The earliest appearance of domesticated plant species and their origins on the western fringes of the Eurasian Steppe

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ABSTRACT – *This paper presents the results of the first archaeobotanical investigation of Neolithic-Chalcolitich-period sites in eastern Ukraine and southwest Russia. The goal of this research is to understand the timeline of the earliest appearance and possible geographical origins of domesticated plants species in the region of study. The research conducted consists of the retrieval and study of macrobotanical remains and the analysis of plant impressions in pottery. Three possible corridors of influence upon agriculture in eastern Ukraine are postulated in this paper, originating from the Balkans, the Caucasus, and the Eurasian steppe.*

IZVLEČEK – *Članek predstavlja rezultate prve arheobotanične raziskave neolitskih in eneolitskih najdišč v vzhodni Ukrajini in jugozahodni Rusiji. Namen raziskave je razumeti časovnico pojavljanja prvih domesticiranih rastlin in njihov geografski izvor. Raziskava temelji na pridobivanju in analizi makrobotaničnih ostankov ter analizi odtisov rastlin v lončenini. V članku predstavljamo tri možne koridorje, po katerih so lahko prihajali vplivi zgodnjega poljedelstva, in sicer iz področja Balkana, Kavkaza in Evrazijske stepe.*

KEY WORDS – *Eurasian Steppe; domesticated plants; archaeobotany; Ukraine; Neolithic; Chalcolithic*

Introduction

Archaeological research into cereal cultivation during the Neolithic-Chalcolithic periods in Ukraine to date has been concentrated on the western regions of the country, especially investigations into the Cucuteni-Tripolye Culture. In contrast, the study of archaeobotanical remains in eastern Ukraine has been limited. The theory most often postulated for the earliest appearance and spread of cereal cultivation in western Ukraine states that this phenomenon is connected with the west to east movement of the Linearbandkeramik Culture (hereafter LBK) peoples and Tripolye farmer expansions during the second half of the 6th–5th millennia calBC (*e.g.*, *Chernysh 1962; Zvelebil 1989; Zvelebil, Dolukhanov 1991; Anthony 1995; Zvelebil, Lillie 2000; Dolukhanov, Shilik 2007; Dolukhanov 2008*). It has been suggested that agricultural expansion into the central territories of Ukraine was undertaken by farmer groups from the Cucuteni-Tripolye Culture, who followed the forest-steppe belt to the Dnieper River no earlier than the first half of the 5th millennium calBC (*cf. Dolukhanov 1986; Anthony 1994; Whittle 1996; Sanzharov* et al. *2000; Zvelebil, Lillie 2000; Pashkevich 2003; Telegin* et al. *2003; Davison* et al. *2006*). According to Telegin (*1968*), the contacts between the Dnieper-Donets forager cultures and the Tripolye farmer populations are marked by the appearance of Tripolye pottery imports, the occurrence of cereal impressions in pottery, and some domesticated animal remains (*Telegin 1968*). The further eastward spread of cereal cultivation to the other half of Ukraine (eastwards from the Dnieper River) as well as to the south-east did not occur until the 4500–3000 BP (*e.g.*, *Velichko* et al. *2009.7*).

Some researchers, however, have envisaged crop cultivation and the formation of domestic animal husbandries in Ukraine arriving from the opposite

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direction – the Caucaso-Caspian corridor (*Shnirelman 1989; 1992; Jacobs 1993; 1994; Kotova 2003; Levkovskaya* et al. *2003; Kotova, Makhortykh 2009*). Based on human dental studies from the Dnieper Rapids, Ukraine Jacobs (*1993; 1994*) for example, suggested the possibility of an independent and pre-Danubian route of cereal cultivation in central Ukraine, arriving via the corridor between the Black and Caspian Seas. Some Ukrainian archaeologists, such as Nadezdha Kotova, have envisaged a very early Neolithic agriculture in south-eastern Ukraine (starting from end of the 7th millennium calBC) (*Kotova 2003*). Kotova based her arguments on Pottery Neolithic sites in the northern Azov Sea region and Lower Don River, where domesticated animal bones, reaping knives, pestles, horn mattocks, grinding stones and cereal pollen have been reported (*Belanovskaya 1995*). The available pollen evidence includes '20 large grass pollen grains', presumed to be of cereal type, from the Neolithic level (attributed to 6350 calBC) at the Matveev Kurgan–I site on the northwest coast of the Azov Sea (*Krizhevskaya 1992*). Kotova and Tuboltsev (*1992*) reported the presence of domestic sheep at the Semenovka site (beginning of the 6th millennium calBC) located on the northern coast of the Sea of Azov. However, no macrobotanical work has been done in this region. To date, only one hulled barley impression in pottery from eastern Ukraine has been reported from the Serebryanskoe site located on the Donets River (*Pashkevich 2003*). A pottery shard with mollusc temper from the archaeological layer was radiocarbon dated to the 5th millennium calBC (*Sanzharov* et al. *2000*). However, it is not clear if the pottery with cereal impressions can be attributed to the dated layer. This is the only macrobotanical evidence from the Neolithic of eastern Ukraine and southwestern Russia available to date.

An alternative Eurasian steppe belt route for early agricultural dispersal was suggested by Jones (*2004*), proposing the arrival of the broomcorn millet crop (*Panicum miliaceum*) in Neolithic Ukraine from the Eurasian steppe. Broomcorn millet has been identified at several Neolithic sites which lie far to the north from the standard Anatolian east-west crop movement range (*Jones 2004*). Broomcorn millet is not known to have been cultivated in the Fertile Crescent prior to the 1st millennium calBC (*Nesbitt, Summers 1988*). Therefore, the geographical origin of broomcorn millet may thus be presumed to lie elsewhere. The earliest known carbonised broomcorn millet remains are from central China, dated to around 8000 years calBC (*Lu et* al. *2009*). Later dates show broomcorn millet cultivation at the end of the 7th/first half of the 6th millennia calBC in northern China (*Cohen 2002; Zhao 2005; Crawford 2006; Liu* et al. *2012*). Fuller (*2006*) claims that China is without a doubt the place where millet was domesticated. So far, the earliest broomcorn millet record from the territory between China and the Urals is relatively late, coming from the Chalcolithic Sokolniki site (3200–2500 calBC) in the southern Tumen region in western Siberia (*Shnirelman 1992*). However, not much known about the nature of the find.

The broomcorn millet crop has been reported from Neolithic cultural sites in various parts of Europe, including the LBK, Vinča, Körös, Criş, Bug-Dniestr, Volyn, Kiev-Cherkasy, Donetsk, Proto Sesklo/Sesklo, and Tripolye cultures (*Hopf 1962; Kroll 1981; Comşa 1996; Larina 1999; Pashkevich 2003; Kreuz* et al. *2005; Greenfield, Jongsma 2008; Hunt* et al. *2008*). Moving from east to west along the Asian steppe corridor, broomcorn millet was probably the first crop to cross Ukrainian territory. However, during the period under consideration (pre-5000 calBC), macro-remains of broomcorn millet in Europe from Neolithic sites are very rare and rather uncertain in nature (*Hunt* et al. *2008*).

In order to understand the earliest appearance of domesticated crops in eastern Ukraine and to test the existing theories of their origins, the author conducted archaeobotanical investigations of both cereal impressions in pottery and macrobotanical remains recovered from Neolithic-Chalcolithic period sites in eastern Ukraine and south-western Russia.

