Multi-proxy Archaeobotanical Analysis from Mesolithic and Early Neolithic Sites in South-west Ukraine

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Référence: Salavert, A., Emilie, G., Erwan, M., Vincent, L., Dmytro, K., 2020. Multi-proxy Archaeobotanical Analysis from Mesolithic and Early Neolithic Sites in South-west Ukraine. *Environmental Archaeology* 1–14. https://doi.org/10.1080/14614103.2020.1746879

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Abstract

This paper presents the results of archaeobotanical studies carried out on the Late Mesolithic layer at Melnychna-Krucha (6460–6100 cal BC) and the Linearbandkeramik (LBK) site of Kamyane-Zavallia (5295–4960 cal BC), close to the Southern Bug River. Despite the relatively modest dataset presented in this paper, these preliminary results provide new data for a region where the environmental setting and the uses of plant resources during the Early Atlantic period are poorly understood. The main taxa used for firewood are quite similar at Melnychna-Krucha and Kamyane-Zavallia, although they were occupied 1000 years apart. *Fraxinus* (ash) and *Quercus* (oak) dominate both charcoal assemblages. These taxa, as well as *Ulmus* (elm), could have grown together in the alluvial deciduous forest, probably on the Southern Bug riverbank, close to both sites. *Carpinus* (hornbean) was present but probably still not abundant around Kamyane-Zavallia at the end of the 6th millennium. Macroremains and phytolith demonstrate that the plant production economy (cultivation, cereal processing) was well developed and very similar to other European LBK sites. At Melnychna-Krucha, plant macro- and microremains did not indicate a productive subsistence.

Keywords: archaeobotany, Neolithic, Late Mesolithic, Linearbandkeramik, forest-steppe, Ukraine

1-Introduction

Contrary to Western Europe, the presence of cultivated plants and domestic animals is not a key marker to qualify the Neolithic in Eastern Europe (Motuzaité-Matuzevičiūtė 2014). In the Southern Bug valley (Ukraine), the Bug-Dniester (6300–5500 BC) is considered as the earliest known Neolithic culture (Danylenko 1969; Kotova 2009; Motuzaité-Matuzevičiūtė 2014). The first relevant evidence of cultivated plants comes from the Linear pottery/Linearbandkeramik (LBK) site of Ratniv-2 (Volynian region), dated around 5300 cal BC (Motuzaité-Matuzevičiūtė and Telizhenko 2017). However, investigations into the eastern extension of this widespread LBK culture are still limited (Saile et al. 2016). In the same way, concepts about the disappearance of local Late Mesolithic cultures and their role in the emergence of Neolithic communities are based on the surface discoveries of Mesolithic artefacts, and suffer from an insufficient number of radiocarbon dates (Biagi and Starinini 2016).

This study presents the results of multi-proxy archaeobotanical analyses (charcoal, seeds/fruits, phytoliths) carried out on the LBK site of Kamyane-Zavallia in south-west Ukraine (Fig. 1). In order to further explore the characterization of the environmental framework of the Neolithic transition in this area, archaeobotanical analyses was undertaken on the Late Mesolithic stratigraphic unit (SU) at Melnychna-Krucha; a multilayered site occupied from 7250 to 5600 cal BC and located 18 km south-east of Kamyane-Zavallia (Fig. 1). Despite the modest dataset, these preliminary archaeobotanical results provide new data for the environmental setting and subsistence of the Late Mesolithic groups and early farmers, which are poorly investigated in this region (Monah 2007). So far, no study based on archaeological charcoal has been published for the Late Mesolithic (Kukrek) and Early Neolithic (Bug-Dniester, LBK) in south-west Ukraine. The nearest ones were conducted at Maidanetske, a Trypillian mega-site inhabited during the first half of the 4th millennium (Kirleis and Dreibrodt 2016, Dal Corso et al. 2019). Multi-proxy archaeobotanical analyses were also conducted at Buran-Kaya IV rock-shelter (Crimea) on Neolithic layers dated from the first half of the 6th millennium BC (Salavert et al. 2014). Moreover, the cultivated plants, weeds and phytoliths of Kamyane-Zavallia provide additional data to the recent archaeobotanical study of Ratniv-2 (Motuzaité-Matuzevičiūtė and Telizhenko 2017) and contribute to the preliminary definition of the LBK crop package and plant processing in the eastern LBK culture.

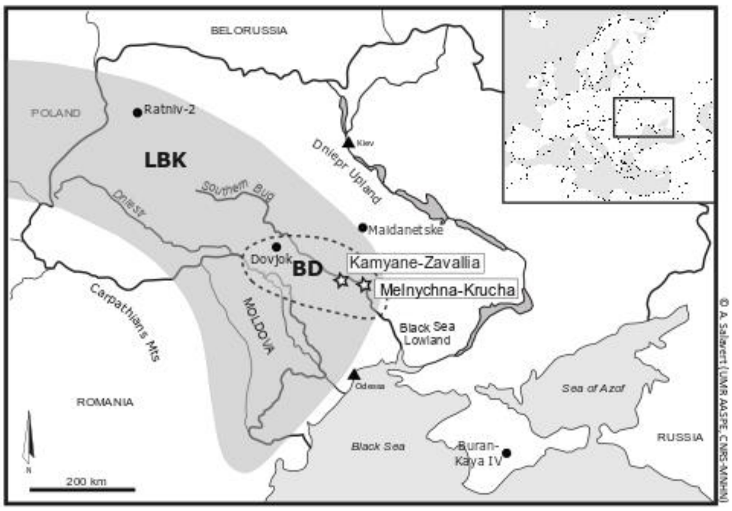

Figure 1: Location of Melnychna-Krucha (Late Mesolithic/Bug-Dniester) and Kamyane-Zavallia (LBK) as well as others sites mentioned in the text (black circles). Extension of the Bug-Dniester (BD) and Linear pottery/Linearbandkeramik (LBK) cultures.

2- Environmental setting

Today, the climate of south-western Ukraine is humid continental, characterized by large seasonal temperature contrasts (Peel et al. 2007). At Zavallia, near the LBK site, the average temperature increases from -4.5°C in January to 20.2°C in July. The average annual precipitation is about 550 mm.

