-blade material from the Linear Pottery culture was located (*Vaškových 2007.152*). The Mistřín site (district Hodonín) is the closest site to Strážnice where *Spondylus* jewellery has been found in a skeletal grave (*Vencl 1959.703*). Then, again in a child's burial remains from the Linear Pottery culture at Přerov-Předmostí (district Přerov) (*Jarošová 1971.28*).

Reconstruction

The necklace contained 70 pieces of beads (Fig. 5), which can be divided into two categories: (1) long cylindrical (10 pieces, Tab. I), and small round pearl shapes (60 pieces, Tab. II). The long beads from Strážnice are 60–80mm long, with diameters from 13–15mm and hole sizes from 3–7mm. According to Vladimir Podborský (*2002a.236*) they belong to the category of 'large' beads. Small beads are 6–12mm long, with diameters ranging from 9–14mm and an almost identical hole size of about 3mm; therefore they belong to the 'small' beads category (*Podborský 2002a.236*). The whole necklace weighed 399g, of which the small bead weighed only 97g[6].

We do not know the order in which the beads were originally assembled, nor if they formed one or more units: several bracelets, individual pendant beads or a combination of these possibilities have been proposed as alternatives to a single necklace. Nor can we exclude the form of a headband, especially in the case of small pearl-shaped beads. Because one side of the beads has a distinct weathered surface, we assume that this side was more exposed to meteorological effects. For this reason, we would suggest that the upper side could help us reconstruct the bead assembly correctly in the future (Figs. 6–8). Since the weathering stage and the state of preservation of all the beads are identical, we can as-

3 It corresponds with the dating of Linear Pottery culture.

4 The period, in which H. Todorova assumes the biggest expansion of *Spondylus* jewellery and in which the Linear Pottery culture appeared in our surrounding, is called the Middle Neolithic in the Carpathian basin.

5 Mostly there were found only a few pottery fragments.

6 For the weight of particular beads see Tab. I.

sume that the beads were found as one unit. This claim can be further supported by a microscopic, pedological analysis of the soil trapped in the crevices of the beads (Fig. 9), which proved to be the same type of sandy soil. Unfortunately, the lower part of the beads contains an adhesive compound, probably the result of the necklace being attached to a hard surface[7] (Fig. 10).

Most *Spondylus* artefacts originate from grave complexes. We can therefore assume that our beads most probably originate from one such grave complex. The idea for the reconstruction derives from the female grave at Cys-la-Commune, in which two types of material, *Spondylus* shells and limestone, were used. Also important, however, is the fact that long beads were mixed with small pearl shapes. The whole unit was placed on the upper part of the chest and in the area of the neck (*Todorova 2000. 436, Fig. 21*). Vencl makes a similar suggestion (*1959. 728*), stating in his synoptic paper that massive beads were usually strung as necklaces or headbands.

Analogy

Although there are several tens of beads made of *Spondylus* shells in the Czech Republic, not all of them correspond in size. The greatest number of these beads originates in Moravia, where about 200 beads made from this raw material were found at a burial ground in Vedrovice village (*Podborský 2002a.229*). Large cylindrical beads (6.9–8.7cm long) were also discovered in Kadaň town, although more details about the find are unknown (*Stocký 1926; Vencl 1959.701*). Ten cylindrical beads came from a children's grave in Vejvanovice town, but these were only 1.6–5.3cm long (*Vencl 1959.702; Zápotocká 1998.818*). The beads from Vedrovice village were 0.8–5cm long, with a diameter of 0.6–2cm (*Podborský 2002b. 223–240*).

bead	lenght (cm)	width (cm)	hole diameter (cm)	weight (g)
A	7.2	1.4	0.5	28
B	6.3	1.4	0.3	26
C	6.8	1.3	0.4	27
D	7	1.4	0.5	32
E	7.3	1.4	0.3	31
F	8	1.5	0.7	36
G	7.9	1.3	0.4	31
H	7.5	1.4	0.4	30
I	7	1.4	0.3	33
J	6	1.4	0.4	23

Tab. I. Proportions of long beads.

Further discussion and new questions

According to the results of several published Linear Pottery culture burial grounds (*e.g.* Vedrovice, *Podborský 2002a; 2002b*; Nitra, *Pavúk 1972 etc.*) containing *Spondylus* jewels, we can assume that *Spondylus* beads were prestigious items and accorded social status (*Pavúk 1972.73; Podborský 2002b.235; Séfériades 2010.186; Lenneis 2007.133*). While at the Nitra site *Spondylus* items dominate in anthropologically determined male graves, this is not entirely typical in the Linear Pottery culture in the territory of present-day Hungary. In the late Neolithic, the occurrence of *Spondylus* jewellery was exclusively limited to women and children (*Siklosi, Csengery 2011.56–57*). Podborský (*2002b.246*) dealt with the issue of gender on the basis of the presence of *Spondylus* jewellery in the Vedrovice village graves. However, this was not systematically considered

bead	lenght (cm)	width (cm)	bead	lenght (cm)	width (cm)
1	1	1.2	31	1	1.1
2	0.7	1	32	0.7	1
3	0.9	1.1	33	0.7	1
4	0.9	1	34	0.8	1
5	0.7	1	35	0.8	1
6	0.6	1	36	1	1.3
7	0.7	1	37	0.8	1
8	0.8	1.1	38	0.9	1.2
9	0.8	1	39	1	1
10	0.7	1	40	0.9	1.2
11	1	0.9	41	0.9	1.1
12	0.8	0.9–1	42	1.1	1
13	0.7	1	43	0.7	1
14	0.7	1.1	44	0.8	1.1
15	0.7	1	45	0.8	1
16	0.8	1	46	0.8	1
17	0.9	1.1	47	0.9	0.9
18	0.8	1	48	0.9	0.9
19	0.8	1	49	1.2	1
20	0.9	1	50	1	1.2
21	0.7	1	51	1.1	1.1
22	0.9	1.1	52	0.9	0.9
23	0.8	1.1	53	1	1
24	0.9	1.1	54	0.9	1
25	1.1	1.2	55	0.9	1
26	0.8	1	56	1.2	1.3
27	0.8	1	57	0.9	1.4
28	0.7	1	58	1	1
29	0.8	1	59	1	1
30	1	1.2	60	0.9	1

Tab. II. Proportions of small beads.

7 It is probably due to exposure in the past.

or investigated over a wider area and any answer would undoubtedly be influenced by the poor preservation of the Neolithic skeletal remains. Why was this jewellery popular, and can we reconstruct its significance?

Popularity of *Spondylus* jewellery

According to several studies (see *Podborský 2002b. 236*), the white colour of this shell was the most popular among people in the Neolithic. Yet, this should be reconsidered. If the decoration had been made from contemporaneous Neolithic specimens, the bead would not necessarily have been white since the colours of recent *Spondylus* shells vary from crimson to yellow-orange. This fact has already been mentioned by Sériades (*2010.186*).

More than 20 years ago, scientists were already occupied with the question of contemporaneous and fossil utilisation. At that time, they absolutely excluded the utilisation of fossil shells (*Shackleton, Elderfield 1990*). The opposite was proven at Cernica in Romania, where fossil mollusc shells were used (by *Comşa 1973.72*). The *Spondylus* artefacts found in the burial ground in Vedrovice village analysed by Šárka Hladilová unambiguously proved the utilisation of recent material (*Hladilová 2002. 257, 263*). The recent return to this issue (*e.g., Dimitrijević, Tripković 2006*) demonstrates that no definitive answer has yet been established and it will be necessary to approach the issue within individual regions.

The necklace from the Strážnice site was made from recent shells. It even seems that only the aragonite part of the shell was used deliberately in its production, probably because of its white colour.

In the case of production of long cylindrical beads, the shell must have been hard and long, and therefore larger pieces of jewelry or beads could have been more valuable and highlight the status of the wearer/person.

Summary

In this article, it has been established that one of the most important issues regarding Neolithic shell jewellery is the accurate identification of genus and species. For those living in the Neolithic, several possible raw materials could have been used to make jewellery. Our attention cannot be focused only on new finds; we have to make a revision of past finds, even at the risk of damaging parts of the samples in the analysis.

Apart from identification, it is necessary to know whether our artefact was made from a recent or a fossil shell. For recent examples, it is then especially appropriate to make further analyses (particularly isotopic analysis and, alternatively, analyses for shell age identification).

To summarise the results of this brief study, we discovered that the necklace from Strážnice site was made from recent shells of very large *Spondylus* individuals and was white (all the coloured calcitic shell layers were removed in production). It was erroneously classified to Moravian Painted Pottery culture. The necklace most probably belongs to the Linear Pottery culture, and judging from the weathering of individual beads and pedological analysis, the necklace is a single item. Based on an analogy from graves discovered earlier, we can try to reconstruct the form of the beads. One of the most probable possibilities is that the beads were placed on the upper part of the torso and neck and, therefore, it could be a necklace. Further analyses of the abovementioned beads could help us to answer the questions of shell age and its place of origin.

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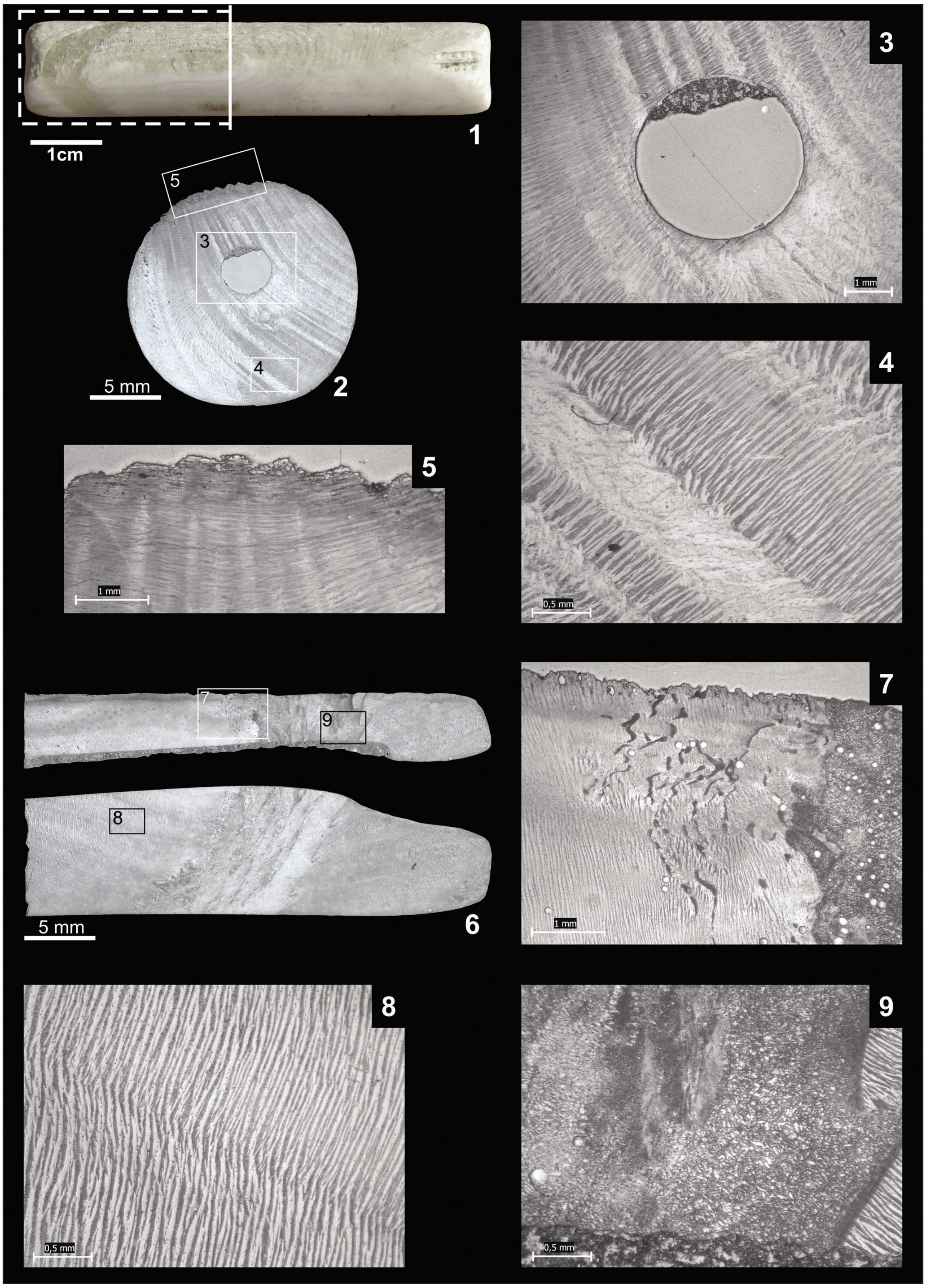

Fig. 1. The Neolithic bead from the Strážnice site, Moravia, Czech Republic. 1 Marking of the longitudinal and transversal sections through the bead with yellowish V-shaped part. 2 Transversal section through the bead with distinct growth lines. 3 Detail of Fig. 1.2. Sandy soil from the original site is trapped in the bored hole. 4 Alternating CL and CCL aragonitic layers. 5 Detail of the weathered surfaces of the bead. The dissolution of aragonite is visible, but no recrystallisation. 6 Longitudinal section through part of the bead and the yellowish part. 7 Contact of the SP and CL layers. The dark irregular lines are also composed of SP aragonite. The weathered, irregular surface, with traces of dissolution. 8 Very well preserved CL aragonite. The dark pores (dots) are visible. 9 Detail of the yellowish part composed of SP and CCL layers. (2–9 Acetate peels).

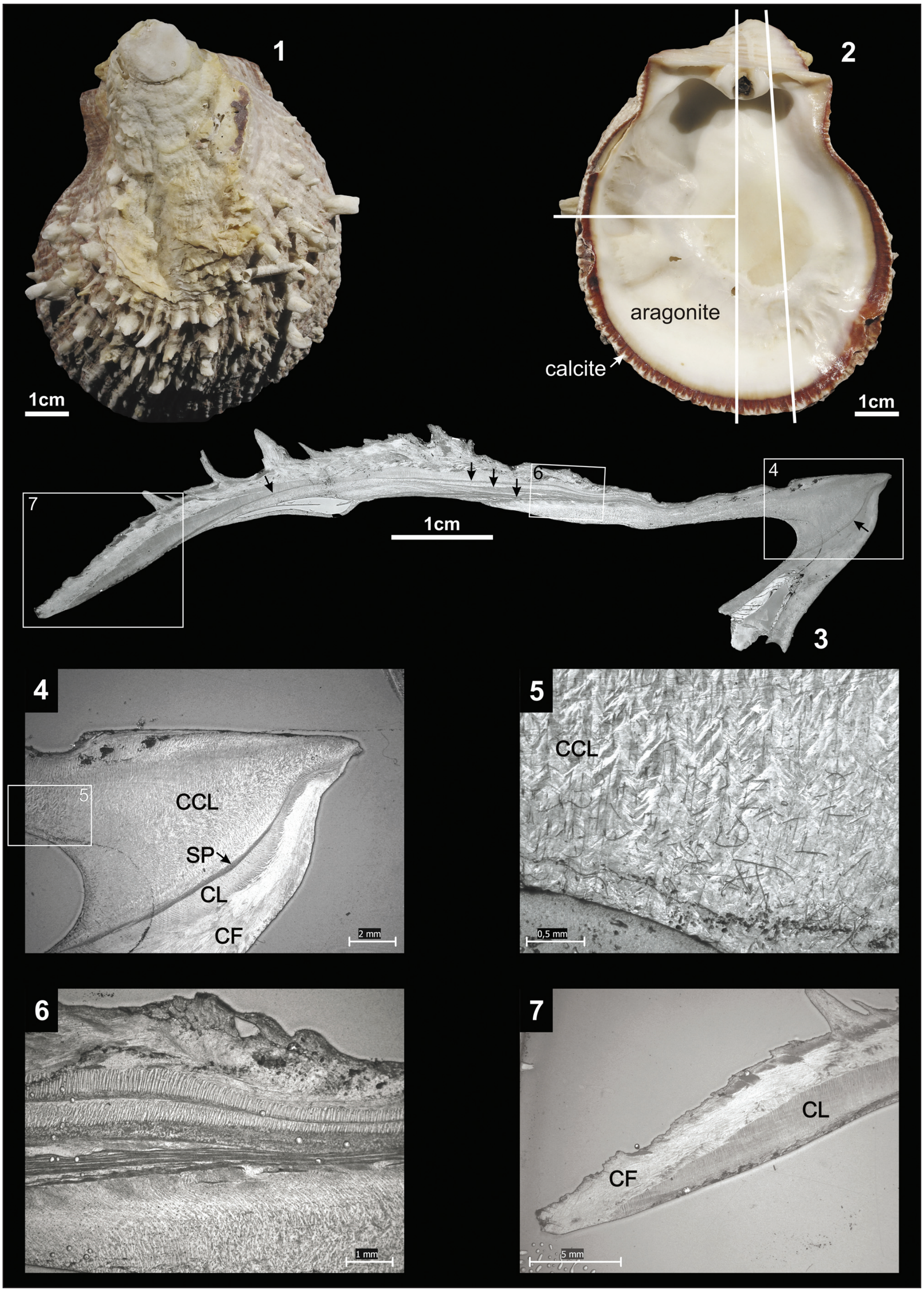

Fig. 2. **Spondylus spinosus Schreibers,** *1793 (unknown locality). Right valve. Recent. 1 Exterior of the right valve with visible attaching area in the center of the discus. 2 Interior of the valve. One transversal and two longitudinal sections and parts composed of calcite and aragonite are marked. 3 Axial longitudinal section. Arrows indicates the dark SP lines which separate the CL and CCL layers. 4 Detail of the umbonal region showing all layers of the spondylid shell. 5 Detail of the CCL microstructure. 6 Part of the shell near the centre of the discus with alternating CL, SP and CCL layers. 7 Detail of the ventral margin of the shell. Note the interfingering of the CF and CL layers and that the colour bearing calcitic layer is the outermost shell layer. (3–7 Actetate peels).*

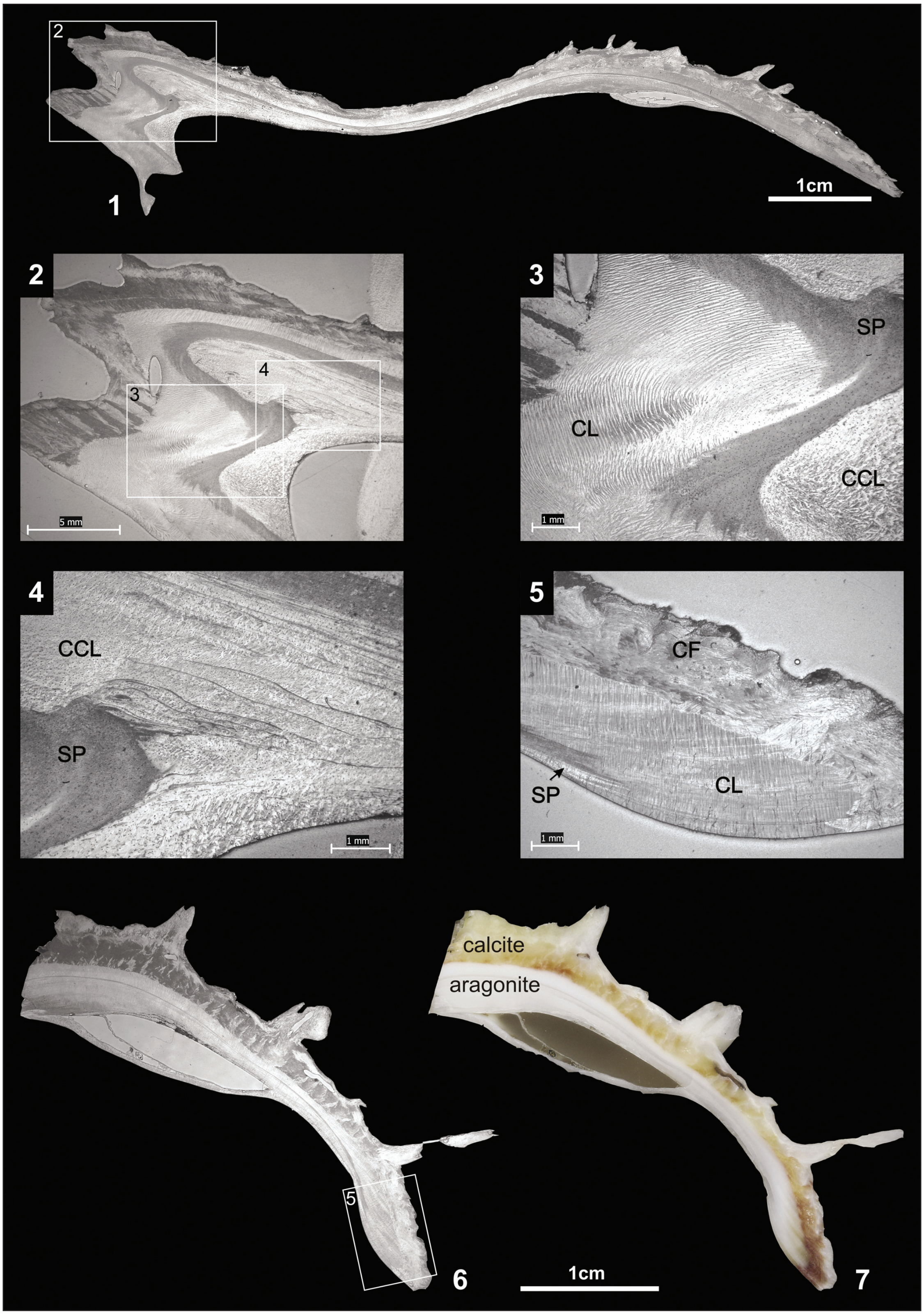

Fig. 3.* Spondylus spinosus Schreibers*, *1793 (unknown locality). Right valve. Recent. 1–4. Longitudinal, slightly inclined section distant from the central axis. 2 Detail of the umbonal part. The dark line is composed of SP aragonite. Its thickness is greater compared with that in Fig. 2.4 because of not perpendicular section to the shell surface. 3 The SP layer occurs between the CL and CCL aragonitic layers. 4 Irregular interfingering of the SP and CCL layers similar as in the Neolithic bead in Fig. 1.7, 5 Transversal section through the shell near the anterior margin. 6–7 Transversal section. Comparison of the acetate peel (5) and shell section, with colour present in the calcitic layer (7). (1–6 Acetate peels).