Background information about the sites under investigation

Archaeobotanical investigations were conducted at 5 principle sites. Analyses of macro-plant remains were conducted at three of the five sites: Starobelsk–I, Novoselovka–III and Razdorskoe–II. The two additional sites of Rakushechny Yar and Zanovskaya were analyzed using pottery impressions only. To augment the study, an analysis of pottery for cereal impressions was conducted using samples from 12 additional secondary sites. All primary and secondary sites are located in the Don and Donets River basins in southwest Russia and east Ukraine (Fig. 1).

Razdorskoe–II site

The Razdorskoe–II site is a well-known multi-stratified site in the steppe region of southwest Russia

(47°32'12.71 N; 40°38'49.28" E). The site is situated on the right bank of the Don River on a 4–8m high terrace, a few kilometres downstream from the Razdorskoe–I and Rakushechny Yar settlements. The cultural layers of the Razdorskoe–II site are overlain by sterile layers of aeolian, colluvial and alluvial sediments 1m in depth. These sediments sealed the archaeological horizon, creating an anoxic calcareous environment which allowed for good preservation of bone material. The stratigraphy of the site consists of 12 cultural horizons. The anthropogenic horizons consist of thick accumulations of molluscs (mostly *Unio* and *Viviparus* spp.), animal bones and lithics. Black lenses in the stratigraphy consist of the charcoal and ash by-products of burning. Between the anthropogenic horizons, sterile layers of peaty humus, aeolian and alluvial silt are present (*Tsybrii 2008*). Nine radiocarbon dates from the early Neolithic layers of the Razdorskoe–II site have been reported (*Aleksandrovsky* et al. *2009*) (Tab. 1). A total of 144 litres of sediments were collected for flotation from two hearths and a mollusc midden at depths of 195–205cm and 200–210cm dated to the early Neolithic period.

Rakushechny Yar site

Rakushechnyi Yar is one of the best-known archaeological monuments in southwest Russia from the Neolithic period, giving the name to the Rakushechny Yar culture (*Belanovskaya 1995*). The Rakushechy Yar settlement is located in the Rostov region, approximately 100km upstream from the present-day city of Rostov (*Aleksandrovsky* et al. *2009*) in the steppe zone of southwest Russia (47°33' N; E 40°40'). The site is situated on an island in the River Don, almost opposite the Razdorskoe–I site and a few kilometres downstream from the Razdorskoe–II site.

23 cultural layers have been identified at the Rakushechnyi Yar site (*Belanovskaya 1995*), consisting of mollusc middens, ash, charcoal, and peaty deposits with alluvial sand clusters, all of which are distributed through a 6m thick stratigraphy (*Aleksandrovsky* et al. *2009*). Tatyana Belanovskaya (*1995*) reports the presence of soil digging tools and grinding stones found in layers 3–5, and 7. Domestic sheep bones have been reported from the 21st layer onwards, while the presence of domestic cattle has been reported from layer 20 onwards (*Belanovskaya 1995*). Pollen analysis of the site has not identified any pollen attributed to domesticated grasses, allowing Belanovskaya (*1995.152*) to state that "*there is not enough evidence to suggest the presence of cereal cultivation by the inhabitants of the site*".

Layers 23–5 belong to the Neolithic period, with pottery making technology appearing already in the 23rd layer; layers 4–2 are attributed to the Chalcolithic and the top layer belongs to the Bronze Age (*Belanovskaya 1995*). Layer 20, the lowest dated Early Neolithic layer, contains three radiocarbon dates (Tab. 1) (*Timofeev* et al. *2004*). Layers 15–14 indicate the start of the Middle Neolithic period (*Tsybrii 2008; Timofeev* et al. *2004; Telegin* et al. *2003*). Layer 5, the top Late Neolithic layer, has three ^{14}C dates (*Belanovskaya 1995.28; Timofeev* et al. *2004; Aleksandrovsky* et al. *2009*). It can be noted that Dmitry Telegin *et al.* (*2003*) attributed layer 4

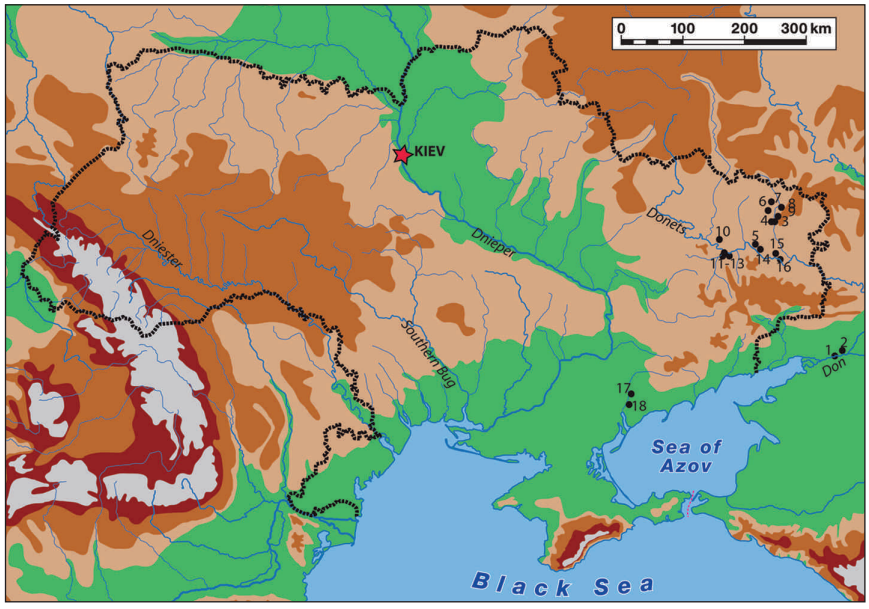

Fig. 1. A map of Ukraine and sites discussed in the text. See legend. 1 Razdorskoe–I; 2 Rakushechny Yar; 3 Starobelsk–I; 4 Novoselovka–III; 5 Zanovskoe; 6 Podgorovka–I; 7 Podgorovka–V; 8 Starobelsk–II; 9 Starobelsk–III; 10 Kleshnya–II; 11 Zelena-Gornitsya–I; 12 Zelena-Gornitsya-V; 13 Zelena-Gornitsya–IV; 14 Tuba–II; 15 Olkhovaya–V; 16 Orekho-Donetskoe–III; 17 Kamenaya Mogila; 18 Semenovka.