Melnychna-Krucha and Kamyane-Zavallia are located close to the current interface of the forest-steppe and steppe provinces of Eastern Europe (Fig. 2). The steppe zone is characterized by the rarety or limited extension of tree cover and the predominance of grasses (Poaceae). In south-western Ukraine, the forest-steppe is a mosaic of open grasslands and *Carpinus*–*Quercus* (hornbeam–oak) forests (Fig. 2). Woodland patches can potentially occur anywhere, though with a decrease in their extension from north to south (Chibilyov 2002). Melnychna-Krucha is surrounded by pastoral meadow steppes dominated by Poaceae and with patches of deciduous broad-leaved forests. The site sits on riverine sediments close to the Southern Bug River. Kamyane-Zavallia is located on the loessic first terrace of the Southern Bug River, covered by podzolized chernozem soils. Today, a large agricultural plain spreads directly around this site, and woodlands are barely visible.

In the western Ukraine area, the few existing pollen sequences that covers the Early Atlantic period (6900-4700 cal BC) are not well dated (Pashkevich 1982, Kremenetski 1995, Vinogradova and Kiosak 2007). These limited pollen studies indicate that around 5000 cal BC, the forest-steppe vegetation was characterized by thermophilous mixed-oak woodlands, mainly composed of *Corylus* (hazelnut), *Ulmus* (elm), *Tilia* (lime tree), *Quercus* and some *Carpinus* (Albert et al. 2019).

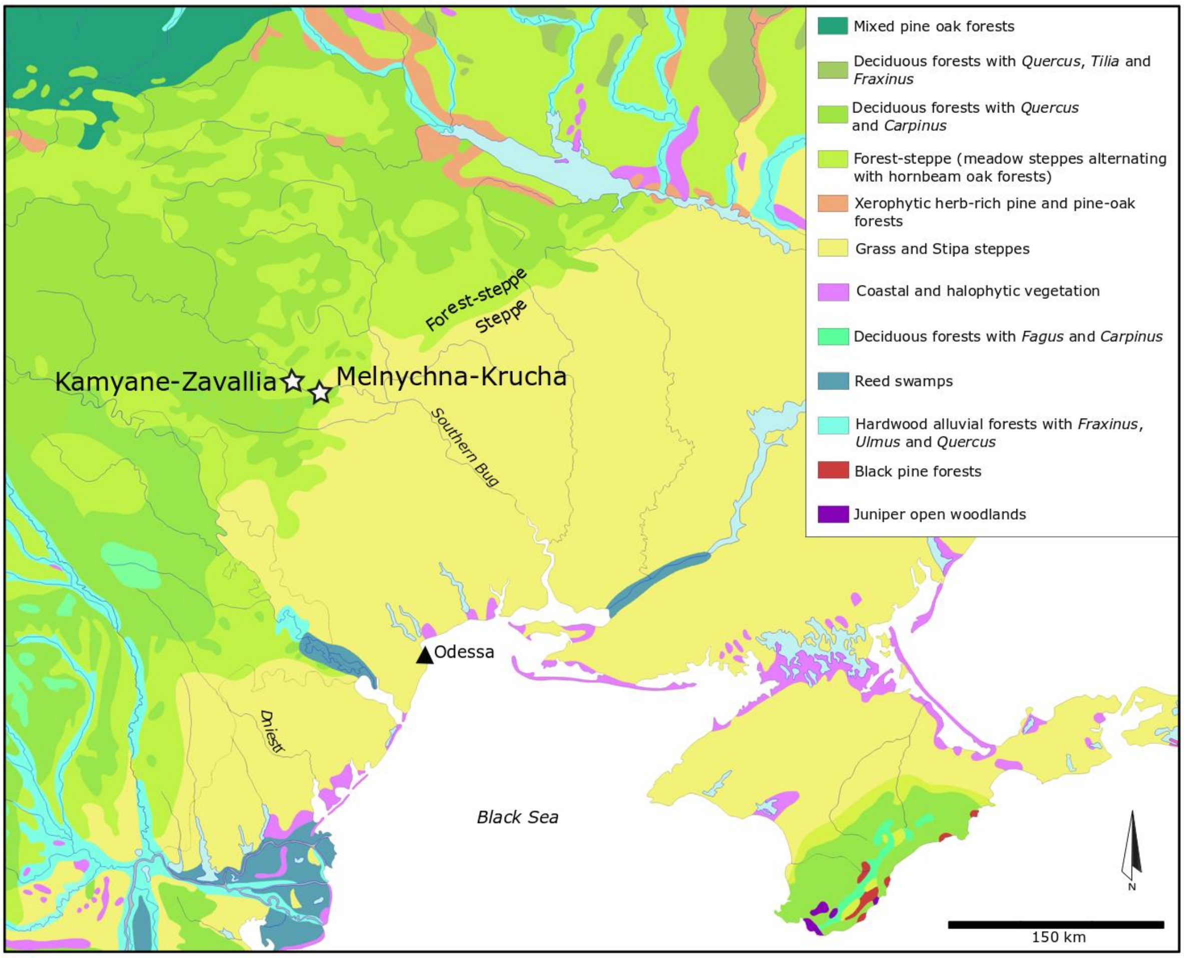

Figure 2: Vegetation units in the Southern Bug (modified from Bohn et al. 2000).

3 Archaeological settings

3-1 Melnychna-Krucha

The deepest stratigraphic units (SU3 and SU2) of the 2012 test trench revealed lithic artefacts belonging to the pre-pottery occupation of the Kukrek tradition (Kiosak 2016). The two radiocarbon dates, obtained on charcoal fragments sampled from SU3, fall into the second half of the 7th millenium (Kiosak and Salavert 2018; Tabl. 1, Fig. 3). The Kukrek culture corresponds to one of the Late Mesolithic complexes of south-western Ukraine (Biagi and Kiosak 2010).