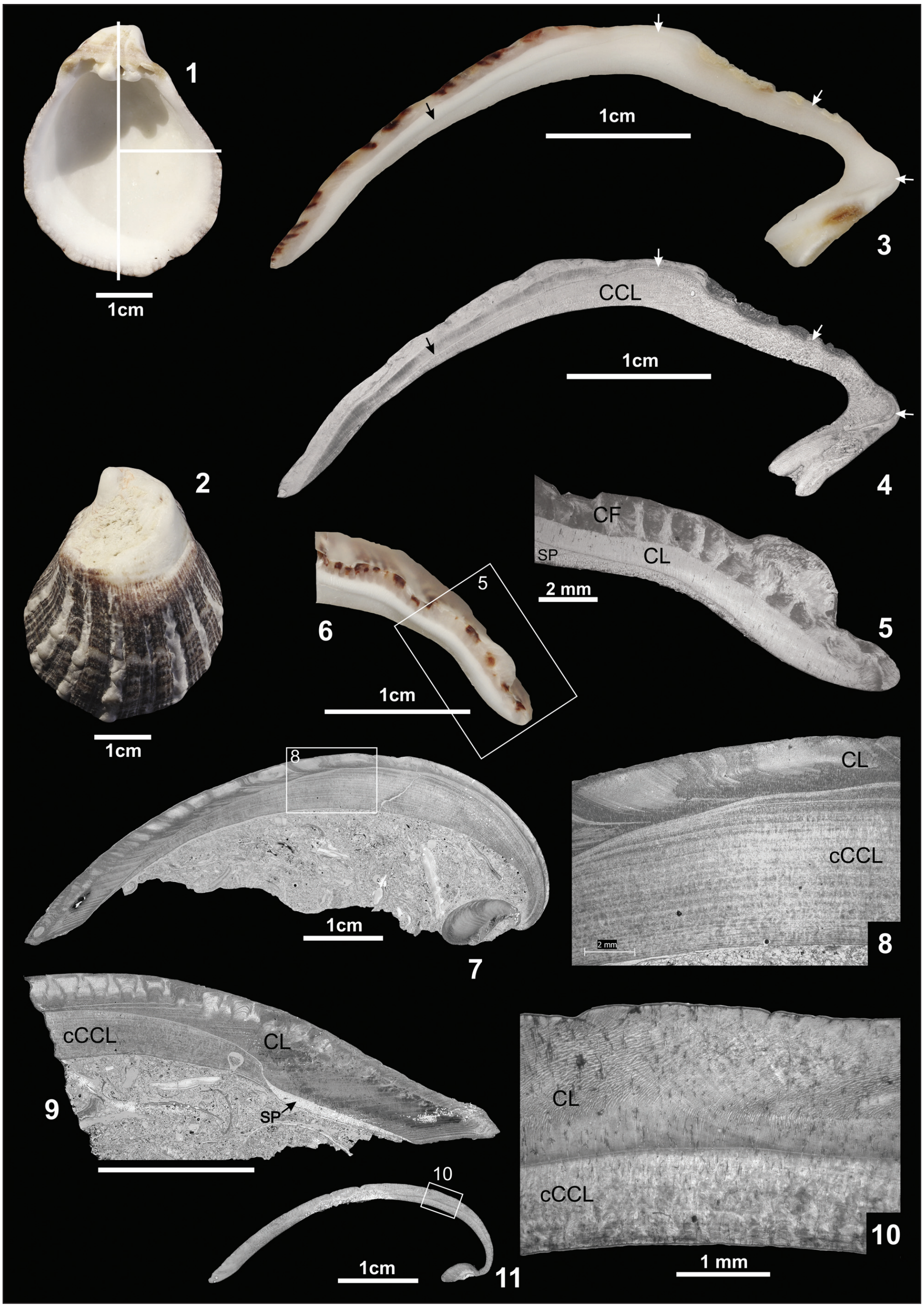

Fig. 4.1–6. Spondylus lamarcki Chenu, *1845 (Camotes Islands, Phillipines). Right valve. Recent. 1 Interior view with marked sections. 2 Exterior of the shell, attaching area is white. 3–4 Axial longitudinal section. Arrows indicate the SP layer (3) View of the shell. (4) Acetate peel. 6 Transversal section with detail (5) of the posterior shell margin (acetate peel). The colour is present only in the calcitic outer shell layer. 7–9* Glycymeris (G.) pilosa deshayesi *(Mayer, 1868). Tertiary – Miocene, Badenian. Slovakia (Borský Mikuláš town). Acetate peels. 7 Longitudinal section. 8 Detail of the shell microstructure. The outer shell layer is composed of CL aragonite, while the inner is composed of cCCL aragonite. Small dots are originally pores and tubes. 9 Transversal section. The SP aragonitic layer within the muscle scar (myostracum) is visible. 10–11* Glycymeris (G.) glycymeris *(Linnaeus, 1758) from Brittany, France. Recent. Acetate peels. 11 Longitudinal section. 10 Detail of clearly visible outer CL layer and inner cCCL layer. Pores and tubes are visible.*

Fig. 5. A view of the complete necklace (possible appearance).

Fig. 6. Detail of weathering on small beads.

Fig. 7. Detail of the back on the example of selected beads.

Fig. 8. Detail of the top of the weathering on the example of selected beads.

Fig. 9. Detailed view of the slot (as shown by the arrow) in beads E and D which was collected from a soil sample.

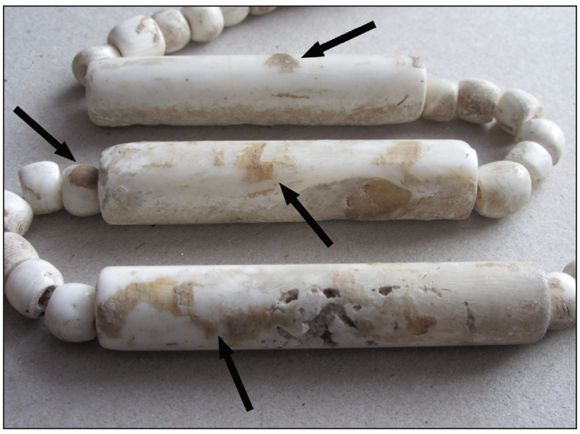

Fig. 10. Arrows illustrate the material glued on beads.

Managing raw materials in Vinča culture: a case study of osseous raw materials from Vitkovo

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ABSTRACT – *In analyses of material recovered from archaeological sites, a dichotomy often exists between 'specialist' and 'archaeological' studies. This is especially noticeable in the case of faunal remains and bone artefacts. Bone artefacts are sometimes treated separately from fauna with emphasis on typological data, or they can be left within the fauna with only a remark on 'other taphonomic traces', thereby overlooking technological features of these artefacts. However, bone industry provides excellent insight into technological choices regarding raw material exploitation, since the availability and mechanical properties of specific materials can be directly observed. In this paper we tried to link bone artefacts with other faunal remains on the basis of a case study of the Vinča culture site at Vitkovo with a special emphasis on the relations between butchering techniques and raw material selection and the relations between the economically most important species and the bones most commonly used in tool manufacture.*

IZVLEČEK – *Pri analizah materiala, ki se ga odkrije na arheoloških najdiščih, pogosto obstaja dvojnost med 'specialističnimi' in 'arheološkimi' študijami. To je še posebej izrazito pri analizah živalskih ostankov in artefaktov iz kosti. Kostni artefakti se včasih obravnavajo ločeno od preostale favne s poudarkom na tipologiji ali pa se jih obravnava skupaj s favno, vendar le z omembo 'drugih tafonomskih sledi', kar pomeni, da se s tem spregledajo tehnološke značilnosti teh artefaktov. Pa vendar nudi kostna industrija odličen vpogled v tehnološke odločitve pri izrabi naravnih materialov, saj lahko neposredno opazujemo dosegljivost in mehanične lastnosti specifičnih snovi. V članku poskušava povezati kostne artefakte z drugimi živalskimi ostanki na študijskem primeru vinčanskega najdišča Vitkovo. Pri tem posebej poudarjava odnose med praksami zakola in izborom naravnih materialov ter odnose med gospodarsko bolj pomembnimi vrstami in kostmi, ki se najpogosteje uporabljajo za izdelavo orodij.*

KEY WORDS – *faunal assemblage; bone industry; raw materials management; Vinča culture; central Balkans*

Introduction

As a discipline that aims to reconstruct past modes of human life, archaeology must rely on numerous scientific methods developed in other disciplines, or created as a result of multi- and inter-disciplinary research. One area where archaeology has to rely on other sciences in particular is the analysis of raw materials, from the process of acquiring foodstuffs and raw materials for tool making, building shelters, or crafting other, utilitarian or non-utilitarian artefacts.

The analysis of raw material acquisition and management is the first and one of the most important steps in a technological analysis. The concept of technology as a culture-driven phenomenon implies the notion that more than one technology can usually satisfy the minimum requirements for any given task, and that the choice of a particular technology from among the alternatives may be strongly influenced by beliefs, social structure and the prior choi-

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ces of the given society (*cf. Lemonnier 1992; 1993; Killick 2004*).

Diverse theoretical concepts and methodologies for technological analysis have been developed, the main goal being to place technological phenomena in a socio-cultural context. Probably the most frequently used, and the one having the greatest interpretative potential, is the concept of the operational chain (*chaîne opératoire*) devised by André Leroi-Gourhan (*1964; 1965; 1971*). This is an analytic technique that explores how an artefact is made, used and discarded: the acquisition of raw material, the choice of manufacturing technique, final shape, and use (which includes thesauring, breakage, repair, sequences of re-use), all the way through to the discarding of the object, and passing through all the stages of manufacture and use of different components. The concept of *chaîne opératoire* enables us to structure the use of materials by placing each artefact in a technical context, and offers a methodological framework for each level of interpretation. It also provides a dynamic perspective, because it takes into account all the stages in the life of an object. This concept allows us to reconstruct the organisation of technological systems and technological strategies through an understanding of the relations between raw material procurement, tool manufacture, tool use, maintenance and discard (*Sellet 1993; Inizan* et al. *1995.14*).

The reconstruction of different steps within a *chaîne opératoire* also implies an analysis of technological choice: why a specific material was chosen and not some other; why specific manufacturing techniques were employed rather than different ones; why the object was discarded in a certain way, *etc*. The decision making may be limited by the natural environment, available knowledge, *etc.*, but the solution is also selected in accordance with cultural and social preferences: some raw material may exist in the environment and yet remain unused. Numerous archaeological studies have been devoted to analysing the mechanisms that govern choices of technology.

B. Hayden (*1998*) suggested a division of technologies into the practical (*i.e.* techniques used to solve practical problems of survival and basic comfort) and the prestigious (those that display power, wealth and prestige and are used to perform a social task). One of the underlying principles in practical technology is to perform tasks (such as obtaining and processing food and raw materials, creating an adequate shelter and storage facilities) in an efficient and effective way. For a given problem, the criteria used in choosing between alternative technological solutions are how effective and how costly each solution is and, in general, practical technology is a logical and empirical response to stresses in the environment. According to the design theory, different kinds of constraint operate in the development of solutions for each problem, and trade-offs between constraints make it unlikely that only a single optimal solution to a problem exists, but, rather, a number of more or less equally acceptable solutions. Among the most powerful of these constraints are functional requirements, material properties, availability, and production costs. Once a field of acceptable solutions for a given problem has been identified, the choice of solution to be adopted may largely be a matter of cultural tradition, ideological values, style, *etc*. (*Hayden 1998*).

Analysis of raw materials may provide information on the exploitation of the environment; relative distances of resources from settlements may indicate a territory controlled by a group, or, in the case of hunter-gatherers, migration routes and/or territory covered. The technology for extracting some raw materials such as stones or ores may indicate the level of technological knowledge and organisation within a community that explored them. Analyses of exotic raw materials (*e.g.*, obsidian, *Williams Thorpe 1995; Williams Thorpe* et al. *1979; 1984*) are an especially attractive field of research, as they may indicate routes and directions of trade and exchange (*cf. Dixon* et al. *1968*). Careful analyses of the use of certain raw materials may also reveal cultural preferences (or avoidance) and related cultural attitudes to them, as well as the crafts associated with them.

Numerous analyses of raw materials focus on lithic materials (*e.g., Antonović 1997; Biró 1998; Gurova 2011*, to mention just a few), but the studies encompass a wide variety of raw materials (*e.g.*, amber, *Palavestra 1993; du Gardin 2002; Murillo-Barroso, Martinón-Torres 2012*; salt, *Weller 2012; Cavruc, Harding 2012; Saile 2012*, and many more).

Analyses of osseous raw materials are not as abundant, although their number has increased in the past few decades (*e.g., Guthrie 1983; Scheinsohn, Ferretti 1995; Margaris 2012*; see also *Choyke, Schibler 2007*). Most of these focus on exotic materials (*e.g.*, *Spondylus* shell, *Dimitrijević, Tripković 2002; 2006; Borrello, Micheli 2004*; tortoise shell, *Rijkelijkhuizen 2010*, *etc*.), but some other studies should also be mentioned. A study by Robert McGhee (*1977*) deals with raw material choices within the Thule culture in arctic Canada. McGhee clearly demonstrates that the use of antler, ivory and bone for specific artefacts is by no means accidental, and that it is in fact strictly linked to a worldview. From the relations between raw materials and their products, McGhee reconstructed the oppositions: land/sea, summer/winter, man/women, antler/ivory.

Gaëlle le Dosseur (*2010*) studied raw material choices in the assemblages from Natufian, PPNA and PPNB periods in the southern Levant area, focusing on the choice of bones from domestic *vs.* wild animals. Also, the problem of using raw materials from wild animals has been addressed by Ingrid Sénépart (*1993*) and Isabelle Sidéra (*2000*).

The choice of raw material may not necessarily reveal symbolic importance, but it may give insight into the economy; for example, the study by Jörg Schibler (*2001*) on lake-dwelling sites in Zürich showed a clear and direct relationship between the use of antler as a raw material and the hunting of red deer. In some periods of occupation, the proportion of antler tools was greater than bone tools, but in periods when juvenile red deer bones were abundant (and, subsequently large, strong antlers from adult individuals were not available), the proportion of antler artefacts was low.

Vitkovo site

The prehistoric site of Vitkovo is situated 3km from Aleksandrovac in central Serbia, 25km from Kruševac, in the valley of the River Stubalska, on the slopes of Vitkovo Field (Map). It was first discovered in the mid-20th century, and the first sondage excavations were carried out in 1969 and 1971. In 2001, small-scale rescue excavations were carried out

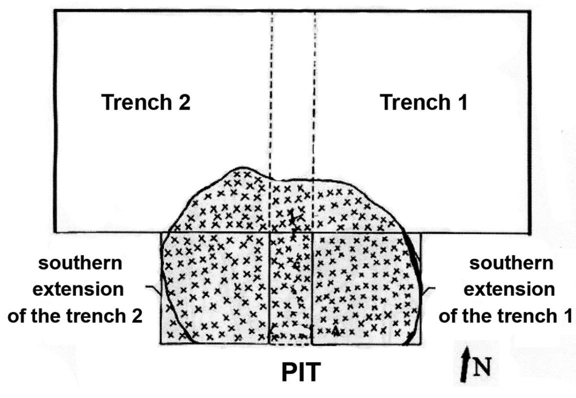

Fig. 1. The feature (pit) excavated in 2001.

Map. The position of the Neolithic site of Vitkovo.

on the property of the Trifunović family. Two trenches, the first 5 x 5m, and the other somewhat larger, were excavated. One pit, probably a rubbish pit (Fig. 1), was discovered, approx. 4.80 x 3.70m, and daub fragments were recovered in its vicinity, suggesting that a dwelling had been situated nearby. The content of the pit was comprised of ash and numerous portable items: stone and flint tools, pottery, terracotta figurines and altars, which dated the site to the later phases of the Vinča culture, to Vinča-Pločnik I (*Čađenović* et al. *2003; Čađenović 2007*).

The careful collecting of animal bones also enabled the first faunal analysis (*Bulatović 2011*) and yielded a relatively large number of osseous artefacts, including manufacture debris (*Vitezović 2011b*).

Materials and methods

The faunal assemblage from Vitkovo was hand collected; it comprises the bones of mammals and birds (11 specimens) and bivalve shells (8 specimens). The distribution of various taxa of the animals is given by NISP (Number of Identified Specimens). The relative frequency based on NISP is calculated only for mammal remains which were identified at least to the genus level. Of the total of mammalian specimens collected (1838), identification up to the level of genus was completed for 471 fragments. The distribution of various skeletal elements is given for the most frequent taxa (ovicaprines, domestic cattle, domestic pig, and red deer). All the bones were carefully examined for traces of manufacture and/or use, and a total of approx. 50 artefacts were singled out for typological and technological analysis.

The Vitkovo faunal assemblage

The remains of 12 mammal species were identified in the Vitkovo faunal assemblage. The domestic species include sheep (*Ovis aries*), goat (*Capra hircus*), cattle (*Bos taurus*), pig (*Sus domesticus*) and dog (*Canis familiaris*), while the wild species were red deer (*Cervus elaphus*), roe deer (*Capreolus capreolus*), auroch (*Bos primigenius*), wild pig (*Sus scrofa*), hare (*Lepus europeus*), fox (*Vulpes vulpes*) and marten (*Martes sp.*). Domestic animals outnumber game (comprising 87% of NISP), and produced the most important and reliable meat supply. Based on the number of specimens identified (NISP), ovicaprines (sheep and goat) are the most frequent taxa (55.4% NISP), followed by cattle (12.7% NISP), domestic pig (11% NISP) and red deer (7.6% NISP). Other mammalian taxa were identified in small numbers and together comprise less than 14% of NISP. Red deer is the best represented game species. Wild pig, roe deer and auroch were also hunted.

The ovicaprine body-part frequencies show considerable variation (*cf.* Table 1). Mandibles, isolated teeth and metapodials are the most common, comprising approx. 70% of identified ovicaprine bones. Tibiae and radii are well represented, while all other elements account for less than ten fragments (maxilla, femur, pelvis), respectively, and less than five (*e.g.*, horn, humerus, phalanges, *etc.*). Regarding the frequency of cattle body-parts, phalanges and isolated teeth are the most frequent skeletal elements, followed by metapodials, mandibles and astragali. The most frequent skeletal elements of domestic pig are scapulae, mandibles and ulnae, while only one pig metapodial bone was found in the assemblage. The most numerous skeletal elements of red deer are fragments of antlers and extremity bones.

Human modifications to this assemblage, apart from their use for producing artefacts, were butchery marks and burns. These marks are observed on approximately 5% of specimens from the site. Butchering marks are observed on the bones of almost all species (except for fox, roe deer, wild pig and marten). Cattle-sized specimens, primarily domestic cattle and red deer, have the most butchering marks, the vast majority being cut marks. Disarticulation is the most evident type of mark, with cuts concentrated around the major limb joints. Filleting marks on long-bone shafts and ribs are also common. Cuts on dog bones are recognisable as butchery marks on radius and ulna, suggesting that dog meat was occasionally consumed (Fig. 2).

Domestic animals played the most important role in the economy. Vitkovo is a rare example of a Late Neolithic site in Serbia showing intensive exploitation of ovicaprines, and the widely accepted strategy of their exploitation was also present here: sheep were herded in large numbers, with a few goats kept alongside. Cattle were more often the focus of exploitation in this period at other sites (*e.g.*, Gomolava, *Clason 1979*; Divostin, *Bökönyi 1988*; Vinča-Belo Brdo, *Dimitrijević 2006*; Crkvine, *Blažić, Radmanović 2011*). The Vitkovo site has a very favourable geographical position, being located in the fertile Župa Valley, which is protected from cold winds by high mountains. The temperature of this microregion is relatively high throughout the year, and it is possible that these are precisely the conditions which provided a suitable environment for herding sheep and goats, as compared to other Late Vinča sites with more humid and colder climates (*Bulatović 2011.247*).

The age structure of domestic animals at Vitkovo indicates a strategy of exploitation primarily for meat

Fig. 2. Left hyoid bone of red deer (*Cervus elaphus*) with butchering marks.

Fig. 3. Right ulna of dog (**Canis familiaris*****) with butchering marks.***

consumption. Sheep and goat were slaughtered between 18 and 30 months of age, when they reach optimum weight gain (*Bulatović 2011.241*). Hunting also focused mainly on providing meat, as adult individuals were killed in general. The presence of non-meat bearing bones shows that animals were hunted in the vicinity and often brought to the site whole, where they were butchered. One red deer hyoid with cut marks (Fig. 3) indicates that primary butchering was practiced at the site at least occasionally. Except for meat, animals may also have been hunted for other raw materials, such as skin; a small number of fur-bearing animals should also be mentioned.

The Vitkovo bone tool assemblage

The feature excavated at Vitkovo also yielded a relatively high number of bone artefacts (approx. 50 items). These were generally made from various mammal bones, but red deer antler, boar tusk and mollusc shell also occur (*cf.* Table 1). The long bones and ribs of medium-sized ungulates, mainly sheep/goat, were preferred, while large ungulate bones were also used to a lesser extent. Red deer antlers were used shed, and probably collected in the neighbouring area. Also, six *Spondylus* shell fragments were discovered.

Débitage phases (*cf. Provenzano 2004*) are more difficult to reconstruct, but they probably include breaking as well as splitting along the incised groove. The techniques used in the façonnage phases observed on this material include cutting with different flint tools, scraping and burnishing. The final shaping of objects includes polishing, and, in one example only, perforation by flint borer.

The artefacts were classified into several groups according to the overall shape and mode of use of the working edge: I. pointed objects; II. cutting tools; III. burnishing tools; IV. percussion tools; V. objects of special use; VI. decorative items; VII. non-utilitarian objects; and VIII. incomplete pieces (*cf. Vitezović 2007.60–82; 2011a.61–68*).

The group of pointed objects (I) is the most numerous and consists of two tool types, awls (medium points) and heavy points. Awls were represented by two subtypes: those made from long bones and those made from ribs. Awls from long bones were made by longitudinally splitting medium-size ungulate long bones, in most, if not all cases, the metapodial bone of sheep/goat (Figs. 4, 5). The final shape was obtained by cutting with a flint tool and polishing with a fine-grained abrasive implement. Sometimes an epiphysis segment is preserved on the basal part. The tips, originally sharp, became blunt from use in most cases. The second subtype comprises awls made from split ribs, shaped by cutting, burnishing and polishing (Fig. 6). The use wear on both subtypes consists of intense polish and shine, the spongy tissue on lower surface being often abraded on rib awls, suggesting they were used on soft, organic materials, such as leather and hides (*cf. Maigrot 2003*).

Several heavy points made from various raw materials were also found: antler, boar's tusks, and bone. Traces of manufacture were poorly preserved, and only polish and wear may be observed of use traces.

Cutting tools (II) were found in low numbers: only one chisel made from a red deer metapodial bone was found, and a knife made from a boar's tusk.

The group of burnishing tools (III) includes two types, spatulae and scrapers. The spatulae were made from antler cortex segments, heavily abraded from use. The scrapers were made from rib segments, irregular in shape and also heavily abraded. These tools too were used on soft, organic materials, probably on leather and hide. No percussion tools were discovered.

Among the artefacts for special use (V), one spoon made from antler cortex segment, with a long, flat handle and slightly concave upper part, should be mentioned (Fig. 7). Also, several working surfaces were found, all with traces of intensive use, polish, shine and fine striations, suggesting they were used on soft, organic materials, such as leathers and hides.

The group of decorative objects (VI) included one fragmented pendant and five shell bracelets. The pendant was made from segments of antler cortex; it was in the form of an elongated rectangular plate and had a broken perforation on the top. Bracelets were also found fragmented, with surfaces heavily destroyed by poor taphonomic conditions. They were made from Spondylus shell and their simple shape is the same as numerous other artefacts of this kind found throughout prehistoric Europe (*cf. Séfériadès 2010*). Non-utilitarian artefacts were not discovered.

The last group – of unfinished items and manufacture debris – was particularly interesting. Several segments of longitudinally split long bones with incised grooves were discovered, as well as pieces with traces of burnishing and polishing. Manufacture debris is very significant, since it is often unnoticed if the faunal assemblage is not examined carefully. These finds not only helped to reconstruct the sequences of the operational chain related to manufacture, but also provide indirect evidence of the existence of a workshop at the Vitkovo settlement.

The bone industry at Vitkovo did not differ significantly from the Vinča culture bone industries in terms of raw material choice, manufacturing techniques and typology, although it yielded two unique pieces made from antler, the spoon and the pendant.

Discussion

For a long time, bone artefacts were completely ignored, or only the most interesting items were included in publications. This situation began to change slowly in the second half of the 20th century; so, although bone industry is no longer marginalised today, many questions remain unexplored. One reason bone industry has been under-explored may be due to difficulties in distinguishing naturally modified bones from tools, except for items made with special care, and also because bone industry gives the impression of the ad hoc use of kitchen debris. Such a view – that the first bone to hand was used – persists to a certain extent.

Fig. 4. Awl from ovicaprine metapodial, with entire distal epiphysis preserved at the basal part as a handle.

The low level of knowledge on bone industry led to some conclusions that were not corroborated by adequate data. It was suggested, for example, that bones were split longitudinally during manufacture in order to 'save' on raw materials, although there is no evidence of insufficient quantities of bone, and the longitudinal splitting also serves to make the final product (awl or fine pointed tool) thinner, finer and sharper. Hypotheses also proposed that roe deer bones were 'preferred', although roe deer has been found in very low proportions at most sites, and tools from roe deer bone, rarely found, have no special characteristics to suggest they were 'valued' (such as very long use, numerous episodes of repair, *etc.*).

For most Vinča culture bone industries (Divostin, *Lyneis 1988*; Selevac, *Russell 1990*; Drenovac and Slatina, *Vitezović 2007*; Jakovo-Kormadin, *Vitezović 2010*), several common traits may be outlined: bones are predominant, and although antler ratios vary

Fig. 5. Awl from longitudinally split ovicaprine metapodial, with half of distal epiphysis preserved at the basal part as a handle.