Site's name	Dated material	Laboratory number	^{14}C age bp	95.4% ^{14}C age calBC at 2 s.d.	References
Razdorskoe–II	Charcoal	Le–6873	7640±120	6770–6232	*Tsybrii 2008.92*
	Charcoal	Le–6950	7450±100	6467–6087	*Timofeev et al. 2004.77*
	Animal bones	Le–6952	7930±50	7035–6661	
	Charcoal	Ki–15178	8210±80	7460–7059	
	Molluscs from pottery	Ua–37000	8145±110 (AMS)	7480–6776	*Aleksandrovsky et at. 2009.97*
	Charcoal	Le–8428b	8130±100	7454–6775	
	Charcoal	Le–8428a	7920±110	7980–6507	
	Charcoal	Ki–15179	7840±80	7029–6503	
	Charcoal	Ki–15777	7490±60	6637–6446	
Rakushechny Yar site					
Layer 2	Sediments with charcoals	Le–5327	5290±260	4716–3536	*Tsybrii 2008.91*
	Charcoal	Le–5343	6300±300	5787–4546	*Timofeev et al. 2004.76*
	Charcoal	Le–5387	4830±90	3797–3372	
Layer 3	Charcoal	Bln–704	4360±100	3357–2702	*Timofeev et al. 2004.75*
Layer 4	Animal bone	Le–5340	5060±230	4361–3365	*Timofeev et al. 2004.76*
		Ki–3545	5150±70	4227–3774	*Telegin et al. 2003.460*
		Le–5482	6300±90	5471–5056	*Tsybrii 2008.91*
		Ki–15190	7020±80	6026–5736	
Layer 5	Molluscs	Ki–955	5890±105	5020–4501	*Timofeev et al. 2004.76*
		Le–5582a	6440± 35	5479–5341	*Tsybrii 2008.91*
		Le–5582b	6320± 40	5461–5214	*Telegin et al. 2003.460*
Layer 8	Charcoal	Bln–704	6070±100	5286–4727	*Tsybrii 2008.91*
Layer 9	Turtle bone	Le–5344	7180±250	6564–5622	*Manko 2003.15*
Layer 10–11	Pottery	Ki–11091	6955±160	6206–5563	*Manko 2003.16*
		Ki–11096	6810±140	5983–5490	
Layer 11	Pottery	Ki–11095	6850±160	6022–5486	*Timofeev et al. 2004.76*
Layer 12	Pottery	Ki–11090	7090±110	6211–5741	*Manko 2003.16*
		Ki–15189	7580±90	6598–6244	
Layer 13	Pottery	Ki–11093	7205±150	6395–5789	*Aleksandrovsky et at. 2009.97;*
		Ki–11094	7130±150	6355–5721	*Manko 2003.16*
		Ki–15186	7690±90	6748–6382	
		Ki–15187	6750±110	5876–5482	
		Ki–15188	6760±90	5841–5514	
Layer 14–15	Burned organic material on the internal walls of pottery vessel	Ki–6479	6925±110	6006–5636	*Timofeev et al. 2004.76; Telegin et al. 2003.460*
Layer 15	Burned organic material	Ki–6478	6930±100	5999–5646	*Timofeev et al. 2004.76;*
	on the internal walls	Ki–6480	7040±100	6085–5720	*Telegin et al. 2003.460;*
	of pottery vessel				*Aleksandrovsky et at. 2009.97*
Layer 20	Burned organic material	Ki–6475	7690±110	6901–6260	*Timofeev et al. 2004.76*
	on the internal walls	Ki–6477	7860±130	7062–6466	
	of pottery vessel	Ki–6476	7930±140	7246–6472	
Starobelsk–I	Pottery shards	Ki–9437	6800±120	5976–5512	*Manko, Telizhenko 2002.3*
	with mollusc temper	Ki–9438	6570±120	5712–5318	
		Ki–8290	6700±200	6014–5234	
	Wood charcoal	Ki–15034	6810±100	5967–5541	primary date
Novoselovka I&II	Pottery shards	Ki–9241	5970± 180	5300–4464	*Manko, Telizhenko 2002.4*
		Ki–9242	5830± 190	5304–4464	
		Ki–9243	6120± 150	5464–4707	
		Ki–9244	6055± 160	5342–4584	
Zanovskoe	Animal bones	Ki–8257	5460± 90	4462–4050	
		Ki–8258	5420± 80	4446–4046	
		Ki–9245	4910±80	3943–3525	*Manko, Telizhenko 2002.4*
Zelena Gornitsya–I	Pottery	Ki–9436	6700±130	5882–5380	*Manko 2003.15*
Zelena Gornitsya–V	Pottery	Ki–9435	6510 ±120	5661–5225	*Manko 2003.15*
Zelena Gornitsya–VI	Pottery	Ki–9434	6455 ±120	5639–5082	*Manko 2003.15*
Podgorovka–I	Pottery	Ki–9439	6050±90	5214–4729	*Manko, Telizhenko 2002.4*
Tuba–II	Bone	Ki–8253	6220±90	5459–4938	*Manko, Telizhenko 2002.4*
	Bone	Ki–8254	6270±90	5468–5011	
	Bone	Ki–8255	6095±90	5293–4792	
	Bone	Ki–8259	6360±90	5488–5073	
	Bone	Ki–8260	6070±90	5221–4746	
	Bone	Ki–8262	6215±80	5354–4958	
	Pottery	Ki–10389	6260±150	5508–4842	
	Slag	Ki–10388	6170±180	5482–4707	
	Slag	Ki–10390	6290±180	5612–4809	

Tab. 1. The collation of ^{14}C dates from the sites mentioned in the text. All radiocarbon dates were calibrated using the calibration program OxCal 4.1.5, at 95.4 % after (*Bronk Ramsey 2009; Reimer *et al.* 2009*).

to the Late Neolithic period, while most researchers tend to follow Belanoskaya's classification, which attributes this layer to the Chalcolithic. Layer 4 has four radiocarbon dates (*Aleksandrovsky* et al. *2009; Tsybrii 2008; Manko 2006; Telegin* et al. *2003*) (Tab. 1). Of the four dates from the upper Chalcolithic layers No. 2 and No. 3, most fall within the 5th–4th millennia calBC (Tab. 1).

The author conducted an archaeobotanical investigation of the site by analysing pottery for cereal impressions. In total, over 1000 pottery shards were analysed from the Rakushechny Yar site from layers 23–13 and 5–2.

Starobelsk–I site

The Starobelsk–I site is located in the steppe zone of the easternmost region of Ukraine, on the western edge of Starobelsk city (N 49°17'52.3, E 38°50'58.6). The site is situated on the left bank of the Aidar River, about 70–80m from the riverbank. Across the river from the Starobelsk–I settlement lies a steep chalk cliff. The Starobelsk–I site is located about 7km south of the Novoselovka–III site. The main part of the Starobelsk–I site is situated on a small elevation of the second Aidar River terrace, which consists of a narrow strip of raised land overgrown by trees. Part of the Starobelsk–I settlement is situated in an intensively ploughed area; therefore, the cultural layer at the site varies significantly in depth. The stratigraphy of the settlement consists of four clearly distinguishable lithological horizons. Parts of the cultural layer were constituted by anthropogenic mollusc clusters, consisting of *Unio* sp. and *Viviparus* sp. All the mollusc clusters were accumulated on the edge of the settlement, on the fringe of the third horizon.

The Starobelsk–I site contains one of the earliest examples of pottery in eastern Ukraine (*Manko 2003*). It has also been reported that the site contains domestic animal bones belonging to cattle, pig, dog, horse and sheep/goat (*Gurin 1998*). Judging from lithics, Gurin also inferred that the inhabitants of Starobelsk–I settlement used sickles for harvesting and processing domesticated cereals.

The excavation of the Starobelsk–I site was conducted in the summer of 2007 by the author and Sergiy Telizhenko, during which 50m^2 were investigated and 1704 litres of sediments from 12 fireplaces floated for the purpose of archaeobotanical investigation.

The chronology of the Starobelsk–I site was previously established through ^{14}C dating of pottery with a mollusc temper (*Manko, Telizhenko 2002*). One conventional and two AMS radiocarbon dates received from the site attributed it to the beginning of the 6th millennium calBC (Tab. 2). The AMS radiocarbon dates were conducted on a tree-branch charcoal and a *Sus scrofa* bone, which were found in the fireplace together with fragments of the one of the oldest potteries in Ukraine (Tab. 2).