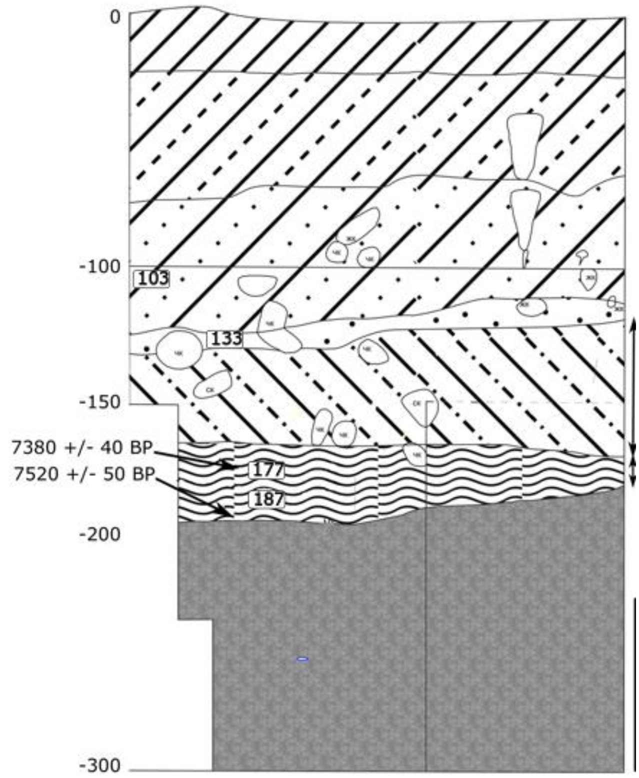

Figure 3: Stratigraphy of the north wall of square 3 from Melnychna-Krucha with projected position of the two samples for radiocarbon dating in the SU3 and phytolith samples positions (modified from Kiosak and Salavert 2018: fig. 2).

3-2 Kamyane-Zavallia

The excavation focused on an elongated pit, in which numerous ceramic and lithic artefacts were mixed with domestic and wild animal bones (determination of O.P. Sekerska), pieces of burnt clay, charred macroremains, grinding stones and bone tools (Kiosak et al. 2014a, 2014b; Kiosak 2016, 2017). No postholes have been detected so far (Fig. 4). The fine pottery mostly bears Notenkopf-style decoration that is a regional variation of LBK pottery. The Romanian Dudeşti-style ornamentation of some of the potsherds could illustrate long distance contact with the eastern LBK settlements (Saile et al. 2016). The two radiocarbon dates from animal bone and charcoal fragments mostly encompass the last quarter of the 6th millenium (Tabl.1) and correspond well with the duration of the Notenkopf-style phase in the eastern area of LBK distribution (Kiosak and Salavert 2018).

3- Material and method

3-1 Macroremains

3-1-1 Sampling

At Melnychna-Krucha, the botanical material sampled from the SU3 corresponded to a layer of greyish loess-like loam with finds scattered throughout its depth and with no clear walking surface. In this context, macroremains are mixed with wild animal bones and Late Mesolithic lithic material (Kiosak and Salavert 2018). The charcoal, originating from local vegetation, probably corresponds to several burning activities *(i.e.* to firewood) or even natural fires (Chabal 1997). The sampling strategy consisted of taking small-size soil samples (average of ca. 1, 5 litres per sample) in the 2012 test-trench section reopened during the 2014 field mission. We focused on areas with charcoal inclusions without apparent taphonomic disturbances (*i.e*. plant roots, burrows). Other samples were handpicked from previous campaigns where the charcoal material had been detected with the naked eye. No large charred seeds or fruits were noticed during excavations. In total, 21 samples, including the four small-size samples, were studied (Tabl. 2).

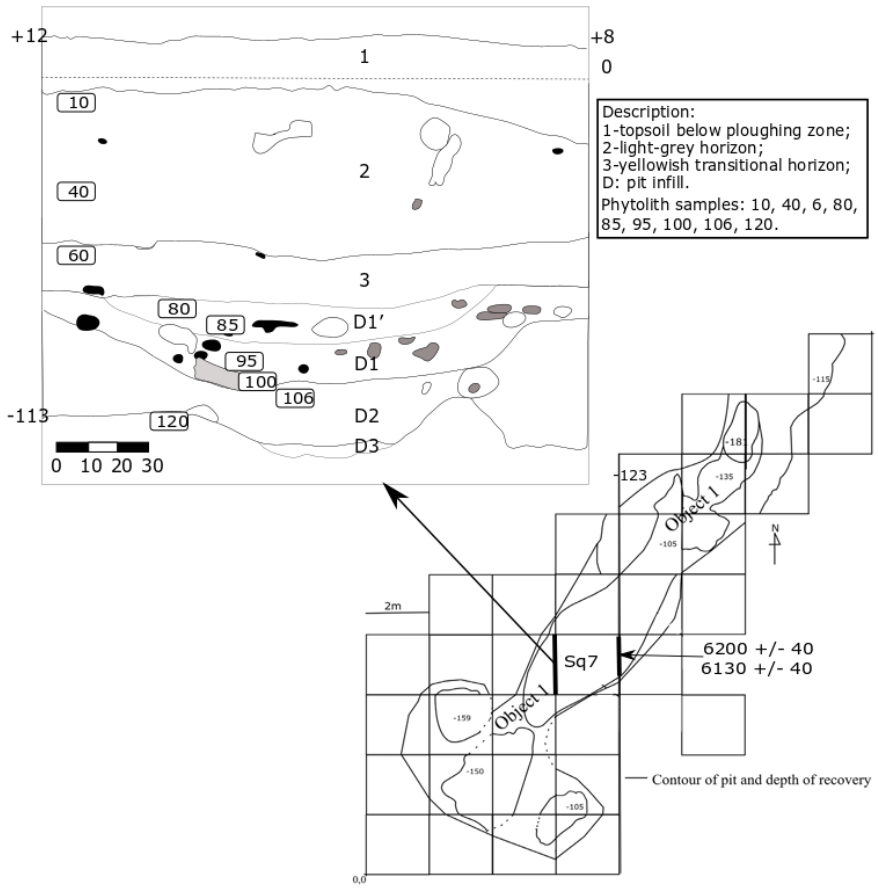

Figure 4: Plan of the pit (object 1) and stratigraphy at Kamyane-Zavallia, location of samples for radiocarbon dating and projected positions of the phytoliths samples (in Kiosak and Salavert 2018: fig. 5). The macroremains and dating material were sampled from horizon D. The stratigraphic section corresponds to the western wall of square 7 (Sq7).