Fig. 6. Awl made from split rib.

from site to site, they rarely exceed 50%. Teeth are rarely used, with boar tusks being used only for tools, while other teeth were perforated and used as decorative items. Mollusc shells also occur, again, in different ratios from site to site, and several species have been recorded: *Spondylus*, *Glycimeris*, *Cardium* and *Dentalium* (all four have been confirmed only at Vinča-Belo Brdo, see *Srejović, Jovanović 1959*). Metapodials prevail, the most common being from medium-sized ungulates (sheep, goat, rarely identified roe deer), followed by ribs. Also, different segments of unidentified long bones were used, and the occurrence of astragals should be noted. Some skeletal elements are rare, such as mandibles, or almost never used, such as cranial bones. Large ungulate bones are less common, and pig bones are almost non-existent.

In the Vitkovo bone industry, long bones were the most commonly used skeletal elements. Metapodials dominate, and various segments from un-identified long bones were also found (Figs. 4, 5). Judging from the diameter and wall thickness, these were long bones from medium-size animals, most probably metapodial and perhaps also tibiae. Only one ulna was identified with certainty, while other long bones (humeri, radii, *etc.*) present in the faunal record were not used for tools.

Metapodial bones are the first to be removed during primary butchering (*cf. Olive 1987*), but at the same time they have adequate physical and mechanical properties: generally, long bones may be easily split and made into a tool with sharp, but resistant pointed tip (for manufacturing techniques, *cf. Murray 1979*). Ungulate metapodials above all seem to have been very attractive to prehistoric people; the oval condylus of the distal epiphysis is often preserved as a handle (this very type, a pointed tool with distal epiphysis on metapodial, is present in prehistory from the Natufian period, where gazelle bones were used – *cf. Stordeur 1988.5–8; le Dosseur 2010* – to the Neolithic and later periods throughout Europe – *e.g., Voruz 1984.73–5, Fig. 24*).

Ulnae also have an epiphysis that may be used as a handle, and pointed tools from ulnae are known from Neolithic sites in Western Europe (*e.g.*, *Pascual Benito 1998.46*). In Starčevo culture, they may occur occasionally (*e.g.*, at Donja Branjevina, *Vitezović 2011a.82*), but they are almost non-existent at Vinča sites.

Ribs are the next most common skeletal elements. Both ribs and metapodials were split longitudinally (Fig. 6). However, since the results were slender, sharp pointed tools, it may be assumed that the purpose of splitting was to create a thinner object, and not to save on material. Several pieces with 'mistakes' (long bone shafts with traces of groove, split somewhat irregularly and discarded) also confirm that there was no need to save raw materials, as they could have been easily repaired by abrasion. Also, the spongy tissue on the lower surface of rib

Fig. 7. Spoon made from red deer antler segment.

tools is usually heavily abraded from use, suggesting such a coarse surface was needed (especially in the case of scrapers).

Other skeletal elements are practically non-existent in tool assemblages. Apart from ribs, no other flat bones were noted, nor short bones, although on other Vinča culture sites worked astragals may occur in relatively low numbers (*e.g.*, at Selevac, *Russell 1990.538–9*; Divostin, *Lyneis 1988.313–5*; Slatina, *Vitezović 2007.98–100*; Drenovac, *Vitezović 2007.157–8*).

It should also be mentioned that cranial bones were not used (only one was reported from Selevac, *Russell 1990.697*). Occasionally, mandibles were used at some Vinča culture sites; they are mentioned at Selevac (*Russell 1990.540*), and Opovo (*Russell 1993.171*), but in all of these cases these are expedient tools. Mandibles can be successfully used for tools, as can be seen from some examples from Neolithic sites in France (*cf. Maigrot 2003.24*).

Bones were obtained from animals that had been killed presumably mainly for food. There is no evidence of the use of bones from discovered dead animals (such as taphonomic traces preceding manufacture traces). On Vitkovo, ovicaprines dominate in the faunal record and, at the same time, ovicaprine bones provided the main raw material for tools. At the majority of other Vinča culture sites, cattle is the dominant domestic species (*e.g.*, Selevac, *Legge 1990*; Divostin, *Bökönyi 1988*), and ovicaprine bones also prevail as raw material. This suggests that the choice of ovicaprine bones was not linked to their relative abundance, but that it was the result of deliberate choice.

Antlers were the only skeletal elements of the cranium used systematically as raw material. They were also obtained in a completely different manner from bones. At most Vinča sites, shed antlers are used, although there are some examples of antlers taken from killed animals. For example, at Divostin (where the wild fauna is found in extremely low percentages, about 15% – *Bökönyi 1988.420*), a very rich antler industry was discovered, with several heavy percussion tools made from the basal segments of shed antlers; however, one artefact was made from *bois du massacre*, and one piece of raw material (with traces of tine removal) was also from a killed animal. Antler artefacts are not numerous at Vitkovo, and generally come from segments of smaller dimensions (mainly from cortex pieces; Fig. 7), suggesting that antlers were not abundant. Only one antler fragment without traces of manufacture or use was discovered in the faunal record.

The antlers that were used are almost exclusively from red deer. Roe deer antlers were rarely used for tools, and are completely absent from some sites. Different ratios of antlers at particular Vinča culture sites (a high number at Jakovo-Kormadin, relatively low at Slatina) may be the result of different strategies of exploiting neighbouring areas (for antler procurement) and/or of different uses (in most cases, these are heavy tools, probably intended for woodworking).

Decorative items reveal a somewhat different picture of the exploitation of osseous raw materials. The materials are often exotic, such as marine shells (six specimens found at Vitkovo), or related to an area outside the settlement in some other ways, *e.g.*, the perforated teeth of wild animals (*cf.* red deer canine from Selevac, *Russell 1990.pl. 14.7*), or they were made from antler, such as the pendant from Vitkovo, or several decorative items from Selevac (*Russell 1990.534*). Perhaps the very origin of raw material was also important (domestic *vs.* wild, *sensu Hodder 1990*).

Conclusion

Despite some misconceptions about the osseous industry as an ad hoc use of kitchen debris, a careful analysis of the raw material selection in the case study of the Vinča culture site of Vitkovo revealed a different picture.

The skeletal elements and species were carefully chosen in a planned and systematic way, perhaps even separated and set aside already during primary butchering. Although some expediency in raw material selection may occur from time to time, the Vinča culture bone industry is generally planned, revealing the systematic use of specific skeletal elements for determined tool types.

Metapodial bones were used most commonly, followed by other long bones and ribs, generally from ovicaprines. Other bones may have occasionally been used, such as astragals, but some bones were almost never transformed into artefacts (such as cranial bones). Large ungulate bones occur rarely, and pig bones seem to have been avoided.

Such a choice of raw materials is consistent with their mechanical and physical properties and with the desired final products (sharp tip, heavy percussion tool). The avoidance of some skeletal elements and some species (cranial bones, pig bones), however, is difficult to explain. Some degree of cultural preference for certain skeletal elements and species is beyond doubt (*e.g.*, preferred choice of wild species and exotic raw materials for decorative items), but still more evidence is needed for a thorough analysis of the degree of influence of cultural reasons on technological choices, as well as their meaning and symbolic value.

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New Pre-Pottery Neolithic sites and cult centres in the Urfa Region

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ABSTRACT – *The present study assesses the sites and the corresponding artefacts that were recently discovered during cultural inventory studies in the Urfa region in south-eastern Turkey. The studies were conducted at PPN sites located at Herzo Tepe, Başaran Höyük and Kocanizam, Taşlı Tepe and İnanlı Tepe within the borders of Viranşehir and Siverek boroughs; the already known site at Sefer Tepe is also re-examined. The sites extend in a north-south direction and were founded within a 3–5km distance, and they exhibit unique characteristics for this region. Recently discovered sites are compared to already known PPN sites in the region to reveal similar features and characteristics. In particular, the article elaborates similarities and discrepancies between sites with T-shaped pillars and sites with circular structures. The recently discovered sites demonstrate that the pillar tradition is predominant in the region and that the settlements have a distinct layout.*

IZVLEČEK – *V študiji ovrednotimo najdišča in pripadajoče artefakte, ki so bili nedavno odkriti pri študijah kulturnih inventarjev v regiji Urfa na območju južno-vzhodne Turčije. Analize so bile opravljene na najdiščih predkeramičnega neolitika na območjih kot so Herzo Tepe, Başaran Höyük in Kocanizam, Taşlı Tepe in İnanlı Tepe znotraj mestnih okrajev Viranşehir in Siverek; ponovno smo preiskali tudi že znano najdišče Sefer Tepe. Najdišča se raztezajo v smeri sever-jug in so postavljena v razdalji od 3 do 5km, poleg tega pa izkazujejo edinstvene značilnosti za to območje. Nedavno odkrita najdišča primerjamo z že znanimi predkeramičnimi najdišči v regiji in na ta način ugotavljamo njihove podobnosti in značilnosti. V članku se podrobneje ukvarjamo s podobnostmi in razlikami med najdišči s stebri v obliki črke T in najdišči s krožnimi strukturami. Nedavno odkrita najdišča kažejo, da v tej regiji prevladuje tradicija stebrov in da imajo naselbine značilne prostorske ureditve.*

KEY WORDS – *Pre-Pottery Neolithic; T-shaped pillar; circular structures; Siverek; Viranşehir*

Introduction

Herzo Tepe, Başaran Höyük, Kocanizam Tepe, Sefer Tepe, Taşlı Tepe and İnanlı Tepe sites (Map 1), which are being investigated in the Şanlıurfa Province Cultural Inventory studies since 2011, are located within the borders of Şanlıurfa Province in southeastern Turkey. All sites are located within borders of today's Viranşehir and Siverek boroughs of Şanlıurfa (Urfa) Province.

The recently discovered sites extend in a north-south direction and were founded within a distance of 3–5km. Tools made from flint stone and obsidian were discovered during the field survey at these sites. The archaeological material from the sites features finds dating to the Pre-Pottery Neolithic Period. T-shaped pillars, known from locations such as Nevali Çori, Göbekli Tepe, Sefer Tepe and Hamzan Tepe, were

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also discovered at some of the sites. Moreover, architectural remains with a circular layout are also encountered at some sites. The other characteristics of these sites will be elaborated in this article according to the region where they were discovered.

Neolithic in Siverek region

Siverek is located in the borough in the north-eastern part of Şanlıurfa province. Karacadağ, the only dormant volcanic mountain in Şanlıurfa, with an altitude of 1938m, is located on the northeast border of the region. The geological formation of the mountain is dominated by basaltic rocks in the north, while the southern and south-western sections are made of calcareous rocks. The southern and south-western areas are in the form of plains and low plateaus.

Areas with water sources cover large parts of the Siverek region compared to other regions in Şanlıurfa province. Water sources arising from Karacadağ flow to the Habur stream in a north-south direction. The southern side of Karacadağ and the northern sections of the region have an abundance of water sources. The period of drought starts in Siverek region in the middle of the summer and encompass fields serving as pastureland. In general, the Siverek region is on average 3°C cooler than the Şanlıurfa city center.

No inventory studies have been conducted in the region, but are currently in progress in the region at the sites of Taşlı Tepe (*Çelik* et al. *2011b.225–236*) and İnanlı Tepe dating to the Pre-Pottery Neolithic period that were discovered during the studies since 2011. The site at İnanlı Tepe will be presented for the first time in the present article (Map 1).

Taşlı Tepe

The Taşlı Tepe site is located in the north-eastern part of the Şanlıurfa Province (*Çelik* et al. *2011*). Located *c.* 740m above sea level, the site covers a surface area of *c.* 12 000m^2 (Map 1). The site extends *c.* 4m above the bedrock. Today, this location is used for agriculture (Fig. 1). Two dry stream beds extend in an east-west direction *c.* 300m to the north and 250m to the south of the site. The examination of the geological structure revealed that the region is formed by calcareous and basalt platforms. The closest source of basalt to the site is 2km to the south. Flint stone outcrops are encountered 2km southeast of the site. High plateaus with heights varying from 800 up to 850m are present in the southwest, east and north of Taşlı Tepe. The southern and western sides of the site, on the other hand, extend as partially plain terrain.

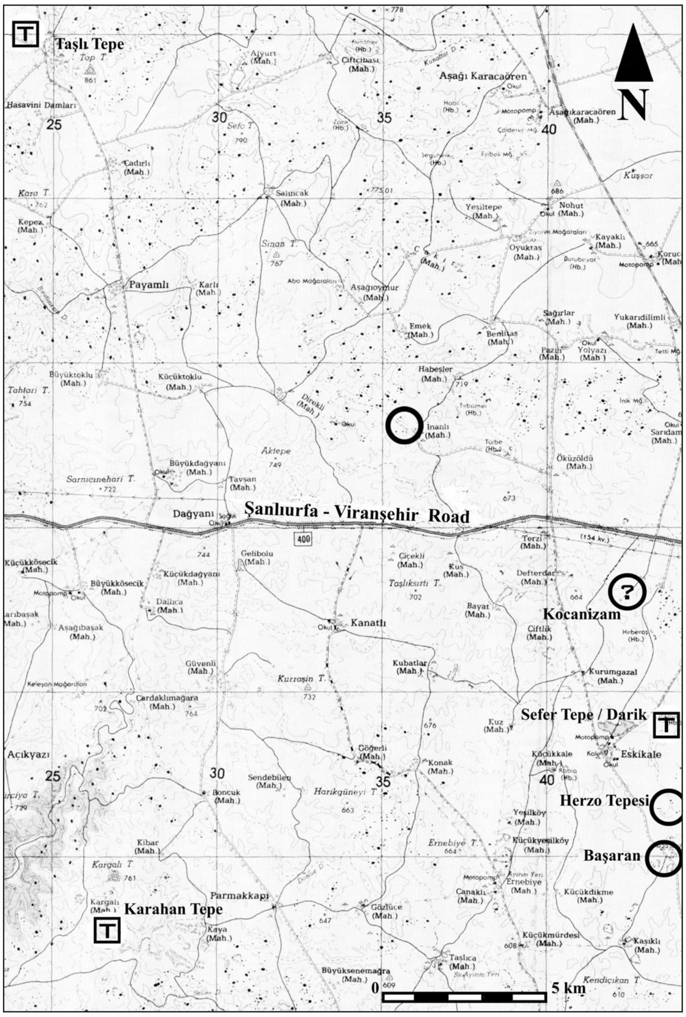
The Taşlı Tepe site was inhabited only during the Pre-Pottery Neolithic period. The archaeological finds have been divided into two categories: architectural elements and small finds. Accordingly, the small finds might be listed as tools made of flint stone, small flat axes made of river pebbles, stone beads, stoneware pottery pieces, grind stones and pestles. The finds comprise 6 small finds and 7 architectural elements. All the architectural elements are pieces of a T-shaped pillar. As a result of the examinations of the flint stone finds and architectural elements discovered at the site, it is understood that Taşlı Tepe settlement site was used as a cult centre during the Pre-Pottery Neolithic period.

Pre-Pottery Neolithic assemblage in Taşlı Tepe

Architectural elements. The architectural remains at Taşlı Tepe were destroyed by agricultural activity. However, during an excavation carried out on the south-eastern slope of the site, fragments of T-shaped pillars were found in an area of 7 x 8m and 1m deep. All pillars are made of limestone. One of the fragmented pillars has been restored and reassembled; its apparent length is 152cm; the width of the capital section is 93cm, while the thickness is 22cm (Fig. 2). The dimensions of the T-shaped pillar pieces discovered at Taşlı Tepe site demonstrate a significant similarity with the Level II pillars at Göbekli Tepe (*Schmidt 2002.8, Fig. 7*)[1], the pillars of the temple building at Nevali Çori (*Hauptmann 1991/1992.28, Abb. 21*), and in-situ pillars located on the surface of Karahan Tepe (*Çelik 2000b.6–7, Fig. 1*) and Sefer Tepe (*Çelik 2006a.23–25, Fig. 2*). The Taşlı Tepe pillars had no preserved relief or engravings. A fragment of terrazzo floor was also discovered from the same excavation site (Fig. 3). Similar terrazzo floors were also discovered in Göbekli Tepe, Nevali Çori and the Şanlıurfa-Yeni Mahalle mound unearthed in the region (*Çelik 2007.Fig. 16; Hauptmann 2007.142, Fig. 7–8a–b*).

Small finds. A total of 16 small finds were collected from the Taşlı Tepe site. The finds comprise 7 flint tools (Fig. 4. 1–7), 1 small flat axe made of river pebble (Fig. 4.9) and 1 stone bead (Fig. 4.8). The other finds are 2 basalt pestles, 1 stone dish (Fig. 5), 3 upper parts of a grind stone and 1 lower part of a grind stone (Fig. 6), respectively. Flint finds are com-

1 Pillars at L10–71, L9–80, L9–55 and L9–56 trenches.



Map 1. Pre-Pottery Neolithic Period sites in Viranşehir and Siverek boroughs.

mon in the entire area. The number of flint tools discovered is around 12 per m^2.

The small finds at Taşlı Tepe are mostly flint and a small number of obsidian tools. The majority of the flint and obsidian tools are blades. High-quality flint stones were used as raw materials and the nearest flint deposits were found 2km southeast of the site. The flint tool assemblage comprises 4 arrowheads (Fig. 4.4–7) and 1 round end scraper (Fig. 4.3). Only one core was discovered at Taşlı Tepe, *i.e.* a naviform core, which appears to be bipolar (Fig. 4.1). Moreover, 1 piece of crested blade was also unearthed as a core renewal piece (Fig. 4.2). An examination of the colour distribution of all flint finds revealed 3 dark gray and 4 light and dark brown colours. The blade flaking of the bipolar cores varies from 1 to 1.5cm. One core is grey; cores of similar colour were also found at Göbekli Tepe (*Beile-Bohn* et al. *1998.54*) and Nevali Çori (*Schmidt 1988.162*).

One intact flint arrowhead appears to be of the Byblos type (Fig. 4.4). Similar specimens of were found at Göbekli Tepe (*Schmidt 1988.Fig. 8; 2001.52, Fig. 10/3–11/5; Beile-Bohn* et al. *1998.Abb. 23.3*), Şanlıurfa-Yeni Mahalle (*Çelik 2000a.Fig. 5.1; 2007.Fig. 20/6*) and Karahan Tepe (*Çelik 2011b.Fig. 18.1 type I*). Typologically, the types of tools from the Pre-Pottery Neolithic Period are observed when the flint tools are examined as a whole. The single shallow stone dish, which was discovered at Taşlı Tepe, is an interesting find since similar stone dishes were encountered in Level II at Göbekli Tepe (*Schmidt 2007.Catalogue 129*) and as a grave good at Körtik Tepe (*Özkaya, Coşkun 2007.86–88, Catalogue 144*). Another extraordinary artefact discovered at the site is a bead made of green river pebbles in the form of a bull's head (Fig. 4.8). Similar beads were found at Köşk Höyük from the Late Neolithic period (*Öztan 2012. Fig. 18b*)[2].

The T-shaped pillars discovered at Taşlı Tepe greatly resemble the pillars discovered at Sefer Tepe, Karahan Tepe and Level II of Göbekli Tepe with respect to their dimensions. In the light of all these artefacts, Taşlı Tepe appears to be contemporaneous with the excavated sites at Göbekli Tepe (Level II) and at Nevalı Çori (Level III). Therefore, we can date the Taşlı Tepe site into the early PPNB period.

İnanlı Tepe

İnanlı Tepe is located *c.* 697m above sea level in the northern end of the İnanlı village, 64km east of Urfa, 80km south of Siverek and *c.* 12km north of Sefer Tepe (Map 1). Founded on a calcareous hill, the site covers an area of *c.* 15000m^2. The mound soil extends *c.* 2m high, starting from the bedrock. The site is comprised of two small, low hills presenting an ample structure (Fig. 7). The area, on which the site was founded, is currently used as pasture. A dried stream bed is located 700m to the south. The geological structure of the region is formed by calcareous plateaus. Such plateaus present an extremely low and frequent structure. The closest source

2 The red coloured bead at the middle is the bead with the shape of bull's head.

of basalt is *c.* 5km northwest of the site. Plain areas are present to the east and southeast, 7km from the site.

Flint stone artefacts could be collected over the entire area at İnanlı Tepe; the number of flint tools discovered is *c.* 7 per m^2 area. The results of the examinations on flint tools and architectural elements discovered at the site show that İnanlı Tepe was used as a settlement during the Pre-Pottery Neolithic period.

Pre-Pottery Neolithic assemblage at İnanlı Tepe

Architectural elements. The remains of three well-preserved circular structures were found in the area southeast of the site. The diameter of the structures varies from 2 to 2.5m. All three structures are formed by arranging the flat sides of the shaped stone slabs in a horizontal form (Fig. 8). Similar structures were identified at Hamzan Tepe (*Çelik 2010.259, Fig. 3–4*). Other circular structures in the region from the same period are known from settlements at Çayönü (*Erim-Özdoğan 2011.191–193, Fig. 6, 9*), Hallan Çemi (*Rosenberg 2011.61–63, Figs. 2–6*), Hasankeyf Höyük (*Miyake 2013.40, 43, 46, 47*), Gusir Höyük (*Karul 2011.2–4, Figs. 4–5, 11*) and Körtik Tepe (*Sicker-Akman 2001.389–394; Özkaya, Coşkun 2011.90–93, Figs. 2–5*). Moreover, the dimensions of the circular structures at İnanlı Tepe are similar to two structures with terrazzo flooring discovered at Şanlıurfa-Yeni Mahalle (*Çelik 2007.162, Fig. 16; 2011a. 142, Fig. 15–16*).

Small finds. Lithics dating to the Pre-Pottery Neolithic period were found during the field survey at the site. The assembladge is comprised of blades, flakes and flint by-products. The flint is mostly dark grey, light and dark brown. The flint tools consist of arrowheads, a scraper and silica flakes (Fig. 9.1–6). Rare flakes of obsidian are also present at İnanlı Tepe.

The circular structures discovered at İnanlı Tepe, pieces of Byblos and Nemrik arrowheads made of flint stone discovered on the surface, and unavailability of any Çayönü tools and Palmyra points most probably indicate that the settlement should be dated to the early PPNB period.

The Neolithic of the Viranşehir region

Viranşehir is a borough of the Şanlıurfa province, located in the eastern part of the province. The mountain of Karacadağ is located on the northeast border of the region and is dominated by basaltic rocks in the north and calcareous rocks in the south and south-west. The southern and south-western areas are in the form of plains and low plateaus.

Areas with water sources cover large parts of this region, similarly to the Siverek region in this province. The Aşağı Cırcıp and Yukarı Cırcıp streams rising from Karacadağ and flowing north-south to the Habur stream are the most significant water sources in the region. There is also a large number of springs on the southern side of Karacadağ and in the northern parts of the region. In spring the drought starts in the Viranşehir region which encompasses broad fields serving as pasture land.

The Sefer Tepe (Yukarı Darik Harabesi) site, which dates to the Pre-Pottery Neolithic period, was discovered during inventory studies in 2003[3]. The Başaran Höyük, Herzo Tepe, and Kocanizam Pre-Pottery Neolithic period sites (Map 1) were discovered during the study[4] in 2011 (*Güler* et al. *2012.169–191*).

Başaran Höyük

Başaran Höyük is located inside the Başaran village, 62km east of Urfa and 26km southwest of Viranşehir (Map 1). Sefer Tepe (*Çelik 2006a.23–25*), discovered in 2003, is located at 652m altitude above sea level and 5km south of the settlement at Başaran Höyük. The mound is elevated and conical, and located on a calcareous hill; the village cemetery which is currently in use covers a part of the mound (Fig. 10). The mound soil is *c.* 10m high, measured from the bedrock. The mound covers an area of *c.* 20 000m^2. The geological structure of the region is formed by calcareous plateaus. A stream bed is located to the 5.5km north of the site. The closest source of basalt is *c.* 6km north and the area is used primarily as pasture land.

The flint artefacts discovered at Başaran Höyük site are not concentrated throughout the entire area; the

3 Project for Social and Cultural History of Turkey, Project for Inventory of the Cultural Assets in Eastern and Southeastern Anatolia Regions.