Novoselovka–III site

The Novoselovka site is located about 6km south of the Starobelsk settlement on the second terrace of the River Aidar (N 49°17'09.79; E 38°49'41.69). The site is situated in an open field, which is presently ploughed and irrigated, within a large loop of the Aidar; a few kilometres to the west and northwest, steep chalk cliffs surround the site valley. The total area of the settlement is not known. However, mollusc clusters ('mollusc middens' or 'kitchen middens'), representing a disturbed cultural layer, are distributed throughout the field over a few hectares. During the period of site's occupation, the entire territory was an island in the Aidar (*Gurin 1998*). The recovered bone remains and pottery at Novoselovka–III were mostly concentrated within the mollusc midden horizon, indicating that the basic environment (high pH) created by the mollusc remains allowed for the preservation of some artefacts.

The Late Neolithic period of the second half of the 6th millennium calBC at the Novoselovka–III site was determined from one AMS radiocarbon date. During

Site's name	Dated material	Laboratory number	δ^{13}C	^{14}C age bp	95.4% ^{14}C age calBC at 2 s.d.
Starobelsk STAR–3B	Bos Taurus	OxA–22278	–20.40	6950±39	5971–5736
Starobelsk STAR–3C	Wood charcoal	OxA–22279	–24.36	6954±35	5970–5740
Starobelsk	Wood charcoal	Ki–15034	–	6810±100	5967–5541
Novoselovka–III NOV–7B	*Sus scrofa*	OxA–22281	–18.13	6297±34	5342–5213
Semenovka	*Ovis aries/Saiga tatarica*	BA–071462	–	6595±40	5617–5482

Tab. 2. AMS ^{14}C radiocarbon dates from the Starobelsk, Novoselovka and Semenovka sites.

the summer of 2008, 1060 litres of sediments were floated for the purposes of archaeobotanical sample collection.

Zanovskoe site

The Zanovskoe site is situated in the steppe zone of eastern Ukraine in the Lugansk district, near the village of Orovskoe (or Barovskoe) (48°48'28.77" N – 38°37'27.78" E). The Zanovskoe site is situated on a periodically inundated flood plain on the left bank of the Donets, and surrounded by two oxbow lakes, Zanovskoe and Matkino. Excavations revealed Chalcolithic pottery shards and flint tools (*Telizhenko, Motuzaite Matuzeviciute 2007*), and a range of domesticated animal species, including cattle, sheep, goat, pigs, horses and dogs (*Zhuravlov, Telizhenko 2008*). The site is chronologically younger than the Starobelsk–I and Novoselovka–III sites. Three existing ^{14}C dates from the Zanovskoe site were received from the Kiev Radiocarbon Laboratory from animal bones and pottery (Tab. 1) (*Manko, Telizhenko 2002; Manko 2006*). The dates attribute this site to the Chalcolithic period Sredny-Stog culture, dated by Telegin *et al.* (*2003*) to 4400–3500 calBC. No flotation was conducted from the Chalcolithic period layers; only pottery shards were analysed for cereal impressions.

Methods

Samples of macrobotanical remains were collected from a variety of archaeological features and phases encountered at the archaeological sites: fireplaces, pits, house floors, and waste dump places such as mollusc middens. The collection of sediment samples and the procedure for manual flotation followed the descriptions in Deborah Pearsall (*2000*). Soil samples from each archaeological feature were collected in bags, according to the stratigraphy within each feature. The quantity of sediments taken for each sample and from each feature was then recorded. A standard 12l size bucket was used in order to keep track of the sample volume taken from the feature. Water for flotation was obtained from whatever nearby water source was available, such as oxbow lakes, rivers and springs. A 300μm mesh size was used for flotation to ensure the full recovery of plant seeds. Once the botanical material was retrieved from the sediment, each mesh containing the float was collected, labelled, and dried in a location away from direct sunlight. The sorting and identification of archaeobotanical material took place at the University of Cambridge in the George Pitt-Rivers Laboratory for Bioarchaeology. Each flotation sample was sorted individually by selecting, counting and identifying all charred seeds within the sample.

The procedure used for initial analysis of cereal impressions in pottery from shard collections involved a careful visual review of each pottery shard from both sides, specifically concentrating on evaluations of the pottery's clay temper and noting any full or partial plant part or seed/grain impression through the use of a magnifying glass.

The criteria applied for the identification of plant impressions are as follows. For a satisfactory identification to species, a cereal impression had to contain not only a distinctly impressed seed or grain shape, but also other features such as an impression of the lemma/palea pattern, grain/scutellum, or the ventral furrow with hilum. Usually, cereal impressions were identified to species if chaff components were found; chaff characteristics can be more species-specific than grain impressions, especially the glume bases of *Triticum spelta* or spikelets or rachis segments of *Hordeum vulgare*, *etc*. Cereal impressions found to fit the identification criteria to genus or species levels were usually recorded as *cf*. Plant impressions that did not fully fit the identification criteria were not recorded at all. Access to pottery shard collections was obtained at the Lugansk History Museum in Ukraine and at the State Hermitage Museum of Saint Petersburg, Russia.

AMS ^{14}C dates were provided by Malcolm Lillie (Hull University, UK) via a NERC ORADS grant at the Oxford Radiocarbon Accelerator Unit (OxA) and by Zhou Li-Ping from the Accelerator Mass Spectrometer Unit in Peking University, Beijing. Conventional radiocarbon dates were received from the Kiev Radiocarbon Laboratory (Ukraine). All radiocarbon dates were calibrated using the calibration program OxCal 4.1.5, at 95.4% after (*Bronk Ramsey 2009; Reimer* et al. *2009*)

Archaeobotanical results

Razdorskoe–II site

The flotation samples contained a large quantity of charcoals and constituted mostly of woody plant species. As can be seen in Table 3, the samples contained a very low quantity of charred plant seeds. Only fractions of *Chenopodium* cf. *album* (fat-hen), *Hedera helix* (common ivy), *Persicaria* sp. (knotweeds), *Thlaspi* cf. *arvense* (field penny-cress) plants and one un-identified seed were found in samples

1 and 12, from fireplace No. 1 at a depth of 195–205cm.

Some small pieces of charred starchy parenchyma were also found in samples 2, 3, 7, 8, 9, 12, and a few culm-nodes of grass stems were identified in samples 8, 10, 12 from fireplaces No. 1 and No. 2. The rest of the charcoals originated from tree trunks and branches.

The flotation samples also contained a large amount of charred and un-charred bone remains, consisting of mostly fish and various microfauna. The amounts of fish scales, bones, teeth and vertebra parts were sometimes more numerous than the wood charcoal, such as in fireplace No. 1, sample No. 9. The preservation of charcoals at the site is quite good and the very low incidence of plant seeds cannot be explained only by the site's taphonomic processes; rather, this is an indicator of the population's passive plant gathering and activities directed towards the exploitation of fresh water resources.

Rakushechny Yar site

Pottery samples from the Rakushechny Yar site were analysed for cereal impressions at the Hermitage State Museum in Saint Petersburg, Russia. Over 1000 pieces of pottery from settlement layers 2–5 and 13–22 were analysed (Tab. 4). The analysis of pottery from the stratigraphic sequence revealed not only changes in pottery-making technology over time – including change in vessel styles, clay temper and the complexity of ornamentation – but also revealed the first evidence of cultivated cereals in the region.