Lab code	**Depth (cm)**	**Sample**	**Support**	**Conventional Age ^{14}C age BP**	**Age cal BC 2σ**
Poz-67497	170	MK3	Charcoal (*Fraxinus*)	7380 ± 40	6380–6100
Poz-67496	200	MK2	Charcoal (Angiosperm)	7520 ± 5050	6461–6253
Poz-67554	82	KZ2	Charcoal (*Fraxinus*)	6130 ± 40	5211–4962

Poz-67121	130	KZ1	Animal bone (undetermined)	6200 ± 40	5295–5045

Table 1: Radiocarbon dates from Melnychna-Krucha SU3 (MK, Late Mesolithic) and Kamyane-Zavallia (KZ, LBK).

	MK (Late Mesolithic)	**KZ (LBK)**
Handpicked	17	10
Sieved (volume)	4	13
Volume of sediment	5	104
Total	**21**	**23**
Charcoal fragments	79	540
Number of wood taxa	3	7
Charred seeds/fruits	0	35

Table 2: Archaeobotanical dataset of Melnychna-Krucha (MK) and Kamyane-Zavallia (KZ).

At Kamyane-Zavallia, samples came from the elongated pit. Macroremains were dispersed in the sediment and mixed with LBK domestic artefacts that cannot be strictly associated with the primary functions of the structure. The macroremains could result from several heterogeneous activities, without any functional or temporal links between them. Regarding charcoal, several plant groups, at different states of maturity, were represented within one sample, according to vegetation dynamics and the gathering practices of past societies for firewood. A total of 23 samples provided charred macroremains (Tabl. 2), ten of which were handpicked during the 2013 excavation. The others corresponded to large (ca. ten litres each) or small volume samples collected during the excavation, or sampled from the north wall section of the pit in 2014.

3-1-2 Extractions, identifications and countings

In 2014, the large and small volume soil samples were water sieved (250 µm) then floated directly on-site (Fig. 5). Charcoal fragments were fractioned according to the three wood anatomical planes and identified under an optical reflection microscope at x100 to x500 magnification, with the help of a comparison atlas (Schweingruber 1990) and the charcoal reference collection from the Muséum national d'Histoire naturelle in Paris. At both sites, most of the charcoal fragments measured around or less than 1 mm in their transversal section.

The charcoal fragments from each sample were counted for each taxon, with the dominant taxa being assumed to be the most harvested (Chabal 1997). Usually, the most common species is the lead species of a community, such as *Quercus* sp. in the deciduous oak forest or *Alnus* sp. (alder) in the mature riparian forest (Chabal 1992). At Melnychna-Krucha, most of samples were handpicked, but this method does not document a reliable overview of past forest diversity. At Kamyane-Zavallia, the grouping of all the samples from pit 1 ensured the maximum of palaeoecological diversity. In addition, the number of taxa occurrences were calculated (*i.e.* each taxon determined in a given sample is counted as a single individual whatever the number of fragments), to assess, for each taxa, the minimum number of logs burnt at both sites. This method valorizes the taxa that are regularly present in small quantities on sites (Delhon 2016). Regarding charred seeds and fruits, remains were scarce and badly preserved. The number of remains corresponds mainly to fragmented remains. Few cereal seeds were sub-complete. Most of the time, bad preservation of the material did not allow identification to the species level, especially for cereals.

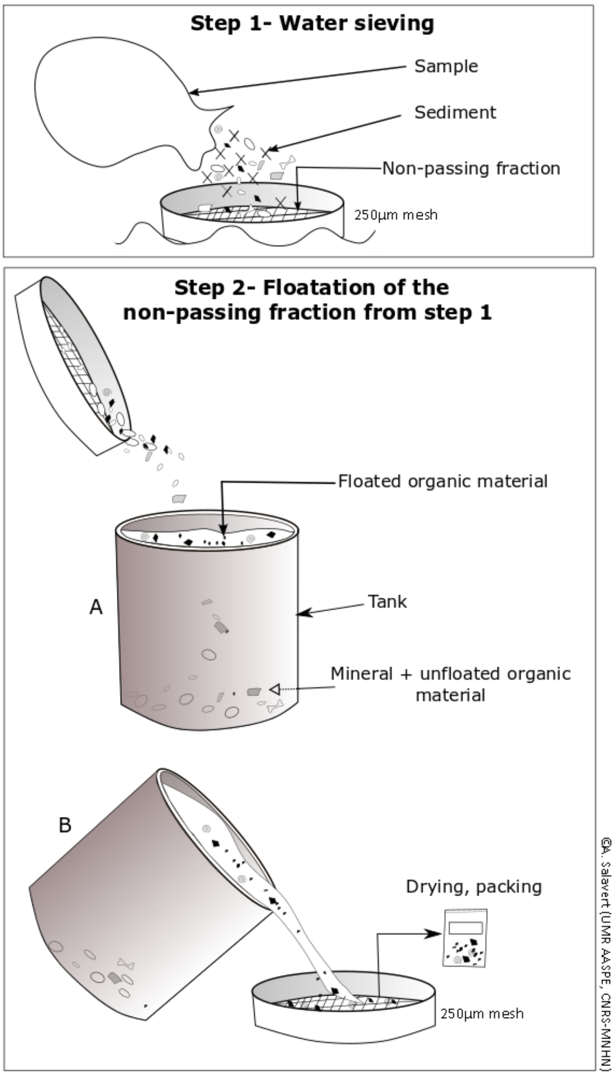

Figure 5: The sieving process applied to small and large volume samples collected at Melnychna-Krucha and Kamyane-Zavallia.

3-2 Phytoliths

At both sites, the sediment was sampled along the test-pit profiles for phytolith analysis. The samples were not systematically collected at regular intervals because of the complex stratigraphy of the pit filling. In Melnychna-Krucha, 20 samples were collected from the archaeological layers of the test-pit section (Fig. 3). In Kamyane-Zavallia, 9 samples were collected in the detritic pit. One additional sample collected in the deposit under the pit was used as a control sample for this site (Fig. 4).