4 These studies were conducted under the scope of TÜBİTAK project entitled 'Determination, Inventory and Assessment of the Immovable Cultural Assets in Şanlıurfa Province and Districts of the Province.' We hereby present our acknowledgements to Mr. Celalettin Güvenç, the Governor of Şanlıurfa, Mr. Muhammed Lütfi Kotan, the District Governor of Viranşehir.

number of flint tools discovered is 3 per m² area. The site was inhabited as a settlement during the Pre-Pottery Neolithic period as presented by the flint tools. However, it is difficult to estimate the actual size of the settlement during the PPN period, since the site was covered with remains of younger cultural periods.

Pre-Pottery Neolithic assemblage in Başaran Höyük

Architectural elements. No architectural elements were discovered at Başaran Höyük. The cultural levels from the Bronze Age, Iron Age and Byzantium period are probably compacted with the PPN levels. However, cut-outs in groups with diameters varying from *c.* 10–15cm in length and depths of 10cm were discovered in the rock floor where the mound cone ends (Fig. 11). These cut-outs chiselled in the bedrock have features identical to those at Göbekli Tepe, Hamzan Tepe, and Karahan Tepe (*Beile-Bohn* et al. *1998.47–50, Abb. 20; Hauptmann 1999.Fig. 32; Çelik 2000b.7; 2004.3, Figs. 2–3; 2006b.222, Figs. 3–4; 2010.259, Fig. 6; 2011b.259, Figs. 18–21*).

Small finds. During the studies conducted at Başaran Höyük, pottery from the Bronze Age, Iron Age and Byzantine periods was discovered in addition to the Pre-Pottery Neolithic finds. The flint tools are comprised of flint blades, flakes and by-products. The flint is mainly light and dark brown, beige and grey. Arrowheads, scrapers, piercing tools and crested blade pieces from this period were discovered (Fig. 12.1–9). Also rare obsidian blade pieces were found at the site (Fig. 12.10).

The arrowheads discovered at Başaran Höyük are very similar to the arrowheads discovered at Karahan Tepe and Sefer Tepe both in terms of their size and form (*Çelik 2006a.24, Fig. 4 b–d; 2011.244–245, Figs. 18.4–9, 19.1–8*). This type of small arrowheads were also found at Nemrik (*Kozłowski, Szymczak 1989.32, Fig. 2; Abbes 1993.Fig. 8.10; Cauvin 1994.Fig. 24.1, 3; Schmidt 2001.52, Fig. 10.4, 6*) and Byblos (*Schmidt 1988.171–174, Abb. 11.1–6, 12.1–3; Cauvin 1994.Fig. 26.3*) and are dated to the early PPNB period (*Cauvin 1994.78–79, Fig. 24.2*).

The presence of cut-out groups chiselled on the bedrock surrounding the mound and used for pool construction technique, as well as the Nemrik and Byblos arrowheads indicates that Başaran Höyük was probably occupied at the end of the late PPNA and in the early PPNB period.

Herzo Tepe

Herzo Tepe is located 62km east of Urfa and 3.5km south of Sefer Tepe (Map 1) and is 574m above sea level. The geology of the region is formed by calcareous plateaus. Founded on a calcareous hill, the mound is a low and ample structure (Fig. 13). The mound soil is *c.* 3m above the bedrock and covers an area of *c.* 10 000m². The closest water source is 4km north of the site. The closest basalt source, on the other hand, is *c.* 4.5km north of the site. A large area of the settlement was destroyed due to the construction of rock-cut tombs in the early Byzantine period and modern agricultural activity.

The flint tools at Herzo Tepe site were discovered throughout the entire area, with a density of *c.* 20 per m². As a result of the examinations of the flint tools, it is understood that The site was inhabited as a settlement during the Pre-Pottery Neolithic period.

Pre-Pottery Neolithic assemblage at Herzo Tepe

Architectural elements. The remains of a circular building were encountered east of the settlement (Fig. 14), with an approximate diameter of 5m. The closest example of this structure is known from Hamzan Tepe (*Çelik 2004.3–5; 2010.259, Figs. 3–4*). Moreover, the diameter of the structure is identical with structures discovered at Hasankeyf Höyük (*Miyake 2013.40, 43, 46, 47*). Other similar structures are known in settlements at Çayönü (*Erim-Özdoğan 2011.191–193, Figs. 6, 9*), Hallan Çemi (*Rosenberg 2011.61–63, Figs. 2–6*), Hasankeyf Höyük (*Miyake 2013.40, 43, 46, 47*), Gusir Höyük (*Karul 2011.2–4, Figs. 4–5, 11*) and Körtik Tepe (*Özkaya, Coşkun 2011.90–93, Figs. 2–5*).

Small finds. The field survey revealed pottery from the early Byzantine period, as well as hand-made straw-tempered ceramic pieces and lithics from the Pre-Pottery Neolithic period. Flint tools are comprised of flint blades, flakes, production waste, unipolar and bipolar cores. The flint is principally light and dark brown, beige and grey. Arrowheads, scrapers, piercing tools, crested blades and blades with a silica sheen were discovered from this period (Fig. 15.1–4, 6, 7). In addition, rare obsidian blade pieces were also found (Fig. 15.5). The tools include small Nemrik arrowheads (Fig. 15.9–13) and one Byblos type arrowhead (Fig. 15.8). Basalt grind stones and pestle pieces were also found.

The circular building at Herzo Tepe and the Nemrik type arrowheads found in the surface survey indicate that the site dates to the end of the PNA period and early PPNB period.

Kocanizan Tepe

Kocanizam Tepe is *c.* 653m above sea level and located in the Kocanizam village, 60km east of Urfa, 25km west of Viranşehir and 3km north of Sefer Tepe (Map 1). The region is formed by calcareous plateaus. Founded on a calcareous hill, the mound is low and ample (Fig. 16). The height of the mound soil is around 6m above the bedrock. Kocanizam Tepe covers a surface area of *c.* 15000m². The closest water source is 1.5km east of the settlement. The closest basalt source is *c.* 1km to the east of the site. A significant portion of the site was destroyed by later construction in the early Byzantine period.

The flint tools discovered at Kocanizam Tepe were spread over the entire area at a density of around 10 per m². As a result of the examinations of the flint tools discovered at the site, the site is dated to the Pre-Pottery Neolithic period.

Pre-Pottery Neolithic assemblage at Kocanizam Tepe

Architectural elements. A calcareous stone believed to be the body of a T-shaped pillar was unearthed in an illegal excavation site at the centre of the settlement area. The stone is flat and chiselled into rectangular shape, with both short edges broken (Fig. 17).

Small finds. During the field survey, pottery and architectural remains from the early Byzantine period were discovered, as well as blades, flakes and waste production made of flint stone and unipolar and bipolar cores that could be dated to the Pre-Pottery Neolithic period (Fig. 18.1–2). The flint is light and dark brown, beige and gray in colour. The most significant lithic artefacts are the Nemrik type arrowheads, scrapers, crested blades and blades with silica sheen (Fig. 18.4–5, 8–11). Furthermore, blade pieces made of obsidian are also encountered (Fig. 18. 6–7) as well as grinding stones and pestle pieces made of basalt.

The Neolithic settlement located inside Kocanizam village should be dated to the end of the PPNA period (LPPNA) and early PPNB period (EPPNB) according to the Nemrik arrowheads discovered at the site and the presence of calcareous stone estimated to be a part of a T-shaped pillar.

Sefer Tepe (Yukarı Darik Harabesi)

Sefer Tepe is a small, broad and shallow mound (Fig. 19) located *c.* 72km east of Şanlıurfa, within the modern province borders of Viranşehir (Map 1). The mound is located at 600m altitude above sea level and covers a surface area of *c.* 7000m². A country house is located in the south-eastern corner of the site. The closest water source is Yukarı Cırcıp creek, 1.5km to the east. The geological foundation is of calcareous rock and the closest basalt source is located 1km to the east.

Pre-Pottery Neolithic Assemblage at Sefer Tepe (Yukarı Darik Harabesi)

Architectural elements. The most intriguing aspect of the Sefer Tepe site are the 16 in-situ T-shaped pillars (*Kürkçüoğlu, Karahan Kara 2005.62–63; Çelik 2006a.23–25*). Most of the pillars were buried and placed side-by-side in a conjugate formation at *c.* 1.5 up to 2m intervals (Fig. 20). The upper sections above the surface are *c.* 50cm long and 20cm wide. The positioning of the pillars is very similar to the architecture at Göbekli Tepe Level II (*Schmidt 2002. 8, Fig. 7*)[5] and the monolithic in-situ pillars on the surface at Karahan Tepe (*Çelik 2000b.6–7; 2011. 241–242, Fig. 7*). Moreover, another pillar was revealed during the construction of the country house in the south-eastern corner of the site. This pillar was found intact (Fig. 21); its length is 198cm and the width of the head section is 72cm, the width of the body section 54cm and the thickness 25cm. The head section of this undecorated stele is extremely flattened; it has features identical with the pillars discovered at Nevali Çori, Göbekli Tepe, Karahan Tepe, Hamzan Tepe and Taşlı Tepe.

Small finds. Only flint and obsidian tools were discovered at Sefer Tepe. The proportion of obsidian to flint tools is 1:7. Arrowheads, piercing tools, end scrapers and blades with a silica sheen were among the lithic artefacts. On the other hand, only one scraper piece and blade pieces were identified among the obsidian tools. Typologically, tools dating to the Pre-Pottery Neolithic were identified among the flint stone finds (Fig. 22.1–6). The flint arrowheads in particular are of the Byblos type with some unidentified types (*Çelik 2006a.25, Fig. 4*), where only the distal and proximal sections are well-preserved (Fig. 22.4–5). Identical arrowheads were found at Göbekli Tepe (*Beile-Bohn* et al. *1998.Abb. 23.3; Schmidt 2001.52, Figs. 10/3, 11/5*), Nevali Çori (*Schmidt 1988.Abb.*

5 Locations of the pillars at L10–71, L9–80, L9–55 and L9–56 trenches.

8.5), Şanlıurfa-Yeni Mahalle (*Çelik 2000a. Fig. 5.2*) and Karahan Tepe (*Çelik 2000b.Fig. 4a*). Moreover, one piece of a stone pot, similar to the ones discovered at Körtik Tepe (*Özkaya, Coşkun 2011.90–93, Figs. 15–21, 26*), was used as whetstone (Fig. 22.6).

The Viranşehir Plain extends to the north and east of Sefer Tepe; the site is located *c.* 20km from Karahan Tepe, 28km from Taşlı Tepe, 50km from Göbekli Tepe and 63km from Şanlıurfa-Yeni Mahalle and Hamzan Tepe[6]. The Sefer Tepe site dates to the early PPNB as it has features identical to Level II of Göbekli Tepe.

Concluding remarks

Circular structures were not discovered during the excavations of the Urfa region, except at Hamzan Tepe and Yeni Mahalle discovered in previous studies. We are used to observing such Early PPNB structures in the catchment area of the Tigris River. The circular structures here, on the other hand, are generally from the PPNA period that has different construction materials. The walls discovered at Hamzan Tepe, Herzo Tepe and İnanlı Tepe were built with large, partially dressed stone. The walls of the structures in the catchment area of the Tigris River, however, were built with small rubble. The flint tools from the surface at Herzo Tepe and İnanlı Tepe, that include circular structures, show that these sites date to the early PPNB period.

The cult/ritual structures recognised at Göbekli Tepe and Nevali Çori include T-shaped pillars with and without reliefs and statues. We acquired plenty of information on this type of buildings from the excavations at Göbekli Tepe. In particular, Level II, dated to the Early PPNB and contemporaneous with the cult structure at Nevali Çori, and Level III, dated to the PPNA period, offer new information on these cult structures. Thus far, no sites or cult centres from the PPNA period, which is contemporaneous with Level III of Göbekli Tepe, have been found.

All the new sites discovered in the Siverek and Viranşehir region are dated to the early PPNB period. Such dating is proven particularly by the resemblance of the pillars discovered at Taşlı Tepe and Sefer Tepe, characterised as cult centres, with pillars similar to Göbekli Tepe Level II in terms of dimensions. The same feature is also found in pillars in the cult structure at Nevali Çori Level III. The pillars here also date to the Early PPNB.

The most significant feature of Taşlı Tepe is the fact that it is the only example occupied in a single period, the Pre-Pottery Neolithic. Unfortunately, the architectural elements found on the surface were removed during levelling works by farming activities on the hill. Taşlı Tepe is characterised as a cult centre with T-shaped pillars. The contemporaneous sites are the Pre-Pottery Neolithic Sefer Tepe, 28km to the southeast, Karahan Tepe, 30km south, and Göbekli Tepe, 35km to the west. The fact that the distance between Taşlı Tepe and Sefer Tepe, Karahan Tepe and Göbekli Tepe is approximately identical indicates that the distance between the sites where T-shaped pillars are present was arranged to a certain pre-planned layout. The sites in the region are generally founded either on or immediately beside high plateaus (*Özdoğan 2011.229*). This fact might be used to designate the borders between the sites. Therefore, Taşlı Tepe is considered a site characterised by T-shaped pillars, such as Göbekli Tepe, Nevali Çori, Karahan Tepe, Sefer Tepe and Hamzan Tepe. The fact, that the number of sites increases gradually, means that they not only comprise cult centres in this period, but that they are also independent cult structures within the settlements as can be seen at Nevali Çori.

The absence of T-shaped pillars at Herzo Tepe and İnanlı Tepe and the presence of circular structures indicate that this type of sites were settlements not cult or ritual centres. The distances between Başaran Höyük, Herzo Tepe, Kocanizam Tepe and Sefer Tepe vary from 2 to 8km. Moreover, all four sites are aligned in a north-south direction. Sefer Tepe, which has T-shaped pillars, is located at the centre of the other four sites; the distance to the other settlements varies from 3 to 5km. This arrangement might indicate that Sefer Tepe was a cult centre for the other settlements. It is of particular importance with respect to presenting territorial areas in the region in the Pre-Pottery Neolithic period. This fact also suggests a settlement type we encountered at other PPN sites in the region.

Sites dating to the early periods of the Pre-Pottery Neolithic period were generally founded on, or on the hillside of, high plateaus in the region. Likewise, Başaran Höyük, Herzo Tepe and Kocanizam Tepe were founded on high plateaus and down bedrock. This type of settlement tradition is also seen at the Sefer Tepe, Taşlı Tepe, Karahan Tepe, Göbekli Tepe, Şanlıurfa-Yeni Mahalle and Hamzan Tepe Pre-Pottery Neolithic sites in the region.

6 Such distances are calculated as beeline distances. The distance between the settlements via modern highway network is longer.

The presence of circular structures constructed at Herzo Tepe and Hamzan Tepe settlements is important, as it demonstrates that two distinct architectural traditions were present in the region during the Pre-Pottery Neolithic period. The presence of sites characterised as cult or ritual centres, such as Göbekli Tepe, Karahan Tepe, Taşlı Tepe and Sefer Tepe, suggests that other settlements must have been present in the region. In the future, it might be possible to find other cult or ritual centres, settlements, or a combination of the two types in the region with systematic studies and excavations.

The absence of Palmyra points and Çayönü tools at Taşlı Tepe, İnanlı Tepe, Başaran Höyük, Herzo Tepe, Kocanizam Tepe and Sefer Tepe, and the fact that these sites have features similar to those in Level II at Göbekli Tepe and Level III of Nevali Çori, enable us to date such sites to the early PPNB.

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Fig. 1. Taşlı Tepe from the east.

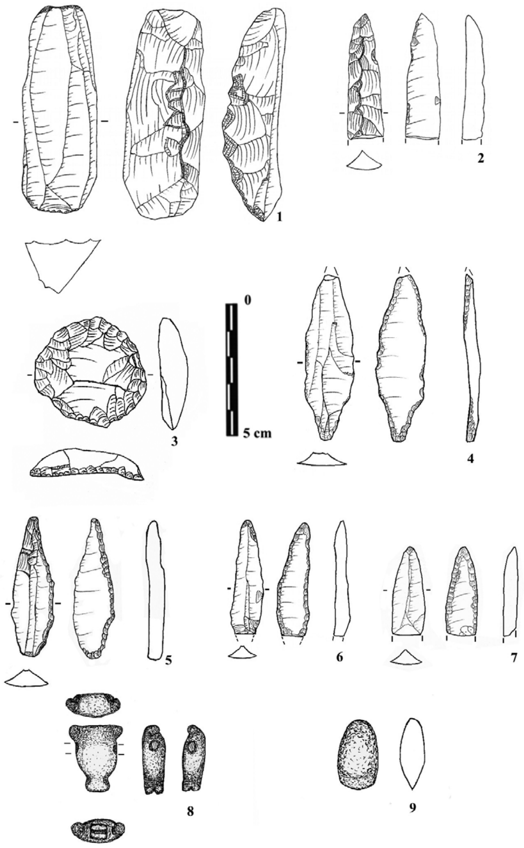

Fig. 4. Taşlı Tepe Neolithic finds.

Fig. 2. T-shaped pillar; front view.

Fig. 5. Stone dish or plate.

Fig. 3. Fragment of terrazzo floor.

Fig. 6. Grind stone.

Fig. 7. İnanlı Tepe from the south.

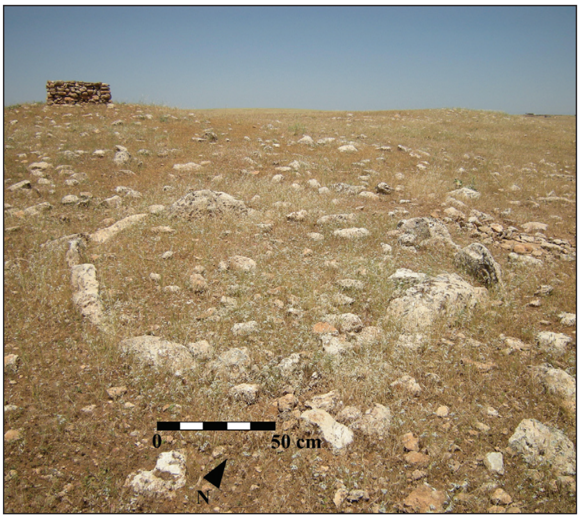

Fig. 8. Circular building at İnanlı Tepe.

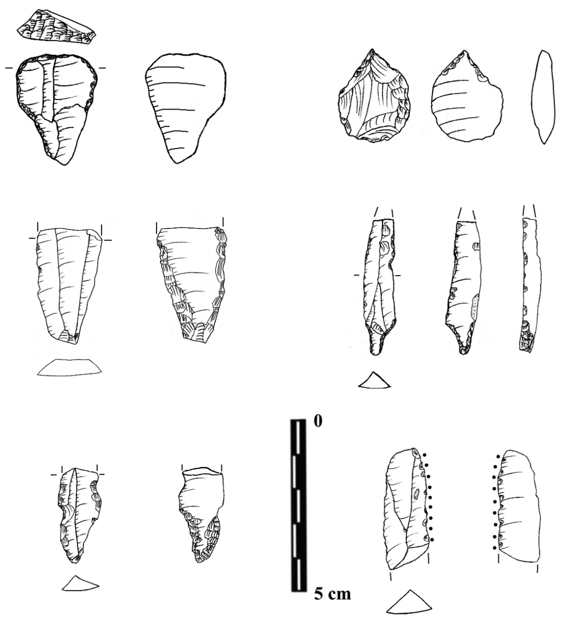

Fig. 9. İnanlı Tepe lithic tools.

Fig. 10. Başaran Höyük from the east.

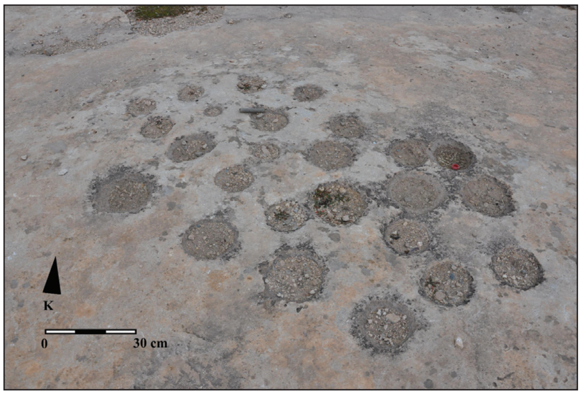

Fig. 11. Small cut-out groups cut into surrounding bedrock.

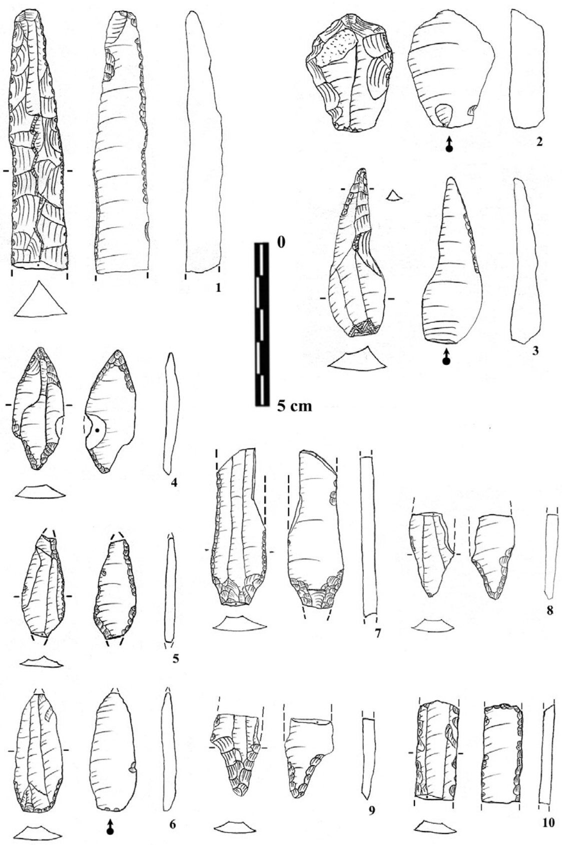

Fig. 12. Başaran Höyük Neolithic finds.

Fig. 13. Southwest view of Herzo Tepe.

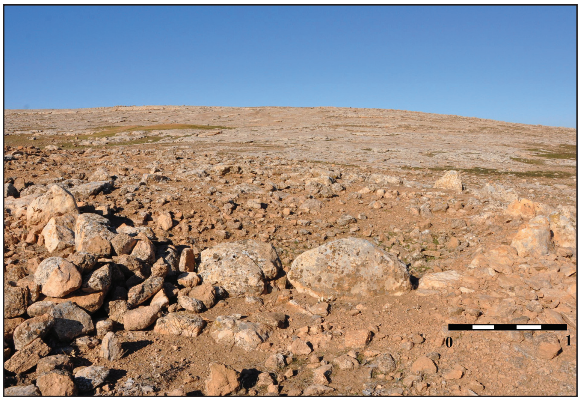

Fig. 14. Circular building at Herzo Tepe.

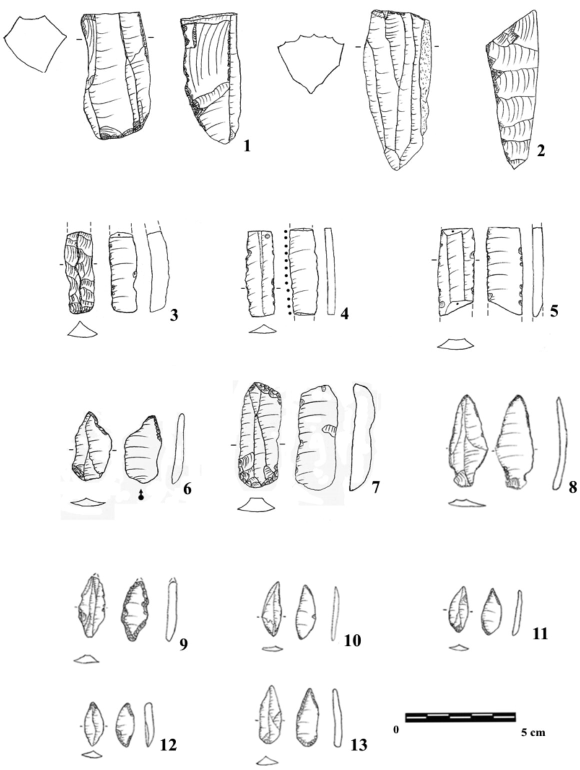

Fig. 15. Herzo Tepe Neolithic finds.

Fig. 16. Kocanizam from the south.

Fig. 17. Kocanizam Tepe piece of T-shaped pillar.