Starting from the uppermost layers, layer No. 2 contains clay vessels with a mollusc, grass and cereal chaff temper. Only the pottery shards with a cereal chaff and crushed mollusc temper contained glume impressions of mostly *Triticum* spp., (wheat) crops. One shard containing a seed impression probably attributable to cf. *Linum usitatissimum* (flax) (4.8mm long and 2.2mm wide)

Sample number		<1>	<2>	<3>	<4>	<5>	<6>	<7>	<8>	<9>	<10>	<11>	<12>
Feature		1	1	1	1	1	1	2	3	1	2	1	1
Feature type		hearth	hearth	hearth	hearth	hearth	hearth	hearth	mollusc midden	hearth	hearth	hearth	hearth
Contex/squire		V-1	V-3	V-1	V-1	V-1	V-2	B-1	A-2	V-3	B-1	V-1	V-1
Depth (cm)		195-205	195-205	200-210	195-205	200-210	195-205	195-205	195-205	195-205	200-210	195-205	195-205
Chenopodium cf. *album*	Fat-hen												1
Hedera helix	Common Ivy	1											
Persicaria sp.	Knotweeds												1
Thlaspi cf. *arvense*	Field Penny-cress												1
Un-identified seeds													1
Parenchyma			2	3				1	1	1			9
Grass stems		+	+					++	+		+		+
Charcoal >4mm		++	++	++++	++++	++	++	++++	++	+++	+++	+	++
<4mm		+++	++	++++	++	+	++	++++	++	+++	+++	+	+++
Fish remains (bones, scales)		++		+++	+	++	+	++	++	+++	+	+	++
Micro fauna		+++		++	+	++		++	++	++		+	++
Molluscs		+	+	+	+	+		+	+	+	+		+
Beadles				+	+			+					+

Tab. 3. Plant macro-remains and micro-faunal remains from the Razdorskoe-II settlement, southwest Russia, collected February 2007 using a 300 µm sieve. Each sample constitutes 12 litres of sediment. Key: + <10 items; ++<20 items; +++ <100 items; >1000 items +++.

(Fig. 2) was found in the pottery with a mollusc temper. In the same shard, the charred glume base of *Triticum spelta* (spelt wheat) (7.5mm long and 3.7mm wide) was found preserved in the inner wall. This impression contains clear characteristics of spelt wheat glume dorsal veins (Fig. 2).

Fig. 2. Flax seed (*cf. Linum usitatissimum*) impression (left) and spelt wheat (*Triticum spelta*) glume base impression (right) in Rakushechny Yar pottery from layer No. 2.

Finally, impressions of what appeared to be *Vicia* sp. genus were noted. However, the impressions were not very clear, and therefore kernel components such as hilum or radicle were difficult to identify with confidence. The second layer has three radiocarbon dates ranging over the period 5787–3372 calBC (*Timofeev* et al. *2004*). As can be seen, the date range of layer 2 is very broad. Such a broad time range from the same archaeological horizon might be the result of dating bioturbated material (thereby including material from the upper layers), dating charcoal, the dates from which may be biased by the 'old wood effect'. Surely, such a wide date range is too wide to gain the most accurate insight into the introduction of agriculture in the region. Nevertheless, cereal impressions in pottery and the radiocarbon dates presented above are so far the only information available to the author.

In layer No 3, both heavy, thick-walled vessels with a mollusc-organic temper and porous, light vessels with a cereal chaff temper were found. The second type of pottery contained glume impressions of wheat (*Triticum* spp.) (Fig. 3). In this pottery, impressions of cereal parts and imprints of wild plants and seeds were noted. This cereal chaff temper-type of pottery from Rakushechny Yar is similar to that of the Tripolye culture, where cereal-processing waste was commonly used as a clay temper for pottery and daub production (*Pashkevich, Videiko 2006*). Pottery with a cereal chaff temper dated to the second half of the 5th millennium calBC was also found at the Zanovskoe site, where impressions of hulled and naked barley were detected (see below). One radiocarbon date exists from the 3rd layer of Rakushechny Yar, falling between 3357–2702 calBC (*Tsybrii 2005*); that this date is younger than the layer above shows the great need to re-date the stratigraphical sequence of the site.

In layer No. 4, cereal impressions were found in two types of pottery: a light and porous pottery with a chaff temper (as above), and pottery with a vegetative matter (grass) and sand-rich temper. Most of the cereal impressions were found in pottery shards with the cereal chaff temper. The vessels with the cereal chaff temper are very light and porous, containing fragments of cereal glumes which burned away during the vessel firing process, but had their shapes preserved within the pottery walls. In this

Cultural layer of Rakushechny Yar	Identified domestic cereal impressions
Layer 2	*Triticum* spp. (Wheat glumes), *cf. Linum usitatissimum* (Flax seed), *Triticum spelta* (The glume base of Spelt Wheat)
Layer 3	*Triticum* spp. (glumes)
Layer 4	*cf. Hordeum vulgare* (grain of Hulled Barley), *Triticum* spp. (Wheat chaff), *cf. Panicum miliaceum* (one seed of Broomcorn Millet), *Tritucum cf. aestivum* (one grain of probably naked wheat)
Layer 5	*Thalictrum cf. minus* (Lesser Meadow- rue)
Layer 13	No impression
Layer 14–15	No impression
Layer 15	No impression
Layer 20	Wild plant seed and stem
Layer 23	No impression

Tab. 4. Archaeobotanical analysis results from the Rakushechny Yar site, layers: 2–5, 13–20.

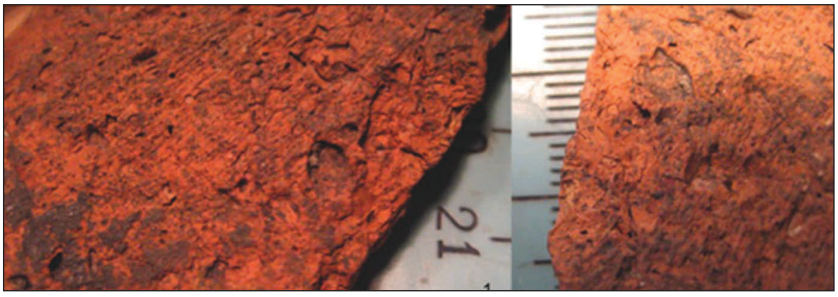

Fig. 3. Pottery shard with cereal chaff (*Triticum *spp.) temper from layer No. 4 of Rakushechny Yar.

type of pottery, the imprints of hulled barley (*cf. Hordeum vulgare*) (4.4mm long and 3.2mm breadth) (Fig. 4), *Triticum* spp. chaff and probably one broomcorn millet seed (*cf. Panicum miliaceum*) (2.8mm long, 1.9mm breadth) were identified. The broomcorn millet impression contained a seed with glumes and preserved parts of the charred grain. The distinct pattern of the lemma and palaea was still present on the pottery shards, which allowed the imprinting seed to be identified to the species level as broomcorn millet. Only one impression of wheat (*Tritucum cf. aestivum*) (3.8mm long and 2.48mm wide) was found in the pottery type with a mollusc and grass temper (Fig. 4). Four radiocarbon dates were obtained from layer No. 4, ranging from 6026–3365 calBC (*Aleksandrovsky* et al. *2009; Telegin* et al. *2003; Timofeev* et al. *2004*).

In layer No. 5, the pottery styles change to a type consisting of only heavy, thick-walled vessels with a grass, sand and mollusc temper. No shards with a cereal chaff temper were found in this layer. Wild plant seed impressions were found only from shards with the grass-rich clay temper. In this type of pottery, only one impression of a seed of *Thalictrum* cf. *minus* (lesser meadow rue) (4.6mm long and 2.4mm wide) was identified (Fig. 4). Layer 5 has three radiocarbon dates, ranging from 5479–4501 calBC (*Telegin* et al. *2003; Timofeev* et al. *2004*).