Phytoliths were extracted from sediment samples using HCl and H_2O_2 baths, sieving, clay removal and densimetric separation (Lentfer and Boyd, 1998). After cleaning, the residue was suspended in immersion oil and mounted on glass slides.

The slides were observed under a Leica DM 1000 ™ Microscope at x650 magnification. Each phytolith was classified according to its morphology, following several systems (Twiss et al. 1969; Mulholland 1989; Fredlund and Tieszen 1994) and the International Code for Phytolith Nomenclature (ICPN Working Group et al. 2019). The observed phytoliths were classified into 10 different categories (Tabl.3). The morphotype silica skeletons (linked phytoliths) corresponding to fragments of silicified Poaceae epidermis were also identified (Rosen 1992). These represent the remains of fragmented pieces of culms, leaves and inflorescences of Poaceae plants. Sponge spicules and diatoms were also observed. Each morphotype's relative abundance was calculated as a percentage of the sum of classified phytoliths. This sum, used for percentage calculations, was based on the total number of phytoliths counted per sample (more than 200 for each sample). Silica skeletons, diatoms and sponge spicules were excluded from the total phytolith sum. The representation of each of these groups was expressed as a percentage of the sum of phytoliths plus the group sum [*i.e*. % of diatoms = N diatoms/ (Σ phytoliths + N diatoms) x 100].

Morphotypes (ICPN 2.O)	ICPN 1.0	Main taxonomic attribution	Bibliography
Elongate entire	Elongate	Poaceae	Twiss et al. 1969 (elongate); Alexandre et al. 1997 (elongated)
Elongate dendritic	Elongate dendritic	Poaceae	Berlin et al. 2003
Acute bulbosus	Acicular hair cell 1	Poaceae	Twiss et al. 1969 (point-shaped); H.-Y. Lu et al. 2006 (long point)
Bulliform flabellate & Blocky	Cuneiform bulliform cell & Parallelepipedal bulliform	Poaceae	Twiss et al. 1969 (fan-shaped); Strömberg 2002 (keystone-shaped bulliform)
Rondel & Trapezoid	Rondel & Trapeziform short cell	Poaceae	Fredlund et Tieszen 1994 (keeled, conical, pyramidal); Mulholland 1989 (rondel)
Saddle	Saddle	Poaceae, Chloridoideae	Mulholland 1989 (saddle); Fredlund et Tieszen 1994 (saddle)
Crenate	Sinuate trapeziform	Poaceae, Pooideae	Brémond et al. 2004 (crenate); Barboni et al. 2007; Mulholland 1989 (sinuate)
Bilobate	Bilobate	Poaceae, Panicoideae/Arundinoideae	Brown 1984 (bilobate); Mulholland 1989 (dumbbell)
Spheroid psilate & ornate	Globular	cf. Dicotyledonous	Alexandre et al. 1997 (circular rugose); Runge 1999 (spherical)
Acute bulbosus 2	Acicular-hair cell 2	No taxonomic value	Piperno 2006 (hair cell); Pearsall 2000 (hair cell)

Table 3: Phytolith morphotypes (following ICPN 2.0, ICPT et al., 2019), with their synonyms in the ICPN 1.0., their taxonomic attributions and the corresponding literature (In brackets, the morphotype name used in the cited literature).

4- Results

4-1 Melnychna-Krucha (Late Mesolithic, 6460–6100 cal BC)

4-1-1 Charcoal

Among the three taxa identified, *Fraxinus* dominated with 62 % of the total amount of fragments, followed by *Quercus* (34 %). *Ulmus* remains were minimal (4 %). The occurrences showed the same rank for the tree taxa (Fig. 6). No seeds/fruits were identified.

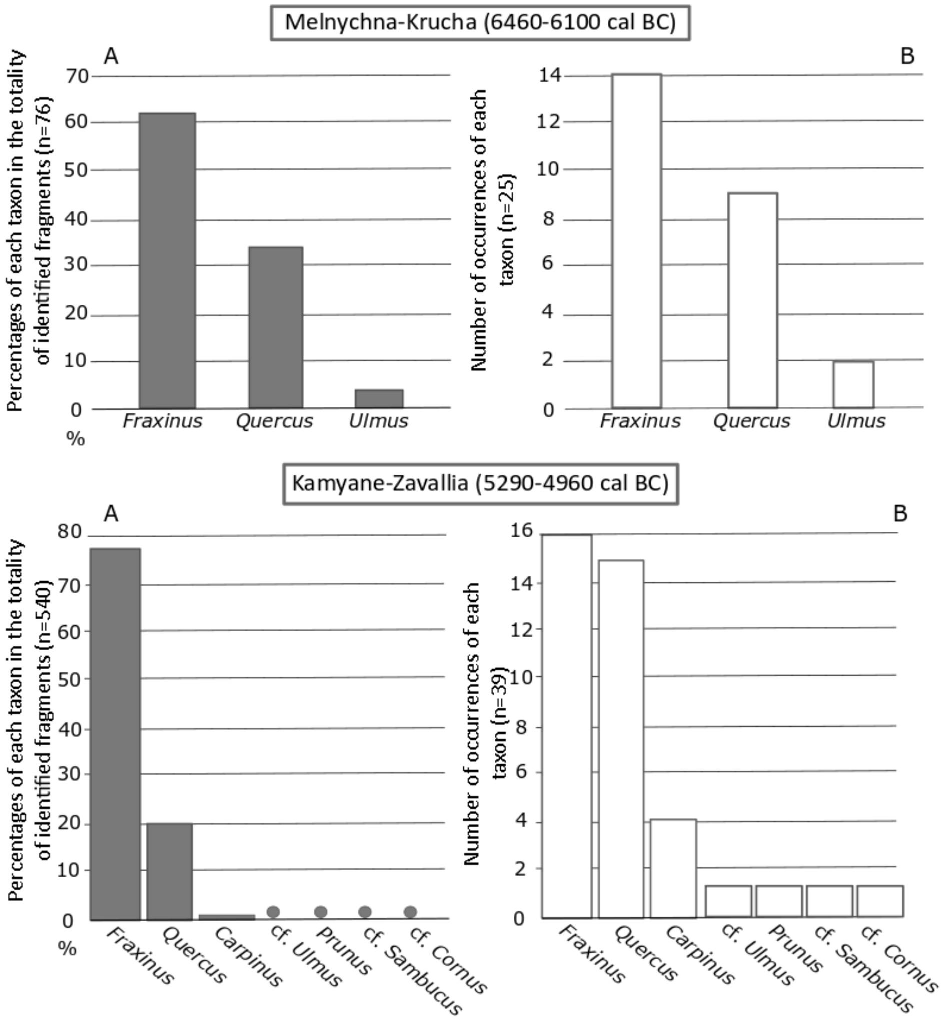

Fig. 6: Results of the charcoal analyses of Melnychna-Krucha (analysis: Salavert A.) and Kamyane-Zavallia (analysis: Gouriveau E., Salavert A.).