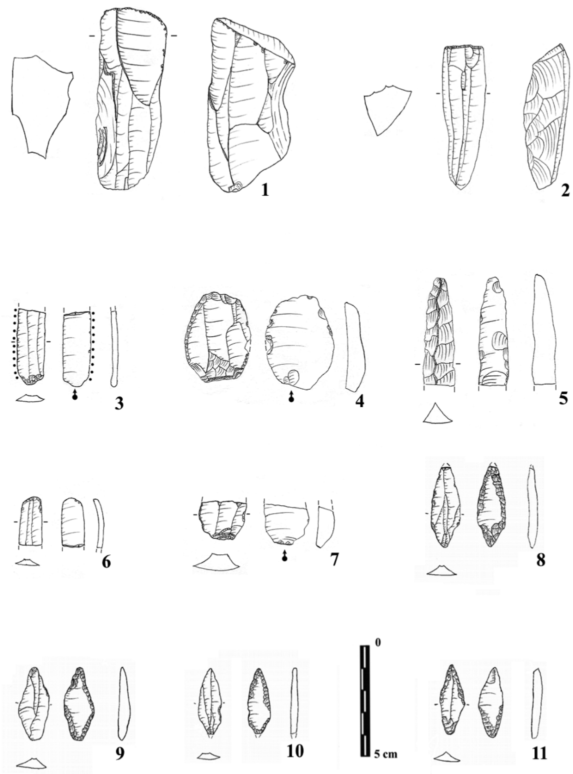

Fig. 18. Kocanizam Neolithic finds.

Fig. 19. Sefer Tepe from the north.

Fig. 20. Pillars at Sefer Tepe opposite each other.

Fig. 21. T-shaped pillar; front view.

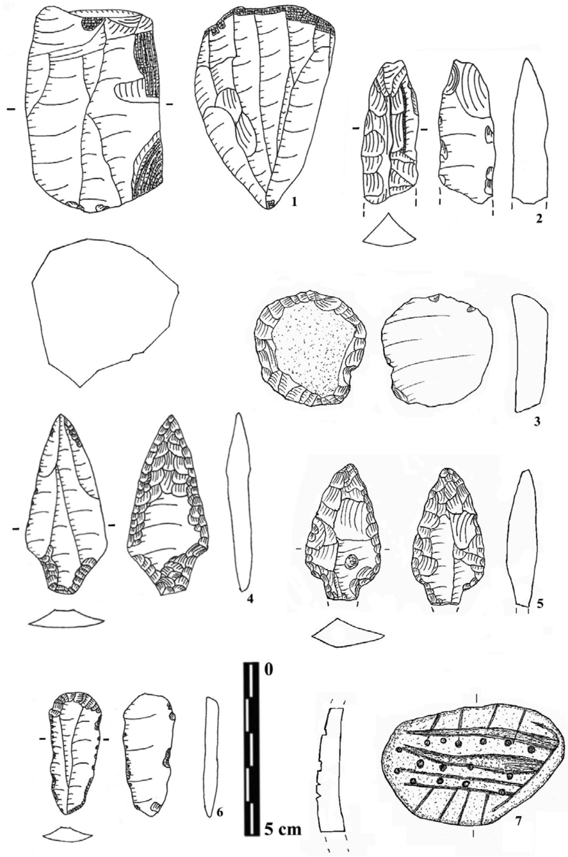

Fig. 22. Sefer Tepe Neolithic finds.

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Origin and contacts of people buried at the LBK graveyard at Kleinhadersdorf, Austria

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ABSTRACT – *In this article we present first information on results of analyses of the Linearbandkeramik (LBK) graveyard of Kleinhadersdorf carried out in recent years. First, we briefly present the excavations and main characteristics of the burials. Analyses of C-, N- and Sr- isotopes, executed within a large-scale international project, showed that most of the people were born and lived in the area and gathered food nearby. Only three individuals came from a geologically different region,* i.e. *the gneiss-granite zone of the Bohemian massif. Adzes and some quern stones were also obtained in this area, while flint raw materials and* Spondylus *shells for ornaments were procured from other regions.*

IZVLEČEK – *V članku predstavljava prve rezultate analiz, ki so bile opravljene v zadnjih letih na materialu iz grobišča Kleinhadersdorf iz obdobja linearno-trakaste keramike. Najprej bova predstavili izkopavanja na grobišču in glavne značilnosti pokopov. Analize izotopov ogljika (C), dušika (N) in stroncija (Sr), ki so bile opravljene v obsežnem mednarodnem projektu, so pokazale, da so bili ljudje, ki so pokopani na tem grobišču, rojeni in so živeli v okolici najdišča, kjer so tudi nabirali hrano. Le trije posamezniki so prišli iz območja, ki se geološko razlikuje od okolice Kleinhadersdorfa, in sicer iz območja z gnajsi in graniti, ki se nahajajo v češkem gorovju. Kamnite sekire in nekateri mlinski kamni, ki so bili odkriti na grobišču, so izdelani iz lokalnih kamnin, druga kamnita orodja in školjke* Spondylus*, ki so jih uporabljali za izdelavo nakita, pa so pridobivali v drugih regijah.*

KEY WORDS – *Early Neolithic in Central Europe; isotope analyses; mobility of people; procurement of raw materials*

Introduction

Kleinhadersdorf is a small village at the western end of the town of Poysdorf in the north-east of Lower Austria, close to the Moravian border. Interestingly, there is a gap within the distribution of the LBK immediately north and east of the small settlement cluster to which this site belongs (Fig. 1). The first finds from the burial site were discovered in 1911. In 1931, Josef Bayer, and after his unexpected death, Viktor Lebzelter effected the first small-scale rescue excavations, digging out 21 graves in all (G1a/c – G19). The results were published quickly, but with only few details about the site (*Lebzelter, Zimmermann 1936*). No further investigation was done until 1987, when the 'Bundesdenkmalamt' in Vienna decided to start a new rescue excavation in the central part of the area. The first campaign under the direction of Johannes-Wolfgang Neugebauer and Christine Neugebauer-Maresch clearly showed the necessity of further investigation, which was done in four more campaigns until 1991. An area of approx. 5000m^2 was uncovered and some 100 pits excavated (Verf. 1–90) (*Neugebauer-Maresch 1992*). In recent years, many analyses of the excavated material were completed. The results will be published in a monography of Kleinhadersdorf, which is currently being prepared for print (*Neugebauer-Maresch, Lenneis in prep.*). In this article, we present a short overview of some of the most important results of these analyses.

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The burial pits

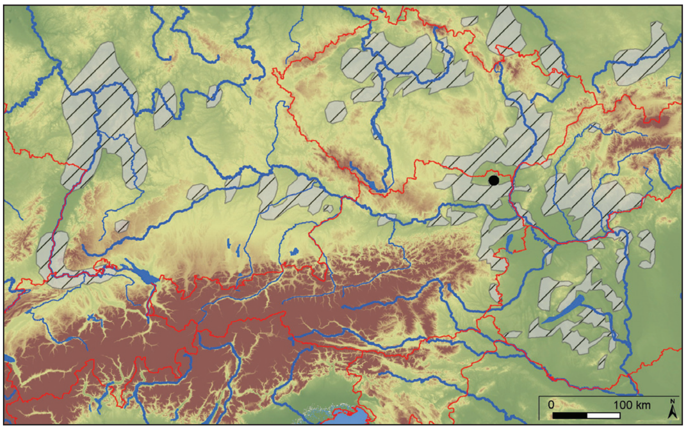

Fig. 1. The situation of the site Kleinhadersdorf within LBK distribution in eastern Central Europe (graph by J. Coolen).

Some 67% of the burial pits at Kleinhadersdorf contained inhumations, while four pits (4%) contained traces of incinerations. The anthropologists identified the remains of 57 individuals (*Tiefenböck 2010*). As far as we can establish, these were all single burials, with two exceptions: a young woman buried with a newborn child (grave Verf. 5), and two small children of the same age. Radiocarbon dates were taken from the bones of 19 inhumations; the calibration of the data gives a time span between 5250–5020 calBC (*Stadler in prep.*).

The orientation is only known for 48 burials. More than half of the dead (55%) were oriented with the head towards south-east; another considerable percentage (19%) was buried with the head to the north-west direction, a few to the west (10%), east or north-east (6%), and to the north (4%). The impressive predominance of the south-east and north-west orientation is typical in other graveyards in eastern Central Europe (*e.g.*, Těšetice-Kyjovice, Vedrovice, Nitra), but is slightly different in other regions of the LBK.

Bodies were placed in a more or less crouched position on the left side in 85% of the burials, and only in 15% of the burials on the right side. More than half of the bodies (65%) lay on their side with the hands before the face; in 32% of the burials the upper part of the body lay on the back, and prone in only a few cases (3%), while the legs are folded and placed to the side. The degree of bending of the legs is extremely varied, and seems to be due mainly to the form and extent of the grave pit.

The custom of spraying red chalk on bodies is a very old burial tradition in Central Europe, with varying importance within the LBK (*Lenneis 2007*). In Kleinhadersdorf, it was found on only nine individuals, placed around their heads. Some traces of red chalk/ochre on grind stones indicate the further use of this mineral, which can be found within the 'home range' (*Bakels 1978*) of the site (Fig. 2).

Twenty-six of the grave pits investigated between 1987 and 1991 had no inhumation, or only a few remnants, but they had precisely the same shape and size as the grave pits containing burials. The empty grave pits, presenting 29% of all graves at the site, and the amount of artefacts in them, seem to be a special feature of the Kleinhadersdorf graveyard as their number is quite high compared to other LBK sites (*Lenneis 2010a*). Nevertheless, these empty grave pits do not have the necessary characteristics of 'cenotaphs' – *i.e.* fully equipped graves of absent person as is the case in some other LBK graveyards.

The grave goods

When analysing the grave goods and their position inside the pits, we observed that in many cases empty space was available for some items which have clearly not been preserved. Therefore, we do not speak of 'rich' or 'poor' graves, but only of graves with many, some, few or no preserved grave goods. As we cannot estimate the value of the lost goods, we should not interpret the quantity of preserved goods as indicators of the social status of the deceased. Nevertheless, it was very interesting to compare the preserved situation of individuals of different sex and age with those in other LBK graveyards in a similar situation.

The position of the different grave goods in the pits clearly shows a preference for the area around the head, especially for pottery, but artefacts are common also around the upper body of the deceased. Only a few of the preserved grave goods were placed on or beside the folded legs. This phenomenon might be more due to the practical reason of lacking spare room inside the grave than a 'taboo' on placing items close to the legs; the area of the legs is more often used for the deposition of several gifts as can be observed in other LBK cemeteries.

The structure of grave goods and quantity of preserved objects vary considerably. As in most LBK graveyards, most males were equipped with the greatest variety and quantities of preserved grave goods. The typical equipment of men at Kleinhadersdorf and other LBK sites consists of adzes, flint arrowheads and a rather large quantity and variability of pottery. The greater quantity of grinding plates and bone artefacts in male graves, compared to female and children's graves, seems to be a local phenomenon.

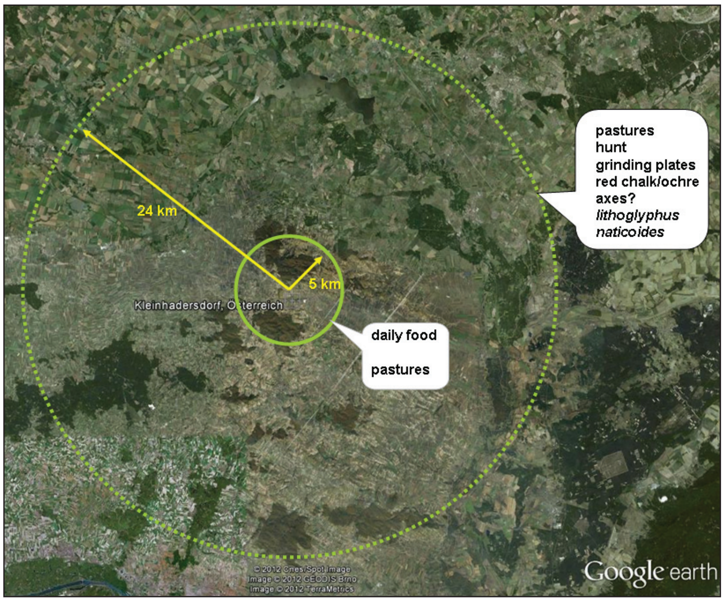

Fig. 2. Site territory and home range of people buried at Kleinhadersdorf (map Google Earth, graph E. Lenneis).

The preserved equipment in the 10 female graves shows less variety and lower quantities of different items. Four of them had no grave goods, which is in clear contrast to their provision with valuable ornaments. Women were much more richly supplied with durable goods in other LBK graveyards in Thuringia and Saxony for example. The quantity of children (including juveniles) of all individuals in Kleinhadersdorf is unusually high (18); ten of them were very young (*i.e.* infants 1 to 6 years old). The preserved equipment of the children burials, especially of infants, is more than the average for the LBK, with the proportion of children with adzes (55.5%) being the greatest from all known LBK burials.

Most of the grave goods consist of pottery, which is typical for LBK graveyards. Nevertheless, only 50% of the grave pits contained pottery. Typologically, the oldest vessels come from the transitional phase, *i.e.* from the oldest to the younger LBK in Austria (*Lenneis 2010b*). Most of the ceramic artefacts are decorated with the so-called music note style, and most pottery is very similar to Moravian vessels of the LBK IIa phase. Only rare vessels have elements typical of the Moravian phases LBK IIb and LBK IIc (*Čižmář 2002*), and these form the basis for identifying the second (LBK IIa) and third phases (LBK II b+c) of the graveyard. Some vessels from the latest phase (Moravian phase LBK III) have decorations with features of the Šárka group and the Želiezovce group, indicating connections with Moravia and Bohemia, Slovakia, and Southern Poland.

Procurement of raw materials

The above-mentioned connections are even more impressive when we consider the procurement of raw materials at Kleinhadersdorf. Inna Mateiciucová (*in prep.*) did an extensive analysis of 25 chipped stone artefacts from the site, which show striking similarities to the relevant objects from the Vedrovice cemetery. Most of the artefacts are made from Jurassic silicates from the Krakow-Czestochowa highlands (which presents a distance of 290km), some are made from Szentgál radiolarites (which is a distance of 190km), and others are cherts of Krumlovský Les in south-western Moravia (which presents a distance of 40–50km).

Different kinds of raw materials were used for the heavy tools of greenstone. The 20 adzes are all made of high-quality amphibolite (Fig. 3). Michael Götzinger (*Götzinger in prep.*) discovered that they might have originated from the Iser Mountains in northern Bohemia (approx. 360km from Kleinhadersdorf), where also adzes from the Vedrovice graveyards

Fig. 3. A selection of 20 adzes and two axes from Kleinhadersdorf (37/1 and 68/1) (photo by A. Schumacher).

might have been procured (*Přichystal 2002*). The most recent investigations in this region of northern Bohemia proved that amphibolite was procured at only one site for the entire LBK period, and this raw material had an extremely broad distribution in Germany (*Ramminger, Šída 2012*). Further analyses will have to be performed for the identification of quarries in the Iser Mountains where amphibolite was gathered for tools used at setttlements in Moravia and Austria. All adzes found in graves had been used, and some of them show considerable wear (as much as 25% were already useless).

The axes were made of significantly different raw material. Their origin cannot be precisely determined at this point, but might be within the 'home range' (Fig. 2).

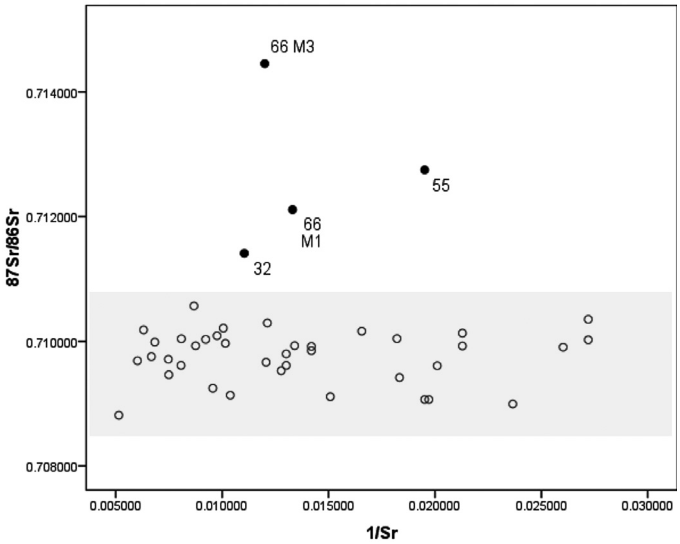

Fig. 4. The $^{87}Sr/^{86}Sr$ ratio plotted against 1/Sr ppm. The solid circles (with the according grave number) are the three Sr outliers (graph by P. Bickle;* Bickle *et al.* in prep.Fig. 76*).

The high amount of grind stones (20) seems to be another special feature of the Kleinhadersdorf grave site. Some are rather thin (2–3cm) and could not have served as 'millstones' for cereals; nevertheless, many fragments of quern stones, used for grinding cereals, were found. Most of the thin grinding plates are of local very fine-grained sandstone, but the fragments of the quern stones are made from a different high quality material. A few of them might have come from central Bohemia (*Götzinger in prep*).

Fig. 5. Kleinhadersdorf, burial 55 of an elder woman with a* Spondylus *necklace (photo of burial by J.-W. Neugebauer, BDA Vienna; photo of necklace by A. Schumacher).

Personal ornaments

Some 18 graves (or 33%) contained personal ornaments made from various materials. Head ornaments were identified in two children's graves. There was one pearl made from dentalium (grave Verf. 67–1) and 124 small shells of *Lithoglyphus naticoides* (grave Verf. 26). Special investigations by Mathias Harzhauser (*Harzhauser* et al. *2007*) showed that these snail shells had been selected and the perforations made by careful grinding techniques; they were then probably sown onto a piece of clothing (*e.g.*, a bonnet?). The evidence of these shell ornaments for an infant is most unusual within the LBK (*Lenneis 2007*).

Ornaments made of *Spondylus* shells are not abundant; 18.5% of all inhumations had at least one piece of this precious material. An adult woman (grave Verf. 55) and an infant (grave Verf. 22) had the only large necklaces made from *Spondylus gaederopus*, which most probably came from the Dalmatian coast on the Adriatic (*Kalicz, Szénászky 2001; Sériadès 2000*). This special jewellery was present in 40% of the female and in 30% of the children burials, but only in 20% of the male burials. The rich adornment with personal ornaments for children at Kleinhadersdorf is as unusual as the low value of personal decoration for men.

Isotope analyses and mobility

The bones and teeth of 39 skeletons from Kleinhadersdorf were sampled for isotope analyses within the large international project at Cardiff University (*Bickle, Whittle 2013*) and 36 of the bone samples returned positive results. In general, the isotopic results from Kleinhadersdorf stress homogeneity, rather than structured difference. Despite a few interesting outliers, the majority of the population lived in the area throughout their lives and gathered their food nearby. The lack of identifiable differences between men and women, and across age groups, suggests that any social hierarchy or differences were not reflected in diet, and that access to certain types of food was not restricted for certain groups in the population.

The strontium results show a low level of mobility in comparison to other LBK cemeteries studied to date. Only three persons had $^{87}Sr/^{86}Sr$ ratios above 0.7111, which links their diet to a different geological background, *i.e.* on gneisses and granites, which are found in the Bavarian forest and the Bohemian Massif (*Bickle* et al. *in prep.*) (Fig. 4).

The archaeological evidence together with the results of the isotope analyses made it possible to reconstruct some individual life stories for the first time. The three 'immigrants' to the community that were buried at Kleinhadersdorf all came from a region north-west of the site and from a minimal distance of 50–60km.

The burial of a young adult of unknown sex was heavily destroyed (Fig. 4 – grave 66). The only remnant of his/her former grave goods was a fragment of a pot with 'Notenkopf' decoration. The different ratios measured in molars suggest that this individual died shortly after arrival at the site.

The older woman in grave 'Verf. 55' (Fig. 4 – grave 55) is from the founding generation of the graveyard, as indicated by the radiocarbon date taken from her bones. She was one of three individuals lying in a crouched position on her right side, and the only one with the upper body in a different position than the others. Her burial was oriented north-south, a position she shared with only one other person, and she was equipped with one of the two big necklaces of *Spondylus* shells (Fig. 5).

Fig. 6. Kleinhadersdorf, burial 32 of a young woman with a pot decorated in Šárka – style (photo of burial by J.-W. Neugebauer; photo of ceramic by A. Schumacher).

The young woman in grave 'Verf. 32' (Fig. 4 – grave 32) is one of the last burials at the site, according to the radiocarbon dates. Her inhumation followed the most common ritual at the site, with a south-east orientation and a position crouched to the left, indicated by the last remains of her legs; however, the upper body was supine, with the hands crossed over her chest in a rather unusual position. The small remnant of a *Spondylus* shell at the pelvis may be the last trace of a belt decoration, which are well-known from other LBK sites. The only remaining grave good is a decorated pot, typical of the late LBK Šárka group, which corresponds with the young radiocarbon dates and supports the indication of her origin from the Bohemian massif (Fig. 6).

Fig. 7. Long-distance contacts of people buried in the LBK graveyard of Kleinhadersdorf as proven by Sr-isotopes and special goods: 1 adzes from the Iser Mountains, northern Bohemia – distance about 360km; 2 quern stones of a special sort of 'Quarzsandstein' from central Bohemia – distance about 230km; 3 silicates from the Krakow-Czestochowa highlands – distance about 280–290km; 4 chert of Krumlovsky Les, Moravia – distance approx. 40–50km; 5 radiolarite from Szentgál, Bakony Mountains, Hungary – distance about 190km; 6* Spondylus gaederopus *shell, most probably from the Dalmatian coast on the Adratic – minimum distance of 500–600km (map Google Earth, graph by E. Lenneis).

The $^{87}Sr/^{86}Sr$ ratios of these three individuals clearly indicate contact with north-western regions, where gneiss and granite form the main geological foundation, and from where also adzes and some of the quern stones were procured. On the other hand, flint raw material, pottery with typical North-East Hungarian/Slovakian Želiezovce group decoration and the *Spondylus* ornaments indicate contacts with other regions (Fig. 7). These contacts will be the subject of future research to clarify the connections over these impressive distances and the role that 'immigrants' played within these activities.

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^{14}C dates and stratigraphy: reconsidering the sequences at Moverna vas (Bela Krajina, southeastern Slovenia)

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ABSTRACT – *Recently obtained AMS ^{14}C dates and the stratigraphic matrix from the Moverna vas site show inconsistencies in the upper part of the stratigraphic sequence. The Bayesian approach to chronological modeling in the OxCal program is used in the paper to present the calendar chronology of Neolithic and Eneolithic settlement phases at the site and to propose a revision of the upper part of the stratigraphic sequence, also partly supported by a typological comparison of a pottery vessel from one of the ^{14}C dated contexts.*

IZVLEČEK – *Novi AMS ^{14}C datumi so neskladni z zgornjim delom stratigrafske matrike iz Moverne vasi. V članku s pomočjo Bayesovega kronološkega modeliranja v program OxCal predstavljamo koledarsko kronologijo neolitskih in eneolitskih poselitvenih faz na najdišču in predlagamo revizijo zgornjega dela stratigrafskega zaporedja, ki jo deloma podpira tudi tipološka primerjava posode iz enega od ^{14}C datiranih kontekstov.*

KEY WORDS – *stratigraphic matrix; ^{14}C dating; Bayesian chronological modeling; Neolithic; Eneolithic*

Introduction

The vertically stratified sites have always been important in conceptualisations of prehistoric cultures and time. Time is conceptualised through the building of stratigraphic matrices, which allow the recognition of the chronological sequence of archaeological deposits and find assemblages. What stratigraphic matrix lacks, however, is temporal depth, the span of calendric time in which deposits and assemblages are formed (*Lucas 2012.121*).