Pottery recovered from lower layers did not exhibit much contact with plants, and only a few impressions of wild plant parts and seeds were noted. Owning to the absence of a plant reference collection in the museum archives of Saint Petersburg, these plant species were not identified. Most pottery vessels in layers 8–20 were very robust and heavy, made of clay or river-marl, with a sand, river silt and mollusc temper, and fired at a low temperature. Most of the dates from these layers fall into the period of the 7th millennium calBC (*e.g.*, *Telegin* et al. *2003*).

Starobelsk–I site

The macrobotanical remains recovered from flotation samples consist of wood charcoal and land snails. The abundance of modern rootlets in the samples strongly correlates with the amount of modern contaminate seeds of *Chenopodium* sp. in the flotation samples. Both modern rootlets and *Chenopodium* sp. seeds were found in areas where the cultural layer was at its shallowest. Among the charred plant seeds discovered, only a few seeds of *Silene* sp. (campions) genus plants were identified in fireplace No. 5. Two seeds of *Galium aparine* (cleaver) were found in fireplace No. 10. In the same fireplace, one seed of *Stellaria* sp. (stitchwort) was identified (Tabs. 5–6). The small quantity of plant seeds found at the site limits any contribution to a wider discussion of human and plant interaction, or the past ecology at the site.

It is important to note a few taphonomic aspects of the Starobelsk site. Firstly, the fireplace structures were constructed directly on the ground surface, with no deepened fire-pit structure. Such a form of fireplace construction might indicate that the fires were burning in an oxygen-rich environment capable of turning any plant remains into ashes, and therefore leaving very little plant material remaining for later recovery. Furthermore, the high abundance of terrestrial molluscs, which is greater than the amount of charcoal found in the samples by many orders of magnitude, indicates that after abandonment, the fireplaces stood exposed on the ground

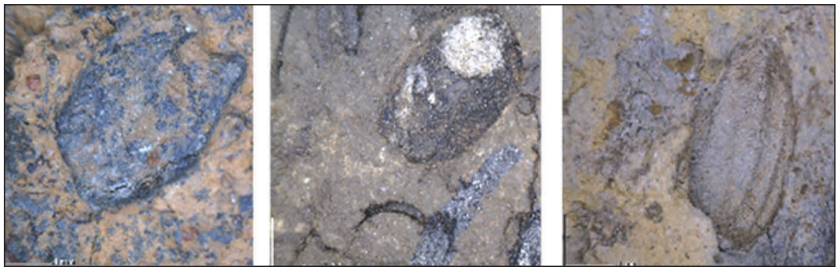

Fig. 4. Pottery shard impressions from Rakushechny Yar:* cf. Hordeum vulgare *grain (left) and* Triticum cf. aestivum *grain (middle) from layer No. 4;* Thalictrum cf. minus *seed from layer No. 5 (right).

surface for a long time, before being deposited by aeolian or alluvial sediments. Their long exposure prior to deposition could also have affected the preservation of charred plant remains at the site. Moreover, experimental work on charcoal preservation in alkaline environments has demonstrated both higher fractionation and degraded preservation quality of deposited material (*Braadbaart* et al. *2009*).

Novoselovka–III site

During the archaeological excavation of the Novoselovka–III site, a mollusc midden zone and one fireplace were used to obtain samples for archaeobotanical investigation. Most of the flotation samples taken for archaeobotanical data collection were from the mollusc midden feature, which was selectively sampled in places with a concentration of charcoal, burned bone and burned flint pieces. Additionally, the entire content of the fireplace was sampled. In total, 1060 litres of sediments were floated from Novoselovka–III. After sorting the archaeobotanical samples from all the floated sediments, a very small quantity of 16 charred plant seeds were recovered (Tab. 7).

The only plant species identified from the charred seeds were *Galium cf. aparine* (cleaver), *Galium* sp. (bedstraws) and *Chenopodium cf. hybridum/ficifolium* (maple/fig-leaved goosefoot), *Brassica* sp. (cabbage family) and *Juncus* sp. (rush family), *Echinochloa/Setaria* genus (cockspur/bristle-grasses), *Matricaria cf. chamomilla* (scented mayweed), *Stachys* sp. (woundworts), *Sambucus* sp. (elders), *Setaria cf. pumila* (yellow bristle-grass) (Tab. 7). Some plants of this genus are native to Europe (*Tutin* et al. *1996*) and grow in meadows, open fields, roadsides and as a weed (*Hanf 1983; Luneva 2011*).

Analysis of pottery impressions from Neolithic settlements in eastern Ukraine

15 Neolithic and Chalcolithic sites in Ukraine were analysed for the presence of cereal impressions in their pottery remains (see the site location map in Fig. 1). Some pottery shards were accessed at the Lugansk History Museum storage centre, while others were analysed during periods of archaeological excavation (Tab. 8). Pottery shards were investigated from the following sites: Orekhovo-Donetskoe–III, Starobelsk–I, II and III, Olkhovaya–V, Zelena-Gornitsya–I, V and IV, Kleshnya–II, Podgorovka–I and V, Novoselovka–I and III, Tuba–II and Zanovskoe. In total, approximately 4500 pottery shards were analysed.

Sample number	<1>	<2>	<3>	<6>	<7>	<8, 9, 10>	<11, 12, 13>	<14>	<15>	<4>	<5>	<16, 17>	<18>	<38>	<37>
Feature	1	1	1	1	1	1	1	1	1	2	3	4	4	12	10/11
Feature type	fireplace	fireplace	fireplace	fireplace	fireplace	fireplace	fireplace	fireplace	fireplace	fireplace	fireplace	fireplace	fireplace	fireplace	fireplace
Depth (cm)	45–50	45–50	50–55	45–50	50–55	50–55	55–60	34–45	35–45	65–80	65–80	55–60	60–70	70–80	65–70
Sample volume – litres	48	48	60	48	48	60	60	48	96	48	48	48	48	24	24
Date of sampling	09.07.'07	09.07.'07	09.07.'07	09.07.'07	10.07.'07	10.07.'07	11.07.'07	11.07.'07	12.07.'07	11.07.'07	11.07.'07	12.07.'07	12.07.'07	18.07.'07	19.07.'07
Chenopodium sp. (Goosefoots)	+++	+++	++	+++	++	++	++	+++	+++	+	+	++	++	++	++
Modern rootlets	+++	++	++	++	+++	+++	+++	+++	+++	++	++	++	++	+++	+++
Charcoal >4mm	+	+	++	++	++	+	+++	+	++	+++	++	++	+	+++	+++
2–4mm	+	+	++	++	+		+	+	++	+++	+	+++	+	+++	+++
<2mm	+		++	+	++	++	+	+	++	+++	+	+++	+	++	++
Bones of microfauna	+	+	+	+	+	+	++	++	+	++	+	+	+		
Molluscs: *Vallonia costata* and *V. pulchella*	++++	++++	+++	++++	++++	++++	++++	++++	++++	++++	++++	++++	++++	++++	++++

Tab. 5. Plant macro-remains from the Starobelsk-I site, eastern Ukraine. Sieve size – 300 µm. Key: + <10 items; ++<20 items; +++ <100 items; >1000 items +++.