4-1-2 Phytoliths

The sediment samples collected were very poor in phytoliths. Among the 20 samples, only four (Fig. 7) yielded more than 100 phytoliths (excluding silica spicules). Samples present very similar assemblages. Grasses (Poaceae) were the dominant taxon. Among this group, Pooideae, represented by sinuate trapeziform and some rondel classes, was the best recorded subfamily. Bilobate was recorded in three samples but in very low quantities. Globular was recorded in every sample. Dendritic elongate phytoliths and silica skeletons, the two morphotypes that are generally abundant at archaeological sites where cereals were processed (Berlin et al. 2003; Portillo and Albert 2011), were completely absent from the Melnychna-Krucha assemblages. The assemblages were marked by the abundance of silica spicules (Fig.7), an aquatic environment marker.

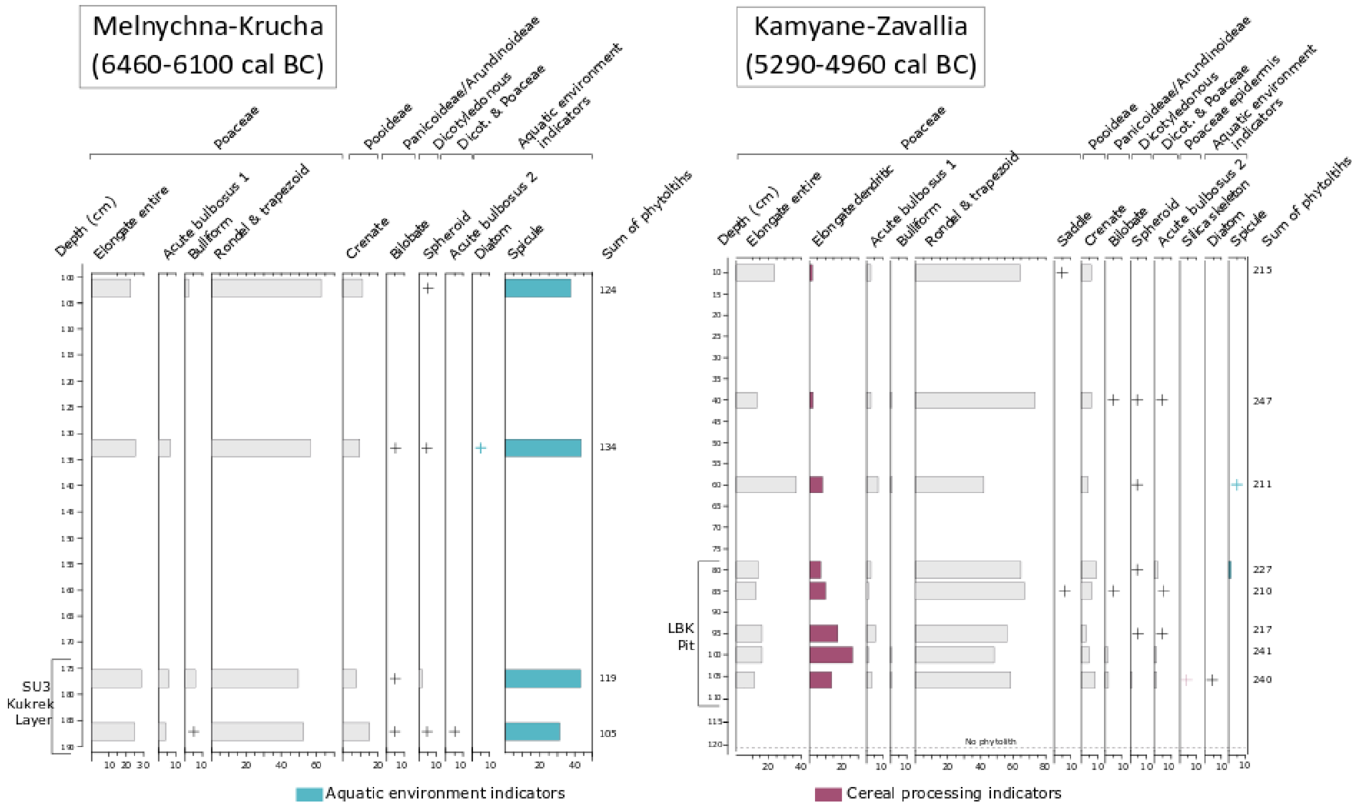

Figure 7: Microremain assemblages (phytoliths+spicules+diatoms) from Melnychna-Krucha and Kamyane-Zavallia (analysis: Messager E).

<u>4-2 Kamyane-Zavallia (LBK, 5290–4960 cal BC)</u>

4-2-1 Charcoal and seeds/fruits remains

Seven woody taxa were identified. *Fraxinus* (77 %) and *Quercus* (20 %) were the most abundant trees. *Carpinus* (1.5 %) was also identified, as were four minor taxa whose identification is uncertain due to the small size of the fragments: cf. *Ulmus*, *Prunus* (e.g. cherry, blackthorn), cf. *Sambucus* (elder) and cf. *Cornus* (dogwood). The occurrence valorizes *Quercus*, which was almost as frequent as *Fraxinus* (Fig. 6).