The ^{14}C method allows the dating of deposits and assemblages within the calendar time-frame. The Bayesian approach to building calendar chronologies (*Bronk Ramsey 2009; Bayliss 2009*) is especially useful for temporalising the stratigraphic matrix, as it provides formal probabilistic estimates for the ages of events important to archaeologists or events that might have actually been experienced by people in the past. Furthermore, it provides the duration of activities recognised in the archaeological record. This enables us to exceed the stratigraphic conceptualisation of time as a sequence and consider the temporality of formation processes that created archaeological deposits and assemblages at sites. A much less discussed utility of ^{14}C dating is the ability to recognise and rectify the problematic parts of the stratigraphic matrix. In establishing chronological sequences, the ^{14}C dating and the stratigraphic matrix should be used as complementary methods, especially in cases where the stratigraphic relationships are harder to observe and where the archaeological deposits are finer than the practice of stratigraphic excavation and recording is able to discern. The Bayesian approach is useful here as a tool for testing hypotheses and alternative chronological scenarios.

In the paper, we present the case study of the Moverna vas site calendar chronology (*Budja 1994*), where recently obtained AMS ^{14}C dates contradict the stratigraphic matrix in its uppermost part. By confronting the two sets of data, we suggest a partial adjustment of the stratigraphic matrix, with the repositioning of some stratigraphic units. Furthermore, the ^{14}C dates reveal two groups of probability

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distributions, suggesting a previously unrecognised phase of occupation at the site. The Bayesian approach to chronological modeling is used in the paper to present the calendar chronology of Neolithic and Eneolithic settlement phases at Moverna vas.

The Moverna vas site is located in the Bela Krajina Region (southeastern Slovenia) on a plateau overlooking and bordering on three sides the bending gulch that the River Krupa has carved through an undulating lowland Dinaric karst landscape (Fig. 1). The observations and analyses conducted at the site provide us with a long stratigraphic and typological sequence of deposits and find assemblages spanning the 5^{th} and 4^{th} millennia calBC (*Budja 1988; 1989; 1990a; 1990b; 1992; 1994; 1995; Andrič 1993; Tomaž 1997; 1999; Žibrat Gašparič 2008; Sraka 2012*).

A series of excavations was carried out at the Moverna vas site in the 1980s, with excavations in 1988 being one of the first in Slovenia that complied with the principles of archaeological stratigraphy (*Budja 1988; 1990a; 1994*). The stratigraphic matrix (Fig. 2) shows the superposition of naturally formed layers in which finds were deposited more or less accidentally, indicating indirect traces of settlement. These layers were largely deposited over the whole excavation area, were vertically separated by recognised interfaces and contained more direct remains of human life at the site, such as post-holes, refuse pits, hearths and collapsed daub walls of houses interspersed within the deposits and on the former living surfaces. According to the excavator, "*The stratigraphic sequence in Moverna vas shows a repetition of natural processes and anthropogenic activity. We recognized the former as processes of loam and soil sedimentation and erosion and the latter as building, destruction and everyday activity [translated by the author]*" (*Budja 1990a.127*).

The linear stratigraphic sequence of layered deposits was integrated with the interlinear correlation of various stratigraphic units, such as posts, pits and walls, which were supposedly associated with human activity and can be considered roughly chronologically synchronous (*Budja 1990a.127; 1994.18–21*). The integration of the two lead to the conceptualisation of the temporally structured archaeological record at Moverna vas as a sequence of cultural phases of human occupation or settlement phases. The sequence of phases is represented by repetitions of activities such as building, destruction and everyday life, complemented by continuous natural processes of erosion and sedimentation (Figs. 2 and 3). Nine settlement phases were recognised, with phases 2 through 6 being associated with the Neolithic period and phases 7 through 9 with the Eneolithic period, according to the pottery typology. The supposed chronological association of find assemblages was examined with the evaluation of the dispersion of pottery fragments that once formed the same vessel within the individual stratigraphic units. Because the vertical dispersion of fragments is delimited by the layer interfaces, the find assemblages consistently represent individual settlement phases at the site (*Budja 1990a.130–2; 1994.21*).

^{14}C samples and their stratigraphic contexts

Thirty-seven ^{14}C dates are currently available from the Moverna vas site (see Appendix), of which twenty-seven were obtained from carbonised residues on pottery and the remainder from charcoal samples. The first charcoal samples were obtained from metrically defined layers of the un-stratigraphic excavations in 1984 (*Budja 1988.50–51; 1989.97*) and were measured at the Ruđer Bošković Institute in Zagreb by the gas proportional counting technique (*Srdoć* et al. *1987.139*). Further charcoal samples were obtained from stratigraphic layers related to the Neolithic phases after excavations in 1988 and were dated at the Oxford Radiocarbon Laboratory (*Budja 1994.Fig. 5*). A programme of direct AMS dating of carbonised residues from the interior surfaces of pottery vessels was recently initiated, together with the application of lipid extraction and characterisation of the organic residues absorbed in vessel walls. Samples relate to all phases and were dated at the Poznan Radiocarbon Laboratory (*Žibrat Gašparič 2008.Fig. 5.1; Sraka 2012.appendix*; see Appendix).

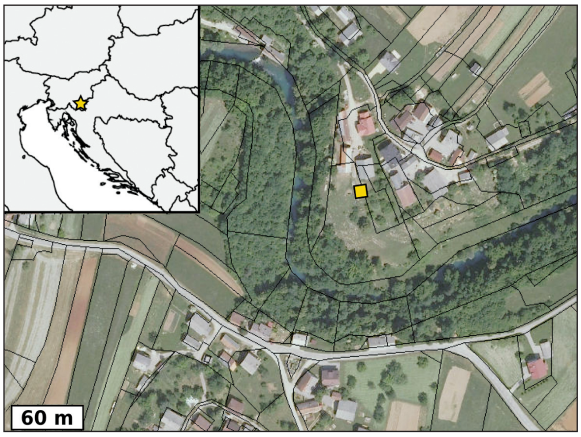

Fig. 1. Location of Moverna vas site in the Bela Krajina region, southeastern Slovenia.

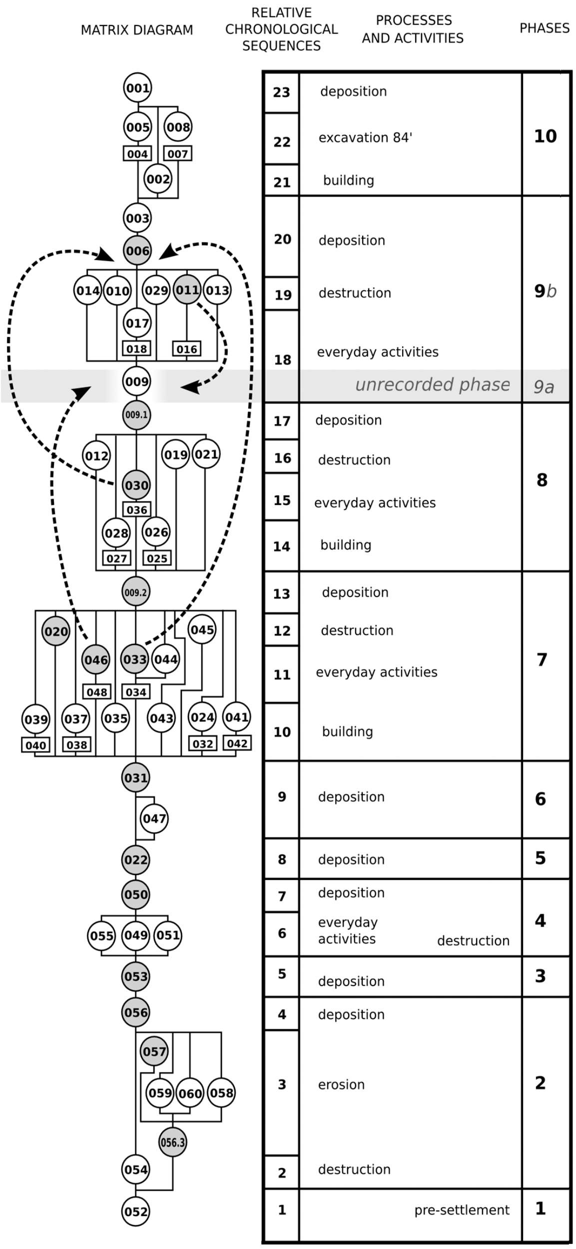

Fig. 2. The stratigraphic matrix and phasing at the Moverna vas site with shaded ^{14}C dated contexts and the indication of the revised parts of the stratigraphic sequence (adapted after **Budja 1988.Fig. 6***).*

In the latest dating programme, ^{14}C samples were obtained from the previously undated Eneolithic phases, in order to expand the chronological model and sketch out the general chronological structure of the whole stratigraphic sequence. Short-lived samples in the form of carbonised residues on pottery were preferred, but due to their limited preservation in the Eneolithic assemblages, mostly charcoal was sampled. All ^{14}C dates from the site are listed in the Appendix, together with the relevant contextual information. In Bayesian modeling, only dates on samples from the stratigraphic excavation in 1988 are used.

Figure 3 shows the modified composite section of stratigraphic units associated within individual phases. New ^{14}C dates originate from each of the Eneolithic layers (009.2, 009.1, 006) as well as from a patch of burnt daub (020) and refuse pits (033, 046, 030, 011). Each layer corresponds to originally defined phases 7, 8 and 9, respectively, with pits and the daub patch also associated with separate phases.

In all cases, the dates from pits (but not the one from the daub layer) contradict those from the layers. Dates from pits 033, 046 and 030 have much younger calendar ages than those from layers 009.2 and 009.1, with which they are integrated in the 7th and 8th phases, respectively. The probability distributions of dates from pits 033 and 030 (Poz-54005, Poz-54007) partly overlap with the ^{14}C date on carbonised residue from layered deposit 006, associated with the 9th phase (Poz-53998). The probability distribution of dates from pits 046 and 011 (Poz-54003, Poz-54009) lie somewhere between the ^{14}C dates from layers representing the 8th and the 9th phase. The probability distributions of the problematic ^{14}C dates thus fall into two groups, one before the middle of the 4th millennium and the second around the turn of the 4th and 3rd millennium calBC (Fig. 4b). These dates contradict the established stra-

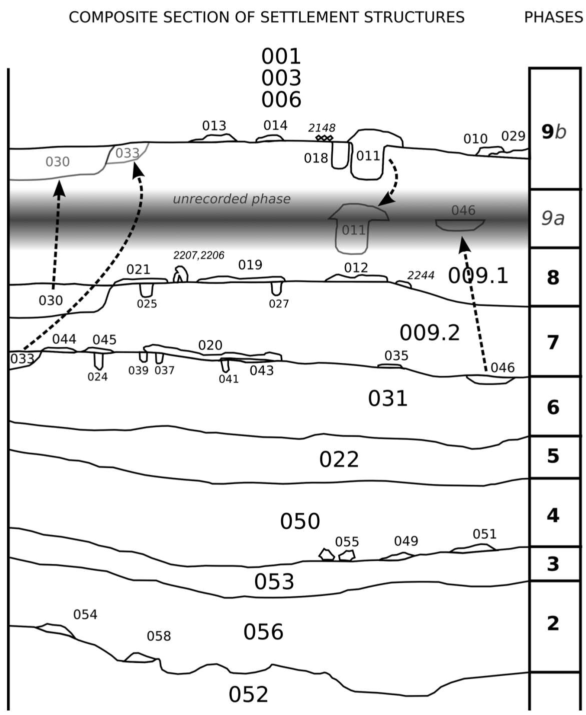

Fig. 3. The composite section, showing associated remains of human occupation within individual phases and the indication of the revised parts of the stratigraphic sequence (adapted after **Budja 1994.Fig. 7***).*

tigraphic matrix, but are invaluable in revealing the problematic parts of the site stratigraphy.

The 'old wood effect' on the charcoal samples, although possible, can not explain the contradiction, as the dates appear younger, not older, than expected. However, sample infiltration is possible, so further, preferably short-lived, ^{14}C samples are needed to resolve the issue. The unexpected results prompted us to revisit the ^{14}C sample contexts and their position within the stratigraphic matrix at the site. The stratigraphic matrix can be partly changed with the repositioning of the mentioned pits. The two mentioned groups of probability distributions suggest at least two phases of occupation within the deposit originally associated with the 9th phase. This is further elaborated in the following section. The suggested modification of the stratigraphic sequence is indicated in Figures 2 and 3.

The inconsistency between the ^{14}C dates for layers and pits point to the difficulties that archaeologists face when trying to define the level from which pits are cut. All Eneolithic phases at Moverna vas are represented by approx. 0.5m of soil deposit on average. So it is not surprising that some of the pits became associated with layers with which they originally were not. Besides the ^{14}C data, the association of pits 033 and 030 with the originally defined 9th phase rather than the 7th or 8th phase is suggested also by the conservatively drawn cross-section from the un-stratigraphic excavations in 1984 (compared to the rather interpretative cross-section from the stratigraphic excavations in 1988) in the section where the two excavation areas meet. The ^{14}C dates suggest at least one phase of occupation at the site for which no associated archaeological deposit was recorded, but which is evidenced by pits 046 and 011, previously associated with the 7th and 9th phases, respectively (Fig. 3).

Bayesian modeling of the site calendar chronology

The basic idea behind the Bayesian modeling of archaeological chronologies is encapsulated in a simple theorem published by clergyman Reverend Thomas Bayes in the mid-18th century: *posterior = likelihood x prior*. This simply means that we analyse the ^{14}C data we have collected about a problem (*likelihood*) in the context of our existing archaeological information (*prior*) in order to arrive at a new understanding (*posterior*). Put differently, the Bayesian approach integrates ^{14}C dates and other chronologically relevant information available to archaeologists and allows the development of calendar chronologies for a wide variety of archaeological situations, from site-based sequences to regional spatio-temporal phenomena. Despite the fact that the statistical procedures and computing necessary for its implementation are incomprehensible to most archaeologists, computer programs such as OxCal provide simple tools for developing Bayesian models (*Bronk Ramsey 1995; 1998; 2008; 2009; Bayliss 2007; 2009*). The Bayesian approach does not provide final answers and is a heuristic tool for testing and comparing chronological models; the results are never absolute and final and are subject to change when additional ^{14}C data and archaeological information become available.

In developing a Bayesian model of the Moverna vas site chronology we use the OxCal computer program, version 4.2.3 (*Bronk Ramsey 2009*) with the implemented IntCal13 calibration curve (*Reimer* et al. *2013*). The intention is to use the sequence of phases, explained above and shown in Figures 2 and 3, as prior archaeological information for grouping and sequencing the ^{14}C dates (Informative prior in Bayesian modeling). Specific ways of chronological modeling imply specific assumptions that underlie the statistical procedures implemented in the OxCal program. In our case, the assumption is that each phase represents a delimited period of occupation at the site.

The recent ^{14}C dating results inclined us to partly change the approach to the Bayesian modeling of the Eneolithic settlement phases, unlike the modeling of the Neolithic phases, which remains unchanged (*Sraka 2012.355–358, Fig. 2*). The chronological model consists of two parts, the first represented by phases 2 to 8 and the second by phases 8, 9a and 9b. These two parts of the model should be viewed differently in terms of conservativeness and the certainty of the dating results. In the first part of the model, the phases are modeled as contiguous, sharing the same transitional boundary. In the second part, the phases are modeled as sequential, as the preliminary assessment of the ^{14}C dates suggests temporal gaps between them. The different parts of the model differ in the way that they deal with samples of different quality (short-lived versus long-lived).

In the first part of the OxCal model, the short-lived carbonised residue dates from the pottery vessels are assumed to sufficiently represent human activity related to individual phases. The program assumes them

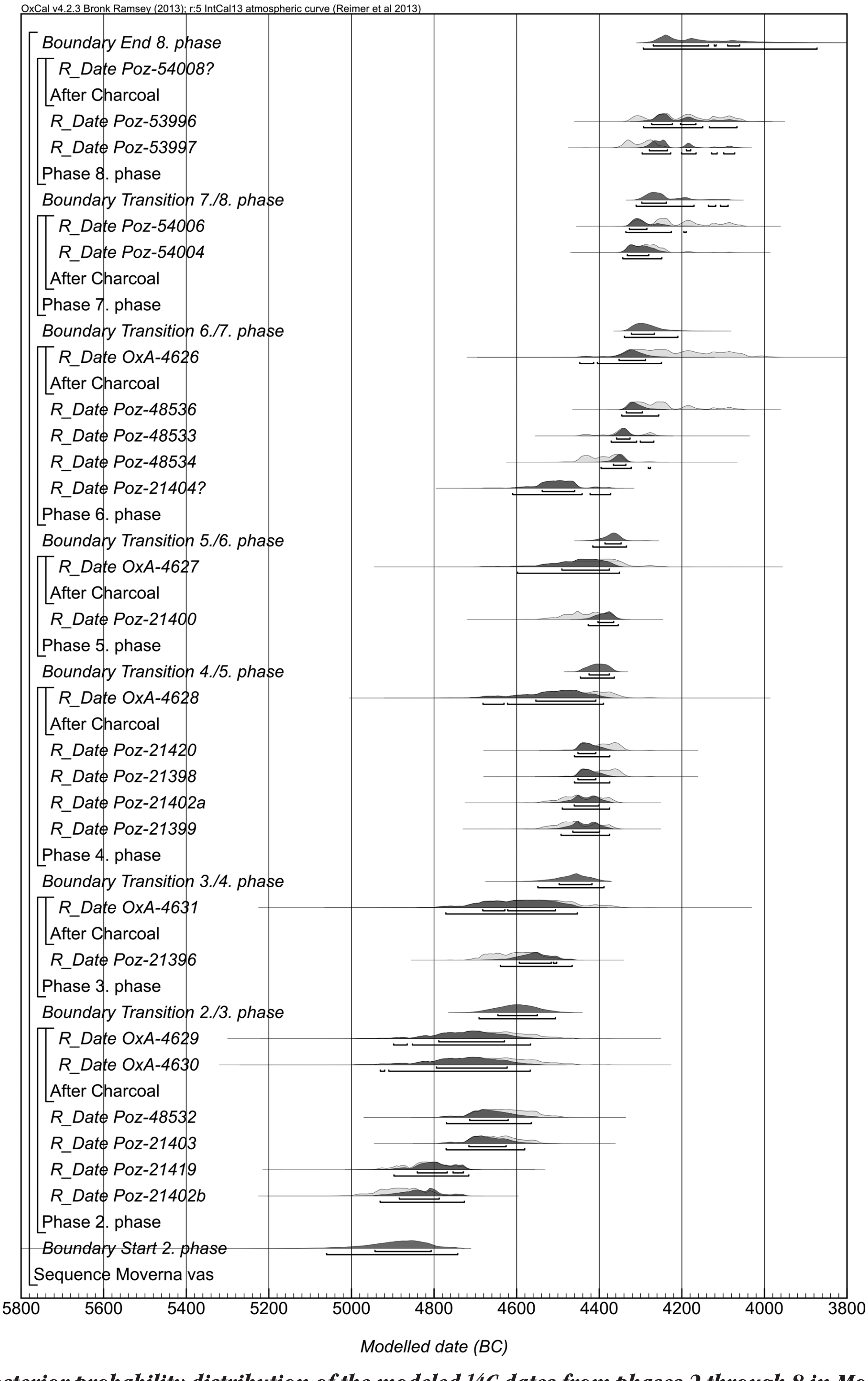

Fig. 4a. Posterior probability distribution of the modeled ^{14}C dates from phases 2 through 8 in Moverna vas.

to be uniformly distributed events within individual phases (Uninformative prior in Bayesian modeling). Charcoal dates, on the other hand, are less directly related to activities within individual phases, due to the possible 'old wood effect'. The probability distribution of the two sample types (where both date the same stratigraphic context) do not differ markedly; nevertheless, the ^{14}C dates on charcoal from the first part of the model are not fully incorporated into the model and are included only as *termini post quos* (*Bayliss* et al. *2011.56–58*). This means that they only effectively define the ending but not the beginning of phases. Despite the loss of precision, not incorporating the long-lived samples fully into this part of model makes the results more conservative.

In the second part of the OxCal model, however, the distinction between the ^{14}C dates of different quality cannot be made, as the majority of the samples are on charcoal. Here both carbonised residue and charcoal dates are fully incorporated into the model. The different treatment of parts of the same model may seem inconsistent or even hypocritical. Bayesian modeling is used here as a heuristic tool for testing and gradually improving the models (*Bayliss 2007*). The ^{14}C dates which date to the 4th millennium calBC fall into two clearly separated groups of probability distributions. The first group is represented by ^{14}C dates from pits 046 and 011, previously associated with the 7th and 9th phases, respectively. The second group of probability distributions consists of dates from layer 006, associated with the originally defined 9th phase, with an addition of the two pits 033 and 030, previously associated with the 7th and 8th phases respectively. On the basis of these two groups of probability distributions, the second part of the OxCal model is divided into two sequential phases, 9a and 9b. The second part of the model should be seen as tentative, both because of the lower quality (charcoal dates probably not directly related to the activities and events of deposition) as well as quantity of the ^{14}C dates, when compared to the well-established first part of the model.

Calendar chronology of the Neolithic and Eneolithic settlement phases on the site

The posterior probability distributions obtained as results of the modeling presented above are presented graphically in Figure 4a for the first part of the model (phases 2 through 8) and in Figure 4b for second part (phases 9a and 9b). The estimated calendar ages for the boundaries between phases and estimated durations of phases are presented in Table 1. The model has an agreement index of 108.5%. One ^{14}C date on carbonised residue (Poz-21404) from the 6th phase is inconsistent and is an outlier, as a replicated sample (Poz-48534) on carbonised residuefrom the same vessel shows consistency with the model. One further ^{14}C date on charcoal (Poz-54008) had to be excluded from the model, as it is significantly later than other dates from the same layer. It is probably an infiltrated sample from later activity on the site.

According to the results, the Moverna vas site was first occupied in the first centuries of the 5th millennium calBC, while the youngest ^{14}C dates point to human activity around the end of the 4th and the beginning of the 3rd millennium calBC. The span of the calendar chronology of the site is approximately two millennia; however, the site does not seem to have been occupied continuously. The Neolithic part of the model is well established and provides a tighter calendar dating for the phases and their find assemblages. According to the estimated phase durations, phases 4 to 8 follow each other at relatively short intervals of no more than a few human generations per phase and suggest continuous occupation in the Neolithic. The dating of the first two Eneolithic phases, 7 and 8, is less secure, due to the limited number of available ^{14}C dates and especially due to the plateau shape of the calibration curve in the 2nd half of the 5th millennium calBC. The supposed continuity of occupation on the site is inter-

Events and intervals	Estimated age (calBC) or duration (years)	
	68.2% probability	95.4% probability
Boundary Start 2. phase	4945–4808	5065–4744
Interval 2. phase	191–377	95–513
Boundary Transition 2./3. phase	4647–4551	4692–4506
Interval 3. phase	71–203	4–248
Boundary Transition 3./4. phase	4497–4418	4551–4387
Interval 4. phase	0–78	0–147
Boundary Transition 4./5. phase	4425–4376	4447–4364
Interval 5. phase	0–44	0–81
Boundary Transition 5./6. phase	4387–4348	4418–4334
Interval 6. phase	38–117	0–167
Boundary Transition 6./7. phase	4322–4267	4340–4210
Interval 7. phase	0–47	0–126
Boundary Transition 7./8. phase	4298–4238	4311–4087
Interval 8. phase	0–115	0–368
Boundary End 8. phase	4270–4061	4294–3874
Boundary Start 9a. phase	3745–3545	4041–3534
Interval 9a. phase	0–327	0–716
Boundary End 9a. phase	3638–3399	3641–3158
Boundary Start 9b. phase	3126–2934	3361–2915
Interval 9b. phase	58–338	0–615
Boundary End 9b. phase	2901–2804	2919–2619
Span Moverna vas	1938–2139	1869–2339

Tab. 1. Calendar age estimates for Boundary events and estimates of durations of Neolithic and Eneolithic phases at Moverna vas.