Sample number	<19>	<20>	<25, 26>	<24>	<21>	<22>	<23>	<27>	<28>	<29>	<30>	<32>	<31>	<33>	<34>	<35, 36>
Feature	4	4	4	5	5	6	6	7	8	9	9	9	10	10	10	10
Feature type	fireplace	fireplace	fireplace	fireplace	fireplace	fireplace	fireplace	fireplace	fireplace	pit	pit	pit	pit	fireplace	fireplace	fireplace
Depth (cm)	65-70	65-70	65-70	35-40	35-40	80-85	80-85	45-55	65-70	67-70	67-70	67-70	60-65	65-70	65-70	70-80
Sample volume – litres	48	48	72	72	24	48	48	60	72	48	72	96	144	24	24	48
Date of sampling	12.07.'07	14.07.'07	14.07.'07	13.07.'07	13.07.'07	13.07.'07	13.07.'07	17.07.'07	17.07.'07	17.07.'07	18.12.07.'07	18.12.07.'07	18.12.07.'07	18.07.'07	18.07.'07	18.07.'07
Chenopodium sp. (Goosefoots)	++	++	++	+++	++			++	+			++				+
Galium aparine (Cleaver)													1			1
Parenchyma																2
Silene sp. (Campions)				2												
Stellaria sp. (Stitchworts)																1
Modern rootlets	++	++	++	++		++	++	+++	+++	+++	+++	+++	+++	++	++	++
Charcoal :4mm	+++	+++	+++	+		+++	+++		++	+++	+++	+++	++	+++	+++	+++
2 - 4mm	+++	+++	+++	+		+++	+++	+	++	+++	+++	+++	++	+++	+++	+++
;2mm	+++	+++	+++	++	++	+++	+++	+	++	+++	+++	+++	++	+++	+++	+++
Bones of microfauna	++	++	++	+		++	++	+	+	++	+++	+	+		++	++
Molluscs:	++++	++++	++++	++++	++++	++++	++++	++++	++++	++++	++++	++++	++++	++++	++++	++++
Vallonia costata and *V. pulchella*																

Tab. 6. Plant macro-remains from the Starobelsk-I site, eastern Ukraine. Sieve size – 300 µm. Key: + <10 items; ++<20 items; +++ <100 items; >1000 items +++.

Except for the Zanovskoe settlement (see below), none of the analysed pottery shards from the sites listed above contained any clearly defined cereal impressions. A few shards from the Novoselovka–I, Olkhovaya–V and Tuba–II sites had impressions of seeds, caryopses and plant parts which appeared similar to domestic cereal. However, none of those impressions could be attributed to a domestic cereal species with confidence. For example, some seed impressions from the organic-rich pottery recovered from Tuba–II were discerned, the shapes of which appeared to be similar to that of broomcorn millet seeds. These elongated seeds were impressed in small clusters together with their stems. The seed impressions in the Tuba–II pottery were not impressed to a full seed shape, and their contours were not distinct. With the absence of either clear seed shape impressions or lemmas and paleas surface patterns, such cereal impressions cannot be confidently identified.

The only pottery shards where cereal chaff and grain impressions were identified with confidence were found at the Zanovskoe site. At Zanovskoe, three main types of pots were found: a type light and rich in organic temper with a polished surface; a type rich in organics with a rough surface; and heavy clay pots with a mollusc and coarse sand temper. Cereal impressions were identified on a few pottery shards of the first pottery type with an organic temper. The pottery shards with cereal impressions were found in the Chalcolithic period pottery, at a 50–60cm depth. This layer has been dated to 4462–3525 calBC (*Manko, Telizhenko 2002*). More precise analysis of these shards under the microscope has shown that the pot clay contains a cereal chaff temper. The cereal impressions represent the glumes and palaea of naked barley and a grain of hulled barley (*Hordeum vulgare var. nudum* and *Hordeum vulgare*), as well as different parts of the cereal chaff, probably that of the *Triticum* genus (Fig. 5).

Discussion of archaeobotanical results from the lower Don and Donets river basins

Archaeobotanical investigation has been conducted on several 8–6th millennium calBC

Feature		<12>	<10>	<14:	<11>	<13>	<6>	<1>	<3>	<9>	<2>	<4+5>	<7>	<8>	<12>
Sample number		19+20	10+11+12	18	13	15+16+17	6+7	1	3	9	2	4+5	7	8	14
Feature type		Chalcolithic	Burned	Bronze Age	Mollusc	fireplace	Mollusc	Mollusc	Mollusc	Mollusc	Mollusc	Mollusc	Mollusc	Mollusc	Chalcolithic
		pit	wood	trench	midden		midden	midden	midden	midden	midden	midden	midden	midden	pit
			and broken												
			vessel												
Depth (cm)		50	35	40	40	35	35	45	50-60	60	35	40-50	60-70	25-35	35
Semple volume – litres		96	150	96	12	178	96	48	48	48	48	96	48	48	48
Sieve size (µm)		300	300	300	300	300	1000	300	300	300	300	300	300	300	300
Date of sampling		02.07.'08	30.06.'08	02.07.'08	01.07.'08	02.07.'08	24.06.'08	32.06.'08	22.06.'08	29.06.'08	23.06.'08	23.06.'08	28.06.'08	28.06.'08	01.07.'08
Brassica sp.	Cabbages												3		2
Chenopodium	Maple/Fig-leaved	1										1			
hybridum/ficifolium	Goosefoot														
Echinochloa/Setaria	Cockspurs/Bristle-		1												
	grasses														
Galium cf. *aparine*	Cleaver						2								
Galium sp.	Bedstraws					1			2						1
Juncus sp	.Rushes						1								
Matricaria cf. *recutita*	Scented Mayweed	1													
Unidentified seeds						2					1				
Modern rootlets		+++	+	+++	+++	+++	+++	+++	+++	+	+++				
Charcoal >4mm		+	+++	+++	+	+	+++	+++	++	+	+++		++	+++	
2–4mm		+	+++	+++	+	++	++	++	++	+	+++		+++	+++	
<2mm		+	+++	++	+	++	++	++	++	+	+++		+++	+++	
Animal bones		+		+	+	+	+	+	+		+		+ (fish)	++	
Molluscs															
Vallonia costata and		+++	++	+++	+	+++	+++	+++	+++	++	+++	+++	+++	+++	+++
V. pulchella															
Seed fragmentation		W	W			F	W/F		W/F		W	W			W
Non-charred plant seeds															
Carex sp.	Sedges				+	+	+	+							
Chenopodium	Goosefoots	+++	++	+++	+	+	+		+	+++					
Datura cf. *stramonium*	Thorn-apple									+					
Echinochloa crus-	Cockspur/Shama			+											
galli/collona	Millet														
Panicum miliacemum	Broomcorn Millet			+											
subsp. *ruderale*															
Sambucus sp.	Elders														+
Setaria cf. *pumila*	Yellow Bristle-	++	+	++											
	grass														
Stachys sp.	Woundworts	++	+	++											
Thlaspi arvense	Field Penny-cress												++		
Trifolium sp.	Clovers	++		++											

Tab. 7. Plant macro remains from the Novoselovka-III site, eastern Ukraine. Key: + <10 items; ++<20 items; +++ <100 items; >1000 items ++++; W-whole seed; F-fragment of seed.

sites situated in the Lower Don and Donets River basins. This investigation has not provided any evidence for cereal cultivation in this area during this particular period of prehistory. In addition, the archaeological or zooarchaeological evidence from these sites suggests that subsistence in this region was based on the exploitation of wild food resources, rather than food production.

At the Razdorskoe–II site, dated to the 8th-first half of the 7th millennia calBC, a large variety of wild animal species were identified (*Tsybrii 2008*), demonstrating highly developed hunting skills amongst the population. This site was especially abundant in mollusc and fish bones, indicating specialised human exploitation of water resources. An abundance of bone harpoons and stone weights probably used for sinking nets, along with tools made from molluscs shells, show that human activities were tightly aligned with fish consumption (*Tsybrii 2005*) and food-procurement activities. The same conclusions were reached from the analysis of the Neolithic layers of the Rakushechny Yar and Razdorskoe–I sites (*Aleksandrovsky* et al. *2009*). Furthermore, previous palynological analysis of the Razdorskoe–II site was carried out by Kremenetski (*1991*) and Spiridononova *et al.* (published in *Tsybrii 2008*) from approximately the same period as the macrobotanical samples reported above were retrieved. The pollen analysis at Razdorskoe–II has shown no evidence of any pollen belonging to domestic cereal species.