For seeds/fruits analysis, cereals with *Triticum turgidum* cf. subsp. *dicoccon* (*T.* cf. *dicoccum*, emmer), *Hordeum* sp./*Triticum* sp. (barley/wheat), *Triticum* cf. *monococcum* (einkorn) and cf. *Hordeum* sp., represent 50 % of the dataset (Tabl. 4). Whole seeds of *Chenopodium album* type (fat-hen), fragments of *Fallopia convolvulus* (wild buckwheat) and of Caryophyllaceae type (Fig. 8) represent the weeds/wild taxa.

Number of samples	16
Volume of sediments (l.)	116
Number of macroremains	35
Hordeum/Triticum sp.	8
Triticum cf. *dicoccum*	6
Cf. *Hordeum* sp.	3
Triticum cf. *monococcum*	1
Chenopodium album type	14
Fallopia convolvulus	2
Caryophyllaceae type	1

Table 4: Charred seeds identified in the elongated pit (object 1) at Kamyane-Zavallia, analysis:

Figure 8: Kamyane-Zavallia, ventral face (up) and profile (down) of *T.* cf. *dicoccum* (A), *Triticum* cf. *monococcum*. (B) and cf. *Hordeum* sp. (C).

4-2-2 Phytoliths

Phytoliths were well recorded, except in the sample located under the pit (Fig. 7). This control sample, from a natural deposit (non-anthropogenous), did not yield any phytoliths. We can therefore assume that the assemblages identified in the archaeological layers were not inherited from older assemblages. As for Melnychna-Krucha, Pooideae (represented by sinuate trapeziform and some rondel classes) was the best recorded Poaceae subfamily. Globular morphotypes were rarely identified.

Among the Poaceae phytoliths, the morphotype elongate dendritic, coming from inflorescences (glumes, lemma, palea) of Poaceae (Ball et al. 2001), was recorded in every pit sample. In the upper samples only a small amount was recorded, but in the bottom of the pit it was abundant (from 14 to 27 %). This class of phytolith is scarcely recorded in natural soil assemblages; however, it is often well-represented in archaeological sites where cereals have been processed (Berlin et al. 2003; Portillo and Albert 2011). Thus, the presence of numerous dendritic phytoliths in the bottom of the pit reveals cereal processing at Kamyane-Zavallia. The class silica skeletons, representing fragmented epidermal cells, was identified by only one fragment in the deepest pit sample.

4.3. First inter-site comparison

Comparisons between the archaeobotanical assemblages from both sites, especially charcoal assemblages, were difficult to undertake due to the differences in the nature of the samples collected and the number of macroremains identified (Tabl. 2). There was no obvious difference in the leading taxa in the charcoal assemblages from the two sites (Fig. 6): *Fraxinus* and *Quercus* dominated and corresponded to more then 90 % of the charcoal assemblage. At this stage of the research, the highest diversity noticed at Kamyane-Zavallia may be due to the higher number of identified charcoal. Not surprisingly, this LBK site bears several indicators of productive economy; in contrast to the lack of botanical macro- and microremains in the SU3 of Melnychna-Krucha, which do not indicate productive subsistence (Tabl.5).

	MK (Late Mesolithic)	**KZ (LBK)**
Charcoal	x	x
Cultivated plants	0	x
Weeds	0	x
Elongate dendritic phytoliths (chaff)	0	x
Domestic animals	0	x
Potsherds	0	x
Wild animals	x	x
Fish bones	x	x

Table 5: Comparison of the absence (0) and presence (x) of production economy indicators at Melnychna-Krucha (MK) and Kamyane-Zavallia (KZ).

5- Interpretation

5-1 Contribution and limit of charcoal and phytoliths analysis to reconstruct past vegetation

At Melnychna-Krucha and Kamyane-Zavallia, charcoal analyses provided a list of taxa that informs about the adjacent territories exploited by human groups, mainly for the collection of firewood. Some of the charcoal could also correspond to wood collected initially for other purposes (construction, crafts) and then later used as fuel. Although the charcoal analyses did not provide direct evidence on the exploited biomass – whether the woodland cover was associated with open (steppe), semi-closed (steppe-forest) or closed (forest) environments around the sites – phytolith assemblages are essentially produced by herbaceous taxa (such as Poaceae) in temperate ecosystems. Unfortunately, on an archaeological site, it is usually difficult to separate the phytoliths coming from crops from those coming from wild plants. At the Maidanetske site (Trypillia culture), the Stipa-type phytoliths (Blinnikov 2005; Fredlund and Tieszen 1994) permitted the identification of wild grasses coming from a steppe environnement (Dal Corso et al. 2018), but this morphotype was not recognized in the Melnychna-Krucha and Kamyane-Zavallia assemblages.

5-2 Firewood resources during the Late Mesolithic (*ca.* 6500–6100 cal BC) and Early Neolithic (*ca.* 5200–5000 cal BC) in Southern Bug

The main taxa used for firewood were quite similar at Melnychna-Krucha and Kamyane-Zavallia, although occupied 1000 years apart: *Fraxinus* and *Quercus* dominated both charcoal assemblages. These taxa, as well as *Ulmus*, could have grown together in the alluvial deciduous forest, probably on the riverbank of the Southern Bug River, in close vicinity of both sites. The presence of heliophilic shrubs (*Prunus*, cf. *Sambucus*, cf. *Cornus*) growing in forest edges may indicate a locally open environment during the LBK, but further analyses are crucial to discuss a possible human impact on the woodland at this period.

The Late Mesolithic and LBK occupations fall into the Early Atlantic palynozone (6900–4700 cal BC). Pollen analyses from the Dovjok swamp, located in the current forest-steppe on the flood plain of the Murafa River (Fig. 1), shows that the vegetation was dominated by arboreal taxa, with *Quercus*, *Corylus*, *Ulmus* and *Tilia* in the first half (8000–6000 BP) of the Atlantic period (Kremenetski 1995). *Tilia*, and more particularly *Corylus*, are important taxa in palynological records (Albert et al. 2019), but they were not identified among the charcoal fragments in our study. Regarding *Tilia*, its rarity in charcoal records compared to its representation in palynological diagrams is common at Neolithic sites, particularly in temperate Europe (Bakels 1992; Van der Sloot et al. 2003; Salavert et al. 2018). Several hypotheses – such as the poor flame resistance of *Tilia* wood, or its use for handcrafts or medicines – may explain what led to its abandonment for firewood and subsequent absence in charcoal assemblages (Salavert et al. 2018). Today, *Corylus* is one of the most dominant trees in the undergrowth of deciduous mixed forests in the Eastern European plain (Serebryanny 2003) therefore, the absence of *Corylus* in archaeological charcoal records could suggest its scarcity surrounding Melnycha-Krucha and Kamyane-Zavallia. Alternatively, it may not have been gathered for firewood by Late Mesolithic and first farmer populations. However, it is premature to generalize the absence of *Corylus* or the use of *Tilia* at both sites pending further charcoal analysis.