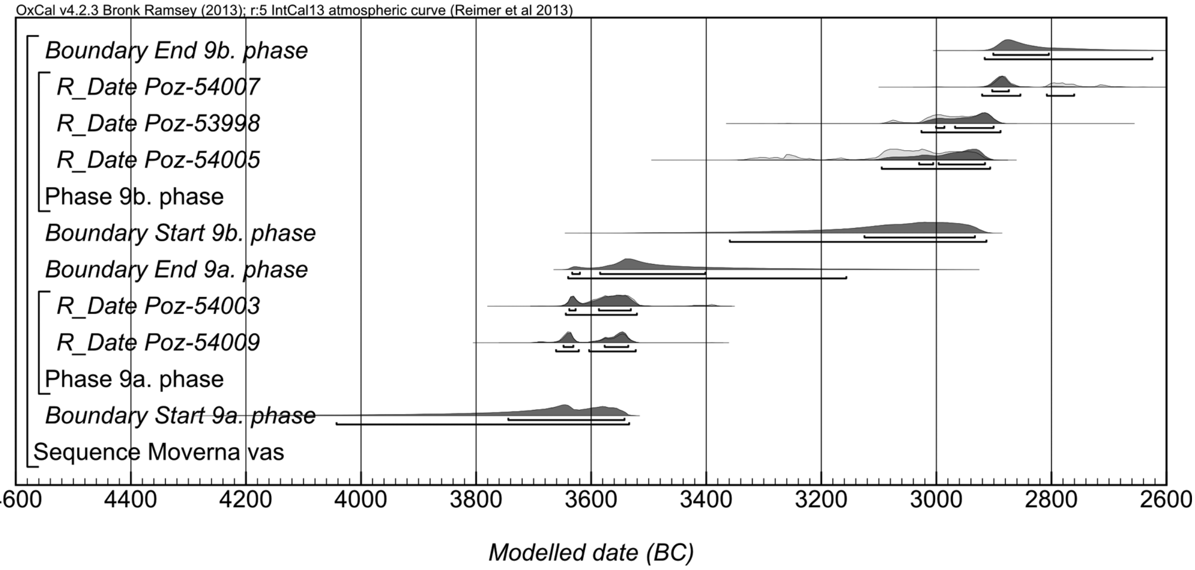

Fig. 4b. Posterior probability distribution of the modeled ^{14}C dates from phases 9a and 9b at Moverna vas.

rupted in the last centuries of the 5th millennium calBC.

The latter Eneolithic part of the model with phases 9a and 9b is provisional, and the results are preliminary at best. Phase 9a can probably be dated to the 37th or 36th century calBC. Phase 9b can be very coarsely dated to the last centuries of the 4th and first centuries of the 3rd millennium calBC. Additional, preferably short-lived ^{14}C samples are needed from the latter part of the stratigraphic sequence at Moverna vas in order to substantiate the dating of phases 9a and 9b.

The association of pit 030 with phase 9b rather than the 8th phase is further supported by the typological comparison of an egg-shaped pot found in the pit. (*Tomaž 1999.Pl. MV39.2*). The pot is decorated (except for the neck) with barbotine application. The rim is bent backwards and stuck on the outer wall and is decorated with finger impressions. The closest analogies can be sought on the Ljubljansko barje, especially at Parte-Iščica (compare *Velušček* et al. *2000.Pl. 4.3*) and Parte (compare *Harej 1987. Pl. 15.7*), where similar backwardly bent rims, decorated with finger impressions and barbotine are numerous. Parte-Iščica is dated to the 29th and 28th centuries calBC (*Čufar* et al. *2010.2036*). The ^{14}C date on charcoal from pit 030, from which the mentioned pot originates, is actually the youngest of all the dates currently obtained from Moverna vas and its probability distribution partly overlaps with the calendar dating of the Parte-Iščica in the early 29th century calBC.

Conclusion

Recently obtained AMS ^{14}C dates contribute to the calendar chronology of the Neolithic and Eneolithic settlement phases at Moverna vas. By confronting the ^{14}C dates and the stratigraphic matrix, we suggest moving pits 011, 030, 033 and 046 to a different position within the stratigraphic sequence and their re-association with other settlement phases at the site. The ^{14}C probability distributions suggest a previously unrecognised phase of occupation at the site. The calendar chronology at Moverna vas spans about two millennia of human occupation. In the 5th millennium, occupation was continuous, with well-established calendar dating of archaeological deposits and find assemblages. The discontinuous occupation in the 4th millennium calBC is at the moment only preliminarily dated. The new calendar chronology allows a more thorough exploration of the palimpsests characterising the archaeological record at Moverna vas and demonstrates the need for ^{14}C dating to be seen as an integral part in constructing the stratigraphic matrices at sites.

ACKNOWLEDGEMENTS

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Appendix

Site	Year	Lab Code	Age (BP)	SD (±a)	Material	Stratigr. unit	Interpre-tation	Period	Pottery assemblage	Reference
Moverna vas	1984	Z–1474	5400	140	charcoal	2//7	n/a	n/a	n/a	*Srdoč* et al. *1987.139*
Moverna vas	1984	Z–1475	4900	130	charcoal	2//6	n/a	n/a	n/a	*Srdoč* et al. *1987.139*
Moverna vas	1984	Z–1476	3875	130	charcoal	2//5	n/a	n/a	n/a	*Srdoč* et al. *1987.139*
Moverna vas	1984	Z–1685	3900	100	charcoal	2//5	n/a	n/a	n/a	*Srdoč* et al. *1987.139*
Moverna vas	1988	OxA–4626	5390	80	charcoal	031.4	6. phase	Neolithic	*Tomaž 1999.Pl. MV33–36*	*Budja 1994.Fig. 5*
Moverna vas	1988	OxA–4627	5580	80	charcoal	022	5. phase	Neolithic	*Tomaž 1999.Pl. MV27–32*	*Budja 1994.Fig. 5*
Moverna vas	1988	OxA–4628	5640	80	charcoal	050.2	4. phase	Neolithic	*Tomaž 1999.Pl. MV17–26*	*Budja 1994.Fig. 5*
Moverna vas	1988	OxA–4629	5830	80	charcoal	057	2. phase	Neolithic	*Tomaž 1999.Pl. MV1–16*	*Budja 1994.Fig. 5*
Moverna vas	1988	OxA–4630	5830	90	charcoal	056.3	2. phase	Neolithic	*Tomaž 1999.Pl. MV1–16*	*Budja 1994.Fig. 5*
Moverna vas	1988	OxA–4631	5720	90	charcoal	053	3. phase	Neolithic	n/a	*Budja 1994.Fig. 5*
Moverna vas	1988	Poz–21396	5750	40	carbonised residue	053.1	3. phase	Neolithic	n/a	*Žibrat Gašparič 2008.Fig. 5.1*
Moverna vas	1988	Poz–21398	5550	40	carbonised residue	050.2	4. phase	Neolithic	*Tomaž 1999.Pl. MV17–26*	*Žibrat Gašparič 2008.Fig. 5.1*
Moverna vas	1988	Poz–21399	5630	40	carbonised residue	050.1	4. phase	Neolithic	*Tomaž 1999.Pl. MV17–26*	*Žibrat Gašparič 2008.Fig. 5.1*
Moverna vas	1988	Poz–21400	5610	40	carbonised residue	022.1	5. phase	Neolithic	*Tomaž 1999.Pl. MV27–32*	*Žibrat Gašparič 2008.Fig. 5.1*
Moverna vas	1988	Poz–21402a	5620	40	carbonised residue	050.1	4. phase	Neolithic	*Tomaž 1999.Pl. MV17–26*	*Žibrat Gašparič 2008.Fig. 5.1*
Moverna vas	1988	Poz–21402b	5990	40	carbonised residue	050.2/056	2. phase	Neolithic	*Tomaž 1999.Pl. MV1–16*	*Žibrat Gašparič 2008.Fig. 5.1*
Moverna vas	1984	Poz–21403	5800	40	carbonised residue	//7	2. phase	Neolithic	*Tomaž 1999.Pl. MV1–16*	*Žibrat Gašparič 2008.Fig. 5.1*
Moverna vas	1988	Poz–21404	5670	40	carbonised residue	031.4	6. phase	Neolithic	*Tomaž 1999.Pl. MV33–36*	*Žibrat Gašparič 2008.Fig. 5.1*
Moverna vas	1984	Poz–21419	5940	40	carbonised residue	//7	2. phase	Neolithic	*Tomaž 1999.Pl. MV1–16*	*Žibrat Gašparič 2008.Fig. 5.1*
Moverna vas	1988	Poz–21420	5550	40	carbonised residue	050.2	4. phase	Neolithic	*Tomaž 1999.Pl. MV17–26*	*Žibrat Gašparič 2008.Fig. 5.1*
Moverna vas	1988	Poz–48532	5780	50	carbonised residue	056.1	2. phase	Neolithic	*Tomaž 1999.Pl. MV1–16*	*Sraka 2012.Appendix*
Moverna vas	1988	Poz–48533	5490	40	carbonised residue	031.4	6. phase	Neolithic	*Tomaž 1999.Pl. MV33–36*	*Sraka 2012.Appendix*
Moverna vas	1988	Poz–48534	5540	40	carbonised residue	031.3	6. phase	Neolithic	*Tomaž 1999.Pl. MV33–36*	*Sraka 2012.Appendix*
Moverna vas	1988	Poz–48536	5390	40	carbonised residue	031.4	6. phase	Neolithic	*Tomaž 1999.Pl. MV33–36*	*Sraka 2012.Appendix*
Moverna vas	1984	Poz–48537	5580	40	carbonised residue	1/4/6	n/a	Neolithic	n/a	*Sraka 2012.Appendix*
Moverna vas	1988	Poz–53996	5360	40	carbonised residue	009.1	8. phase	Eneolithic	*Tomaž 1999.Pl. MV39–40*	first published here
Moverna vas	1988	Poz–53997	5445	35	carbonised residue	009.1	8. phase	Eneolithic	*Tomaž 1999.Pl. MV39–40*	first published here
Moverna vas	1988	Poz–53998	4340	40	carbonised residue	006	9. phase	Eneolithic	*Tomaž 1999.Pl. MV41–42*	first published here
Moverna vas	1984	Poz–53999	5640	40	carbonised residue	2/15, 16/4, 5	n/a	Neolithic	n/a	first published here
Moverna vas	1984	Poz–54000	5300	30	carbonised residue	2/11/4	n/a	Eneolithic	n/a	first published here
Moverna vas	1988	Poz–54003	4785	35	charcoal	046	7. phase	Eneolithic	*Tomaž 1999.Pl. MV37–38*	first published here
Moverna vas	1988	Poz–54004	5420	35	charcoal	020	7. phase	Eneolithic	*Tomaž 1999.Pl. MV37–38*	first published here
Moverna vas	1988	Poz–54005	4410	40	charcoal	033	7. phase	Eneolithic	*Tomaž 1999.Pl. MV37–38*	first published here
Moverna vas	1988	Poz–54006	5370	35	charcoal	009.2	7. phase	Eneolithic	*Tomaž 1999.Pl. MV37–38*	first published here
Moverna vas	1988	Poz–54007	4235	35	charcoal	030	8. phase	Eneolithic	*Tomaž 1999.Pl. MV39–40*	first published here
Moverna vas	1988	Poz–54008	4570	35	charcoal	009.1	8. phase	Eneolithic	*Tomaž 1999.Pl. MV39–40*	first published here
Moverna vas	1988	Poz–54009	4825	35	charcoal	011	9. phase	Eneolithic	*Tomaž 1999.Pl. MV41–42*	first published here

X-ray computed tomography investigations of Cucuteni ceramic statuettes

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ABSTRACT – *Deciphering the internal structure of prehistoric artefacts can provide spectacular insights that might help us understand the people who made them. In order to preserve the integrity of these relics of past civilisations, it is desirable to make such investigations using non-destructive techniques. Recent decades have witnessed a growth in the X-ray computed tomography (CT) applications in the study of cultural heritage objects. This paper presents and discusses tomographic investigations of two Cucuteni ceramic statuettes discovered in Romania. The study was made with a CT device specially designed for archaeometric applications.*

IZVLEČEK – *Prepoznavanje notranje sestave prazgodovinskih artefaktov nudi osupljive vpoglede, ki nam pomagajo pri razumevanju ljudi, ki so te predmete izdelali. Zaželeno pa je, da so takšne analize opravljene z ne-destruktivnimi metodami, da bi obdržali integriteto teh ostalin preteklih civilizacij. V zadnjih desetletjih smo priča vzponu uporabe rentgenske računalniške tomografije (CT) pri analizi predmetov kulturne dediščine. V članku predstavljamo in razpravljamo o tomografskih analizah dveh keramičnih figur kulture Cucuteni, ki sta bili odkriti v Romuniji. Analiza je bila opravljena z napravo CT, ki je bila posebej oblikovana za uporabo v arheometriji.*

KEY WORDS – *ceramics; Cucuteni; statuettes; X-ray Computed Tomography*

Introduction

Computed tomography (CT) is a technique that in recent years has been used with increasing frequency in archaeological and cultural heritage research (*Ghysels 2003; Applbaum, Applbaum 2005; Casali 2006; Morigi* et al. *2007; De Witte* et al. *2008; Van der Linden* et al. *2010; Haneca* et al. *2012; Harvig* et al. *2012; Lehmann* et al. *2010; Tuniz* et al. *2012*).

CT provides information on the structure of objects that otherwise cannot be accessed in any way except through destructive investigations or sampling. CT examinations can be also useful for restoration and conservation procedures.

The X-ray tomographic machine used for the study reported in this paper was specially designed for archaeometric research, being the only one of its kind in Romania. The CT device and the software implementing the reconstruction algorithm were developed in the Department for Applied Nuclear Physics at the 'Horia Hulubei' National Institute for Nuclear Physics and Engineering, Măgurele, Romania (*Constantin* et al. *2010*) (Fig. 1). In the last two years, a large number of cultural heritage artefacts made of ceramics have been examined with this CT apparatus in the course of an on-going post-doctoral project.

In this paper, the results of the tomographic examination of two clay statuettes belonging to the Arad Museum Complex and Moldova National Museum Complex in Iaşi are presented. The objects were discovered in Romania, at the Ghelăieşti-Nedeia settlement in Neamţ County and the Ruginoasa-Dealul Draghici settlement in Iaşi County (Fig. 2), and are attributed to the Cucuteni culture.

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The first object presented here was found at Nedeia, a settlement located on a hill, 2km north-east of the village Ghelăieşti. This site was first recorded by M. Cojocaru in 1933. However, systematic archaeological research started in 1969, being performed by Ştefan Cucoş, Dan Monah and A. Niţu. Two occupation levels belonging to the Cucuteni A and Cucuteni B1 periods respectively were identified at Nedeia (*Monah, Cucoş 1985.97*).

The second statuette described here was found at Ruginoasa – Drăghici Hill. The first systematic archaeological study of this location was performed by H. Dumitrescu in 1926; excavations were resumed in 2001 and the team was led by Magda-Cornelia Lazarovici. Drăghici Hill is located approximately 250m from the village and 1.5km west of the railway station in Ruginoasa; it is on the north-western side of a hilly promontory. The Ruginoasa – Drăghici Hill site was attributed to the Cucuteni A period (*Lazarovici, Lazarovici 2012.13, 21–26*).

Methods and materials

CT machine and experimental procedures

The CT device used in this study was specially designed to study cultural heritage artefacts made from low – Z (low atomic number) materials – *e.g.,* clay, bone, wood.

It comprises a compact X-ray source made by Spellman High Voltage Electronics Corporation (160kV maximum X-ray tube voltage, 3mA maximum current intensity), a home-made positioning system capable of rotation and translation movements and a Varian PaxScan® flat panel detector with large dimensions (40 x $30cm^2$). The detector is amorphous silicon (127mm pixel pitch) engineered for high-speed radiographic imaging. The maximum spatial resolution of this CT machine is approx. 300µm. It can be used to study small objects with a maximum volume of 20 x 20 x $20cm^3$ (*Constantin* et al. *2010*).

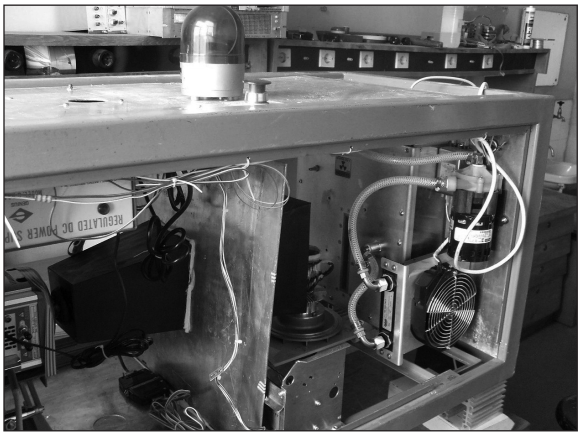

Fig. 1. The X-ray computed tomography device from 'Horia Hulubei' National Institute for Nuclear Physics and Engineering, Măgurele, Romania.

For image reconstruction, home-made software based on a modified Filtered Back Projection algorithm was written using Microsoft Visual C^{++} 2005 (*Constantin* et al. *2010*).

The working procedure consists of two main steps:

- Adjusting the position of the object with respect to the incoming X-ray beam;
- The actual CT scan of the object using the parameters previously optimised for the tomographic examination of ceramic objects (70kV X-ray tube voltage; 700µA X-ray tube current).

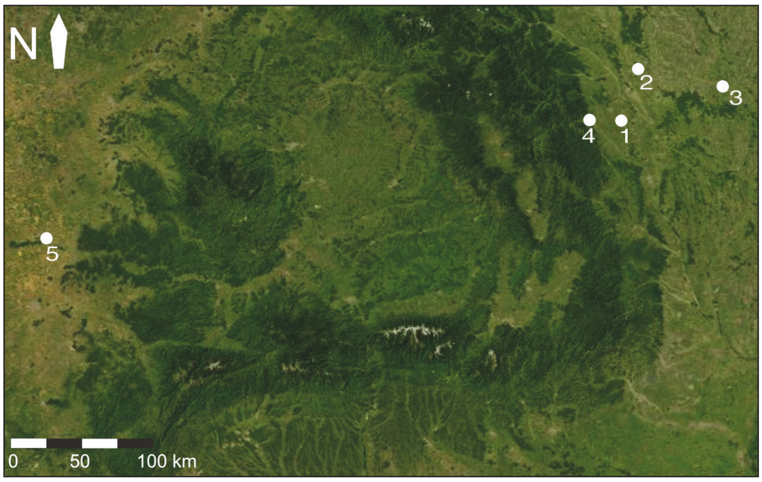

Fig. 2. Map of the northern part of Romania showing the locations mentioned in the text: 1 Ghelăieşti; 2 Ruginoasa; 3 Iaşi; 4 Piatra Neamţ; 5 Arad.

The entire volume of the object is scanned in 120 steps, entailing a 360° rotation of the object around its central axis. The partial images are summed up to obtain the final projection.

The acquisition time for a full tomographic scan is roughly five minutes, while image reconstruction takes less than four minutes. These relatively short times needed allowed the screening of a large number of ceramic objects from various Romanian museums. Thus, over one hundred ceramics artefacts were scanned in 2012 alone.

Description of the artefacts and context of their discovery

The first object approached in this study is a clay statuette belonging to the Arad Museum Complex (inv. no. 4463). This artefact is one of a larger group of Cucutenian ceramic statuettes that were investigated using CT, but the only one that yielded interesting scan results.

There is no precise information about how these Cucutenian clay objects were added to the inventory of the Arad Museum Complex. Taking into account the lack of notes and/or any other documents, one can only hypothesise about how these clay objects found their way into the collection of a museum located 450km away from the Cucuteni area. The most plausible explanation is that they were brought to Arad in an exchange of artefacts with other Romanian museums (in this case, the most likely candidate is Piatra Neamţ Museum) sometime during the 1990s.

The labels of these objects still bear some old identification details. Thus, the statuette with inv. no. 4662 has another number on its tag (probably the old inv. no.), namely 174. The statuette with inv. no. 1473 was found in Costeşti.

The subject of our study (inv. no. 4463) has the following inscription on its ancient label: "*GEL ÇEA; 1969; L2; INV 172*". This can be interpreted as follows: the object was found at a site whose name begins with 'Gel', zone EA, dwelling no. 2, in 1969 (Fig. 3). It seems that the statuettes numbered 4662 and 4463 were discovered in the same place. Our further investigations identified this unknown site as Ghelăieşti in Neamţ County.

To support the attribution to the Ghelăieşti Cucutenian site, we note the following facts: there is no other Cucuteni settlement with a name beginning with '*Gel*'; this site was excavated in 1969 (*Niţu* et al. *1971; Monah, Cucoş 1985.207*); the objects with inv. nos. 4662 and 4463 have several similarities to other objects that were definitely found at Ghelăieşti (4662 – *Monah 1997.Fig. 132/1–4, Fig. 190/1, Fig. 149/9*; 4463 – *Monah 1997.Fig. 160/7, 10, 11, Fig. 165/9*). Moreover, the statuette with inv. no. 4663 is identical to one that was published by Anton Niţu *et al.* (*1971.Fig. 24/4*) and Dan Monah (*1997.Fig. 165/9*).

The statuette under discussion (Fig. 4) is in a fragmentary condition, the head and lower part of the legs being absent. The height of the statuette is 10.3cm; the pelvis is 3.5cm wide, while the width between the armpits is 3.7cm. The vulva is indicated by a 1.4cm vertical incision. The breast is denoted by two small buttons. The statuette has a flat abdomen; the buttocks are very slightly contoured; an incision demarcates the legs. A line incised around the waist descends towards the hips in the dorsal region. The statuette is orange, the clay very fine. When first published, the Ghelăieşti statuette was attributed to Cucuteni AB1 or B1 stages, being connected to "*the divine and magical practice of fecundity and fertility*" (*Niţu* et al. *1971.57*).

The second object discussed in this paper belongs to the Moldova National Museum Complex in Iaşi (inv. no. 21109). It was excavated from zone E2 of the Ruginoasa site, hovel no. 5, at 1.6m depth below ground level (Fig. 5). Hovel no. 5 is 3.8 x 3.4m² in area, including the porch. The eastern, southern and western walls were probably made of wood erected on stone foundations. The other objects found at the site are: six antropomorphous statuettes (of which only one represented a male), four zoomorphic statuettes, two conical idols, one bead, one altar and one shell. The whole settlement was attributed to the Cucuteni A3 period (*Lazarovici, Lazarovici 2012*).

The Ruginoasa statuette (Fig. 6) has no special decoration whatsoever. If the navel is clearly visible, the breast

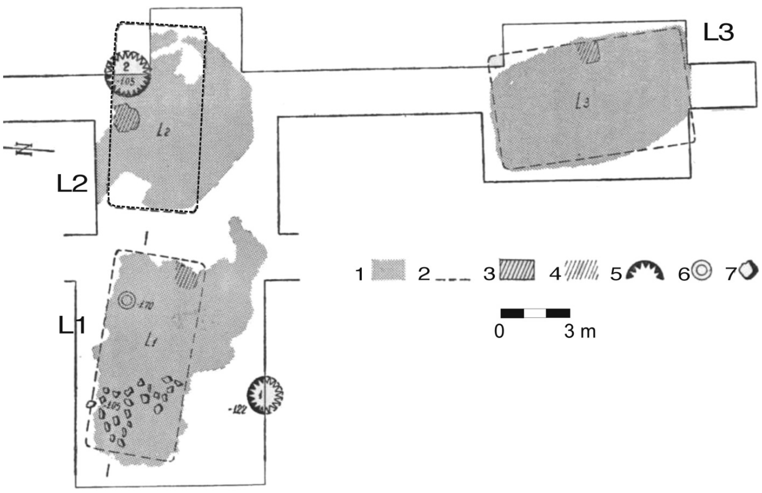

Fig. 3. The layout of the 1969 archaeological excavations at Ghelăieşti. 1 adobe surfaces; 2 the limits of dwelling floors; 3 intact hearths; 4 damaged hearths; 5 Cucuteni A pits; 6 vessel buried under the dwelling; 7 stones; L1 – dwelling 1; L2 – dwelling 2, L3 – dwelling 3 (*Niţu *et al.* 1971. Fig. 2*).

is not marked in any way. The proportions of the different body parts are well-balanced. The head is stylised, executed in '*bec d'oiseau*' technique. A wide incision divides the buttocks (*Lazarovici, Lazarovici 2012*). The statuette has striking steatopygic features, the frontal side being almost flat, with no detail apart from traces of careless finishing. The object is 91.1mm high; the length between the shoulders is 26.6mm, while the pelvis is 33.5mm wide. The stern circumference is 10.9mm, and the abdominal 20.7mm. The head is 12.7mm long (neck including) and 9.1mm in diameter. This object was as carefully finished as many other Cucuteni clay statuettes.