Carpinus was present but probably still not very abundant around Kamyane-Zavallia at the end of the 6th millennium. Mature *Carpinus* trees develop in shaded or semi-shaded conditions, and could have formed part of the forest undergrowth with the other minor taxa identified at Kamyane-Zavallia (cf. *Cornus*, *Prunus* and cf. *Sambucus*). *Carpinus* is recorded since the Early Holocene in the Black Sea region (Filipova-Marinova et al. 2013; Feurdean et al. 2015; Shumilovskikh et al. 2012; Messager et al. 2013). In eastern Ukraine, a few pollen grains of *Carpinus* were identified at the Kamyana Mohyla site before 4600 cal BC (Gobet et al. 2017). In the regional pollen record of Dovjok, *Carpinus* is frequently recorded with low values (Kremenetski 1995). This early occurence in the Black Sea region could be related to the short distance of refuge areas for *Carpinus*. The seedlings of *Carpinus* are light demanding and the tree could have benefitted from natural (or human made) open space like forest edges to spread in the Carpathian–Alpine region (Magyari 2002). Based on archaeological charcoal, it is impossible to infer on the tree cover during Mesolithic and Neolithic times.

<u>5-3 Late Mesolithic subsistences and LBK plant economy</u>

No evidence of the use of edible plants was recorded at Melnychna-Krucha, which may be due to the small size of the excavation, the sampling strategy and the type of site. Phytolith assemblages did not reveal the presence of cereal and rather reflect wild grasses living on the riverside than steppic grasses. Numerous fish remains and wild animal bones have been identified, on the site suggesting the exploitation of the local fresh-water environment and a diet oriented toward aquatic resources and game (Kiosak and Salavert 2018). Thus, the Late Mesolithic layers of Melnychna-Krucha record a broad-spectrum of local resource acquisition, terrestrial and aquatic, near the Bug River.

At Kamyane-Zavallia, *Triticum* cf. *dicoccum*, *T.* cf. *monococcum* and weeds are typical of the LBK crop package (Kreuz 2007; Bakels 2009; Salavert 2011, Motuzaite Matuzevičiūtė and Telizhenko 2017). Regarding cf. *Hordeum*, this cereal is sometimes considered as a weed in Central and Western temperate Europe because of its rarity on LBK sites in this area (Kreuz 2008; Salavert 2011). Ratniv-2, occupied slightly earlier then Kamyane-Zavallia, provided one seed of *Hordeum vulgare* (Motuzaite Matuzevičiūtė and Telizhenko 2017). The further development of archaeobotanical analyses in eastern LBK sites will assess whether the presence of *Hordeum* could be considered as a crop. This would be an originality, compared to the rest of the LBK territory.

Furthermore, the significant contribution of elongate dendritic phytoliths in the pit infill is a good signal of cereal processing (Berlin et al., 2003; Portillo and Albert, 2011). Among the potential cereal processes, dehusking or winnowing are more likely because the remains of threshing processes (silica skeleton) are almost absent. These activities could have taken place in the village, maybe at a household level. No charred chaff remains were identified in the elongate pit at Kamyane-Zavallia, whereas several chaff fragments (glumes of hulled wheat) were present at Ratniv-2 (Motuzaite Matuzevičiūtė and Telizhenko 2017). On this latter site, archaeobotanical samples came from a fireplace in a pit house that may correspond to single-activity refuse (Kreuz 1990), enabling better preservation of the fragile chaff elements than in the detritic context at Kamyane-Zavallia. Among the weed macroremains identified at Kamyane-Zavallia, *Chenopodium album* type and *Fallopia convolvus* can both grow in cereal plots and field edges. *Chenopodium album* is common in summer- and winter-sown fields in temperate areas and can also be used for human consumption (Golea 2016; Mueller-Bieniek et al. 2018).

6. Conclusion

The composition of tree vegetation, or wood acquisition strategies, was quite similar at Melnychna-Krucha and Kamyane-Zavallia. Late Mesolithic groups and LBK farmers mainly exploited *Fraxinus* and *Quercus* for firewood. The Late Mesolithic populations seemed to settle in a forest-steppe environment close to forested areas – to hunt game and collect firewood – and areas rich in aquatic resources. At the LBK site, the development of edge shrubs as a result of anthropogenic impacts from the activities of contemporaneous or previous human groups (*i.e.* Bug-Dniester) will have to be verified by further charcoal analyses in the future. The discovery of a grinding stone in the pit of Kamyane-Zavallia, together with cultivated plants and cereal processing evidence, reinforces the strong agrarian economy of the LBK inhabitants in the eastern margins of the LBK cultural extension. These first multi-proxy analyses of a Late Mesolithic occupation and LBK site located in Southern Bug River gives the potential of botanical macroremains and phytoliths studies to characterize the local environment and use of plant resources. Location and cultural dynamics make the south-west

Ukraine a key area to better understand the development of human societies of the 7th and 6th millennium in Eastern Europe.

Acknowledgements: fieldwork (2014) was supported by the project « Interactions et dynamiques des sociétés et des environnements à la transition Mésolithique-Néolithique dans les steppes du sud-ouest de l'Ukraine » (coord. A. Salavert, program ATM DS-E MNHN). We would like to thank the anonymous reviewers for their meaningful advice.

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Table 1**:** Radiocarbon dates from Melnychna-Krucha SU3 (MK, Late Mesolithic) and Kamyane-Zavallia (KZ, LBK).

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