Results and first interpretations

Results

The tomographic study of the Ghelăieşti statuette (Fig. 7) revealed the existence of a piece of clay that was initially modelled precisely in the way a rope is twisted. The upper part was twisted clockwise, while the lower part was twisted counter-clockwise. This lower part is actually the region surrounding the womb, exactly under the incised line representing the vulva. It can be concluded that it was deliberately modelled to indicate the existence of a pregnancy. The whole statuette was formed around this initial piece of clay. On the other hand, the statuette has no external marking to indicate pregnancy.

The tomographic examination indicates the existence of two stages in the shaping of this statuette. Thus, each of these two pieces – the upper and lower – was modelled separately, a fact also shown by the different consistency of the clay pieces, clearly resulting from two different moments of execution and drying.

The tomographic investigations of Ruginoasa statuette (Fig. 8) indicates that the object was made from two pieces – the left and the right – which were tied together later. The head was modelled after these two halves had been combined, a detail that cannot be seen with the naked eye.

The clay from which the object was modelled was carefully selected, being very compact. Using the CT images, a small stone was found on the left side of the statuette in the central zone of the thoracic region (precisely at heart level), next to the contact zone of these two halves. The CT examinations support the idea that this pebble was added deliberately in this precise spot.

This conclusion was reached by also taking into account the results obtained from the tomographic examination of some 108 other Neolithic and Eneolithic statuettes from Romanian museums – measurements that were taken with the same CT device – which indicated that ancient craftsmen paid special attention to the selection of clay; moreover, not a single big stone/pebble was ever noticed in the ceramic paste of other similar Neolithic statuettes. This small stone in the heart region was visible in the area where these two parts were joined together, supporting the idea of an intentional addition.

First interpretations

At first glance, the Ghelăieşti statuette seems quite unremarkable: it is not painted and the external finishing is far from perfect. Similar conclusions can be also reached from a visual examination of the Ruginoasa statuette, which also has a rough finish. Both objects were found in archaeological contexts which had no obvious ritual significance, at least in the current meaning of the term. The statuettes present no apparent sign indicating their use for cultic or ritual purposes. However, the way in which these objects were manufactured, their structure and the details revealed through tomographic investigation, suggest that they were used in connection with religious or magical practices.

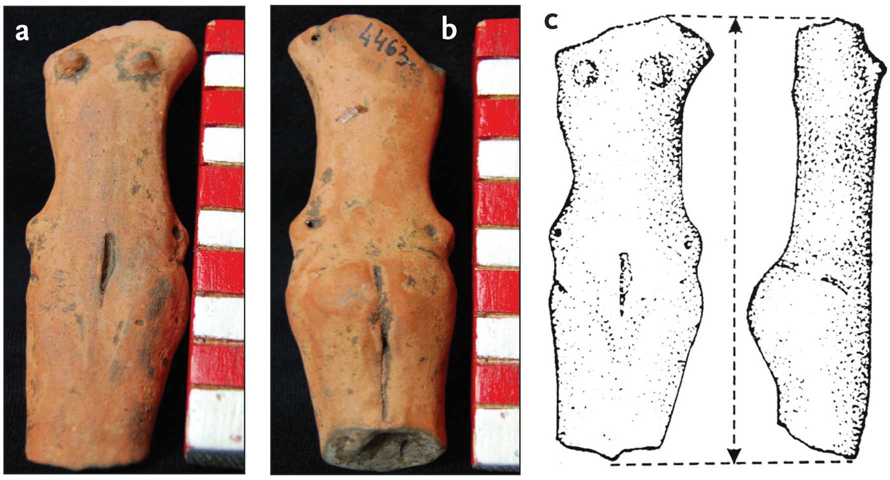

***Fig. 4. Ghelăieşti statuette (inv. no. 4463): a, b – photos 2011; c – drawing from* Niţu *et al.* 1971. Fig 22; Monah 1997.Fig. 165/9.**

Consequently, despite their apparent simplicity and lack of any special finishing, we favour an interpretation of the statuettes as objects used in religious rituals. In the following discussion, we make further arguments to support this interpretation – in spite of the strong doubts raised by post-processualist archaeology, whereby the importance of religion in the everyday life of prehistoric communities is not so easily accepted. This may be related to an inability of the modern world, over-technologised and secularised, that so often fails to understand the significance and importance of faith. The following quotation illustrates this very well:

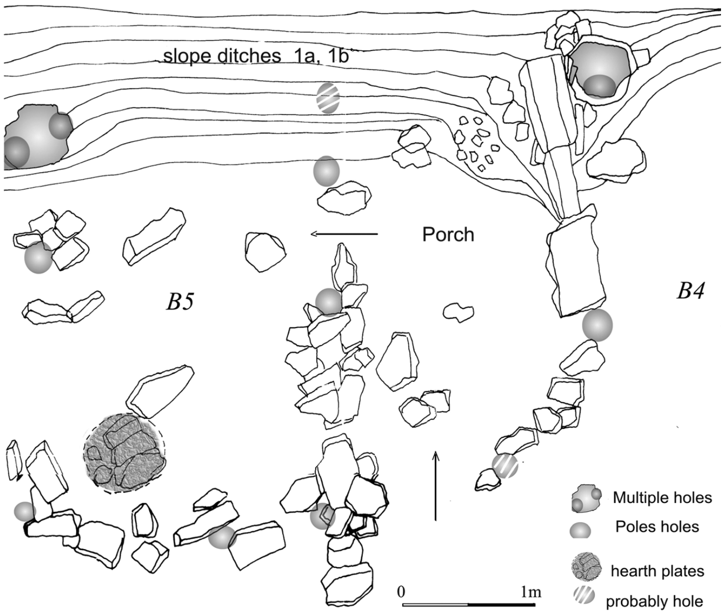

***Fig. 5. Ruginoasa-Dealul Drăghici – the layout of hovel no. 5 (reproduced from* Lazarovici, Lazarovici 2012.Fig. IV.50 a).**

"*But to return to post-processual approaches and religion, perhaps then, many western archaeologists are from the pool of what Eliade (*1978.12*) has defined as "the agnostic and atheistic masses of scientifically educated Europeans". We need to recognise the potentially embedded nature of religion as a key building block, if not sometimes the key building block of identity. For as has been stressed, such an approach allows religion to be seen as part of a holistic package possibly structuring all aspects of life, with "religious" material culture being seen as a very ambiguous category which is very difficult to define"* (*Insoll 2004.5*)

Discussion

It is beyond the scope of this article to review all the hypotheses that have been advanced to interpret Neolithic and Eneolithic clay statuettes. Detailed and critical analyses of these different interpretations, also related to the roles that such objects played in prehistoric communities, were recently made by Douglass Bailey (*2005*) and Dan Monah (*2012*), with the authors reaching different conclusions.

Many examples of foundation rituals, home sanctuaries, communitarian sanctuaries, and small-scale sanctuaries have been found in the Cucuteni-Trypolie area (*Lazarovici, Lazarovici 2007. 158–236*), *e.g.,* finds that suggest that the Cucutenain people enjoyed a complex religious life. In the Cucuteni area, figurines with an external representation of pregnancy are encountered relatively rarely (*Mateescu, Voinescu 1982*).

We cannot proceed with this discussion without mentioning an exceptional statuette from Podurile – Dealul Ghindaru (Fig. 9), also attributed to the Cucuteni culture; its swollen abdomen can easily be interpreted as a sign of pregnancy. This steatopygic statuette turned out to contain 25 small balls of clay (*Monah* et al. *2003.192*). Unfortunately, the manner in which these clay balls were separated from the sta-

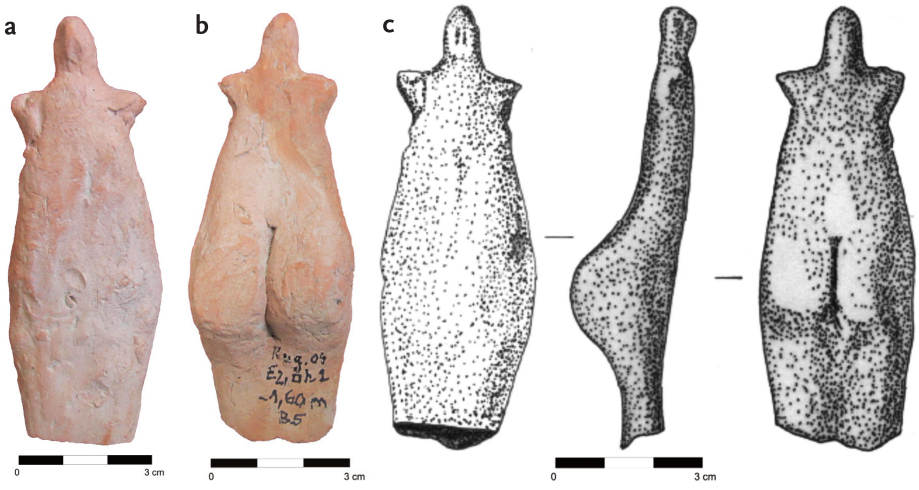

***Fig. 6. Ruginoasa statuette (inv. no. 21109): a, b – photos 2011; c – drawing from* Lazarovici, Lazarovici 2011.Fig. VII. 5.**

tuette's body is not stated – namely, whether the statuette had been cut or broken, or if the internal cavity had a hole or crack through which the small objects could be easily removed by its modern discoverers. In any case, this spectacular find can be connected to complex religious manifestations.

A recent study of Cucuteni statuettes claims that the small number representing pregnant women can be explained in correlation with female and natural fertility (*Monah 2012.236*). The tomographic data reported in this paper show that these representations could be much more numerous than has hitherto been believed. Thus, the identification of a hidden pregnancy in a statuette, as in the case of the Ghelăieşti artefact which was tomographically (and non-destructively) investigated, is absolutely remarkable.

We now review some facts about the circumstances in which the two statuettes were discovered, which can provide some insights for our subsequent interpretation of the tomography results.

A protome shaped like a bird's head and a miniature throne (of an older tradition) were found in dwelling no. 1 at Ghelăieşti (*Niţu* et al. *1971.58–59*). A painted cult vessel shaped like a crater (Cucuteni AB stage) containing two other smaller painted vessels was also discovered in the same dwelling. The archaeologists who excavated the site (*Niţu* et al. *1971. 58–59*) believed that the adobe remains actually came from an altar that was used for ritual purposes and then broken after being burnt ritualistically, together with smaller vessels subsequently placed in the larger one. All these objects were buried before the construction of the dwelling began.

In dwelling no. 2 at Ghelăieşti, a bowl fragment was found, with painted decoration, from which a sheep or goat protome protrudes (*Niţu* et al. *1971.58–59*). Later, two cultic complexes constructed from sanctuary models were discovered (Fig. 10) Thus, in dwelling no. 5/1970, a first complex composed of six vessels of different shapes and sizes arranged in a circle was identified. In the centre of this ensemble, a large ordinary vessel had been placed upside down to protect a pear-shaped vessel, which, in turn was painted and covered with a lid in the form of a Swedish helmet. The pear-shaped vessel was buried up to the decoration limit. In this last vessel, four anthropomorphic figurines – three intact, one heavily corroded – were found. These figurines were leaning on the vessel walls, being placed in a vertical position, and oriented to the cardinal points (*Cucoş 1973.207*).

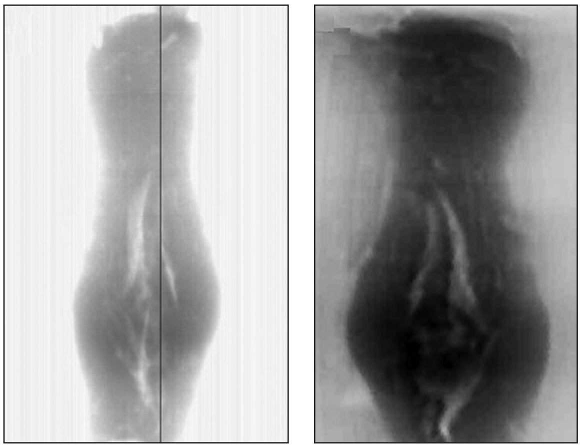

Fig. 7. Images obtained through the CT examination of the Ghelăieşti statuette (inv. no. 4463): left: projection; right: reconstructed slice image – slice coordinates: ρ = 7; θ = 137°; φ = 192°.

A recent interpretation of this find has confirmed that the statuettes were arranged in the form of a cross, but showed that the items were possibly not disposed in relation to the cardinal points, simply because the archaeologist who made the discovery had not used a compass when the complex was found. Moreover, it was claimed that the statuettes were deposited on a bed of straw – the straw was not being used for its usual function of protecting grain, but also had the power to partially transmit its sacred power to items deposited on them (*Monah 2012.59*). In the same dwelling (no. 5/1970), a large vessel containing 497 pig and sheep astragals was found, supporting the archaeologist's claim that this was a ritual complex (*Cucoş 1973.207, note 1*).

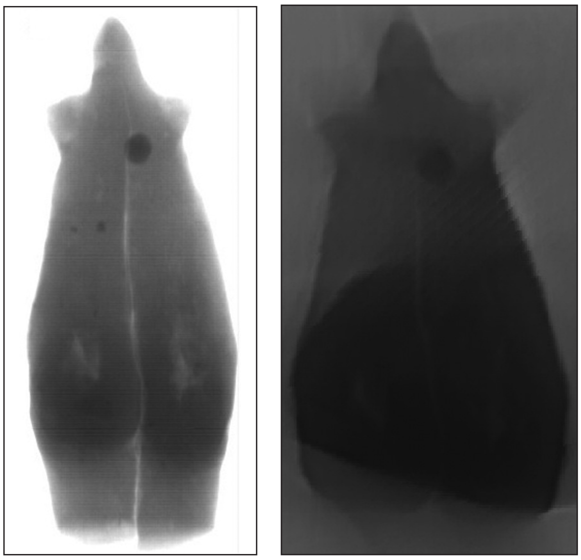

Fig. 8. Images obtained through the CT examination of the Ruginoasa statuette (inv. no. 21109): left – projection; right – reconstructed slice image, slice coordinates: ρ = 32, θ = 189°, φ = 202°.

Ştefan Cucoş (*1973.212–213*) assumed that such depositions were connected to some magical or religious practices, and that this dwelling had been used solely as a sanctuary. The reasons for this hypothesis are that there were no common ceramic finds in this location, nor any implements or clay weights, while the dwelling had no floor or platform, and the hearth showed no signs of serious fire damage. The very siting of this dwelling within the inhabited area also supports this interpretation.

Two models of the painted sanctuaries in which anthropomorphic statuettes were placed were found in dwelling 33/1983 (Fig. 11). Dwelling 33/1983 at Ghelăieşti was also centrally placed in a group of other dwellings, also suggesting its use as a sanctuary. Supporting evidence for such a function is the absence from the inventory of dwelling 33/1983 of any object similar to those discovered in every other house. The structure does not have a platform of wooden beams – unlike all the surrounding dwellings – suggesting that it was used seasonally (*Cucoş 1993.59–60, 65–68*).

Homo religious belief in gods involves unconditional faith and a religious object that is alive and charged with divinity. Religion is manifested through symbols, myths being just another facet of the communitarian spirit.

"From this basic fact of the sensuous realism of the image, in the presence of the autonomy of the sense impression, springs the belief in spirits, and not from any need of explanation on the part of the savage, which is merely a European imputation. For the primitive, thought is visionary and auditory, hence it also has the character of revelation. Thus the magician, i.e. *the visionary, is always the thinker of the tribe who brings to pass the manifestation of spirits or gods. This is the source of the magical effect of thought; it is as good as action, just because it is real. In the same way, the word, the outer covering of thought, has 'real' effect, because the word calls up 'real' memory images. Primitive superstition surprises us only because we have very largely succeeded in de-sensualizing the psychic image,* i.e. *we have learnt to think 'abstractly', always, of course, with the abovementioned limitations."* (*Jung 1953.43*).

Transubstantiation is especially known from the Christian milieu and is one of the few religious rites

***Fig. 9. Statuette of large dimensions (19cm high) from Poduri – Dealul Ghindaru, Muzeul de Istorie Piatra Neamţ (inv. no. 13214), from* Monah *et al.* 2003.192, Fig. 204.**

that are practised and are still alive: a large number of people still believe in such divine transformation. Briefly, transubstantiation[1] means the transformation of divine substance in the sense of spiritualisation, being at the same time a sacrifice and sacred meal offered to a god or gods. This miracle happens continuously, because it involves the transformation of some common elements that are known to all – namely, bread and wine. The priest is just an ordinary person invested with the power to offer the sacrifice. The most important moment is when Christ, playing the roles of both the subject and object of the sacrifice, speaks through the priest. This instant marks the point at which Christ is present in both time and space. "*In so far, then, as the Mass is an anthropomorphic symbol standing for something otherworldly and beyond our power to conceive, its symbolism is a legitimate subject for comparative psychology and analytical research."* (*Jung 1958.203–207*).

Carl Gustav Jung found this type of analogy in some pre-Christian civilisations, in Aztec populations, in the cult of Mithra and in alchemy.

"...so [I] must content myself with mentioning the ritual slaying of the king to promote the fertility of the land and the prosperity of his people, the renewal and revivification of the gods through human sacrifice, and the totem meal, the purpose of which was to reunite the participants with the life of their ancestors. These hints will suffice to show

1 We present here C. G. Jung's opinion on this matter, one of the most objective thoughts on this matter (*Jung 1958*).

how the symbols of the Mass penetrate into the deepest layers of the psyche and its history." (*Jung 1958.222–246*).

The transubstantiation ritual is partially supported by Dan Monah, who mentions the addition of crushed cereals and flour in the ceramic paste from the Tripolie A area and the human sacrifices practised by Cucuteni people, but also the possible existence of ritual anthropophagy or tearing bodies to pieces (*Monah 2012.235–236*). Dumitru Boghian recalls that transubstantiation and consubstantiation are characteristic features of the Cucutenian statuettes (*Boghian 2000.222*). One can also mention here the 16000 ceramic objects found at Gravettian and Pavlovian sites of Central Europe, dating from the Upper Paleolithic. These include figurines and statuettes that were deliberately fragmented, not only mechanically, but also by thermal shock. Mihael Budja suggests that they were deliberately destroyed, insisting that the first ceramic statuettes used in rituals appeared millennia before ceramic vessels and agriculture, implying strong religious motivations. The emergence of agriculture will modify these beliefs (*Budja 2007.41–44*).

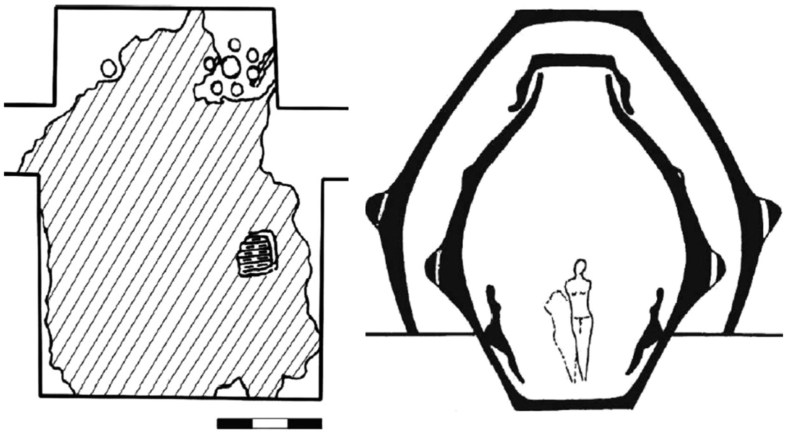

Fig. 10. Ghelăieşti-Nedeia: left – the lay-out of dwelling no. 5/1970 showing details of the ritual deposits; right – cross-section through the central section of the ritual deposit (from* Monah 2012.Fig. 3*).

"Religious creativity was spurred not by the empirical phenomenon of agriculture, but by the mystery of birth, death and re-birth identified in the vegetal cycles." (*Eliade 1991.50*).

The transubstantiation of wet clay into a brittle object that can be spectacularly broken is a process that might induce a very powerful feeling. Transubstantiation is a concept that is also widely documented in ethnographic research, being associated with changes in the human body (conception, gestation, death) and rites of passage (birth, initiation, marriage and funerary rites) (*Taylor 2009.311*). The link between cereal cultivation, sacred bread and rebirth as a continuation of certain agrarian and funeral rituals need not be argued further (*Naumov 2008; Eliade 1991*). It is worth recalling *coliva* (*Kólliva* – in Greek) here, a dish made of boiled and sweetened wheat that is offered at funerals and commemorations (*Eliade 1991*) in the Balkans. *Coliva* signifies the body of the dead while wheat is a human staple. In some regions of Romania, *coliva* is eaten on the first Saturday of Lent (which has a different date in the Christian Orthodox calendar). This moment also corresponds to the celebration of Saint Teodor Tiron and the institutionalisation of *coliva* in the Eastern Christian church. The moment is naturally correlated with the rebirth of plants, clearly a pre-Christian custom (*Marian 1994.239–243*).

The Ghelăieşti statuette can be clearly linked to very ancient agrarian and fertility rites, adopting birth and re-birth, the real conception of the foetus and the transubstantiation of the divine, which is clearly present in this clay statuette. The bread oven can be seen as part of the uterus of the Great Goddess as observed in some types of anthropomorphic oven found in the Balkans (*Naumov 2010.232–233, Fig. 5*). Ethnographic analogies further indicate clear similarities between birth and mortuary rituals (*Gennep 1996.57*). The presence of the heart, represented by a round pebble placed in the anatomically correct position, a detail provided by the tomographic investigation of the Ruginoasa statuette, is quite extraordinary and revealing about the religious imagination of Cucutenian people.

Conclusions

The present study presents the results of a tomographic investigation of two Cucuteni clay statuettes. The analysis of the images obtained, and the internal structures and manufacturing details revealed by the CT scans support the idea that the sacred was a concept very much present in prehistoric communities to an extent which might barely be understood and/or accepted nowadays.

Both statuettes reported in this archaeometric study were rather carelessly finished, at least compared to

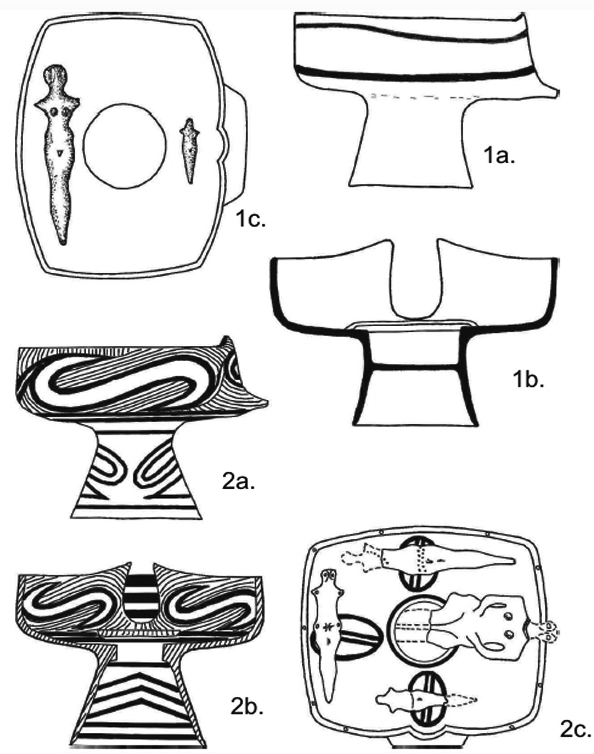

Fig. 11. Ghelăieşti-Nedeia. 1, 2 Sanctuary models with statuettes discovered in dwelling 33 (from* Monah 2012.Fig. 12*).

other clay statuettes discovered in the Cucuteni area and/or dating from the same period. It may be readily concluded that in such cases the external appearance of the objects was not important, but what was hidden inside them and what these figurines represented in spiritual and/or religious terms. Both statuettes contained deliberately hidden objects that may be linked to religious manifestations – the transubstantiation of divinities in ceremonies related to the Cucutenian religious universe, birth and fertility.

The results reported in this paper prove that non-destructive and non-invasive X-ray computed tomography investigations can be extremely useful for understanding the structure of intact ceramic statuettes and/or rattles.

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