A situation similar to the Razdorskoe–II site was revealed while investigating the Starobelsk–I and Novoselovka–III settlements of eastern Ukraine. Except for the remains of dog, the rest of the animal bones from the 2006 excavation of Starobelsk–I resulted in the discovery of only wild species (*Telizhenko, Motuzaite Matuzeviciute 2007*). River mollusc middens combined with fish and turtle bones indicate the exploitation of the fresh water resources at both sites.

The abundance of flint chips at Starobelsk–I was concentrated mostly in areas around the fireplaces, indicating that tool-making activities took place at the site. It has been argued that most flint tools from the Starobelsk–I settlement are linked with hunting, flaying, meat cutting and scraping (*Telizhenko 2007*). It has to be mentioned that Gurin (*1998*) regarded the flint blades at Starobelsk as cereal harvesting tools. However, during the 2007 archaeological excavation, a flint blade was found embedded in a mollusc shell, indicating that it was used to open shells and extract their contents.

It can also be pointed out that the fireplaces at the Starobelsk–I site were wide (up to 2m in diameter), and constructed directly on the ground surface. None of the fireplaces contained any permanent structure, such as a clay bedding or stone circles, indicating their temporary use. The fireplaces at Starobelsk–I often have heat epicentres in a few different places, showing reuse of the fireplace location over different periods. The absence of pits, dwelling construction, or postholes also suggests a temporary, probably seasonal, camp where people had simple ground dwellings, or no dwellings at all. The geographical location of the site also indicates the selection of the site for hunting purposes. Across from the site the River Aidar makes a bend beneath a set of steep chalk cliffs, a situation that may have benefited the hunting strategies of the site occupants. All this evidence seems to suggest that the Starobelsk–I site was a hunting campsite, the inhabitants of which hunted wild animals and exploited river resources.

According to ^{14}C dates the Novoselovka–III mollusc midden site represents a later chronological period than the Starobelsk–I site; however, the subsistence patterns of its inhabitants were still very similar to those at Starobelsk–I. No traces of house constructions, postholes, or pits from the Late Neolithic period were found at Novoselovka–III. The presence of wood charcoals, burned bone and flint fractions in mollusc middens, coupled with a few wild plant seeds, show that cereals were not a part of normal kitchen waste. However, one must keep in mind that very little evidence of fire-making activities were found at the site, and therefore any potential plant

Fig. 5. Lemma and palea impressions of naked barley (*H. vulgare var. nudum*) in Zanovskoe pottery from the second half of the 5th millennium calBC – first half of the 4th millennium calBC layer, 50–60cm depth horizon, square 320.

crops used at the site would not have survived in an un-charred state.

The investigation of Novoselovka–III provided evidence of the population's extensive involvement in mollusc gathering activities for subsistence purposes. The seasonality studies of mollusc consumption among the inhabitants of the Ertebølle culture in Denmark has shown that the molluscs were collected in early spring – March and April (*Milner 2002*). Mollusc meat is not an adequate protein replacement for other animal meats; it is actually highly rich in carbohydrates and can substitute as a replacement for grains (*Greenfield, Jongsma 2008*). Haskel J. Greenfield and Tina Jongsma (*2008*) note that in areas where grains were not consumed, or consumed in very small quantities, the collection of molluscs was of greater importance.

The discoveries of wild animal bones, bone awls, stone axes, a variety of flint tools and flint chips at the Novoselovka–III site indicate more diverse activities at the site than only mollusc gathering. Furthermore, the Novoselovka–III site contained a large quantity of pottery, with the largest vessels being up to 50cm in height and 34cm in diameter (*pers. comm. Sergey Telizhenko*), indicating the reduced mobility of the population. Moreover, a pottery ornamentation stamp made from an incised mollusc shell (*Unio* sp.) was found at the Novoselovka–III site in a shell midden (Fig. 6). All these facts could suggest both local pottery production adjacent to the mollusc midden site and the proximity of human settlement to the mollusc midden site. Such evidence reinforces the argument that the absence of evidence for cereal cultivation is not because the wrong areas were sampled, but rather because it is very unlikely that the people of Novoselovka–III were involved in agriculture.

It has to be mentioned that the Novoselovka–III site is unique in its abundance of pottery and variety of pottery styles. The variety of vessel ornamentation patterns, clay temper, and the amount of pots per area excavated in Novoselovka–III site constitute the greatest pottery collection from Neolithic Ukraine. From the total excavated surface area of 133m^2, 25 complete vessels were found. It can be noted that pottery vessels very similar in ornamentation, clay admixture and shape to those from the Novoselovka–III site have been found in layer 10 at the Rakushechny Yar site (Fig. 7), showing close contacts between the Novoselovka–III and the Lower Don populations. Overall, it has to be pointed out that the similarities in Neolithic pottery-making technology between the Novoselovka I–III and Starobelsk–I sites with the Lower Don region sites are much stronger than with that of the peoples inhabiting the Dnieper River region. The westward movement of pottery technology from Russia to Ukraine has been noted by many researchers (*Danilenko 1969; Belanovskaya 1995; Kotova 1998; Kuzmin, Orlova 2000; Sanzharov* et al. *2000; Gronenborn 2003; Dolukhanov, Shukurov 2004; Dergachev, Dolukhanov 2007*). Such interregional similarities are important for understanding the zones of influence by human interaction along connecting waterways, which later played a role in the exchange of agricultural products.

The evidence discussed above leads to the conclusion that the human populations in the Donets nor Don basins did not practice cereal cultivation during the 6th millennium calBC. A similar situation obtains with domestic cattle. The identification of animal species at Neolithic sites in Ukraine and Russia as domestic has added to the confusion about the origins of agriculture in the region. Animal remains at sites are usually identified as domestic without following standard animal bone gender patterns and morphometric analysis of decreasing size and age. Furthermore, due to the osteological similarity between sheep/goat and steppe antelope (*Saiga tatarica*), especially in dentition (*Hillson 2005*), the identification of Near Eastern sheep and goats are probably often confused with steppe antelope species. Steppe antelope was a very frequent game animal among the prehistoric inhabitants of the steppe (*Vekilova 1971; Dolukhanov 2009*). It has been noted, however, that at many Neolithic sites only sheep/goat or steppe antelope bones have been identified,

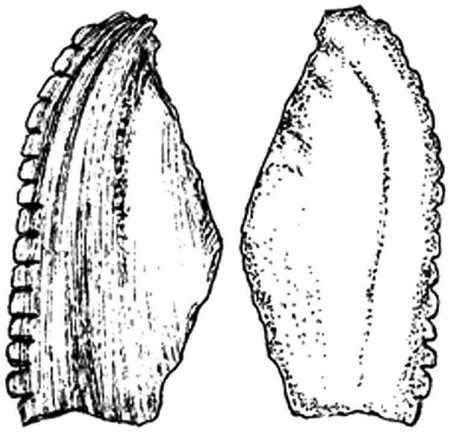

Fig. 6. Stamp for decorating pottery made from fresh water mollusc, found at Novoselovka-III site (S. Telizhenko drawing).

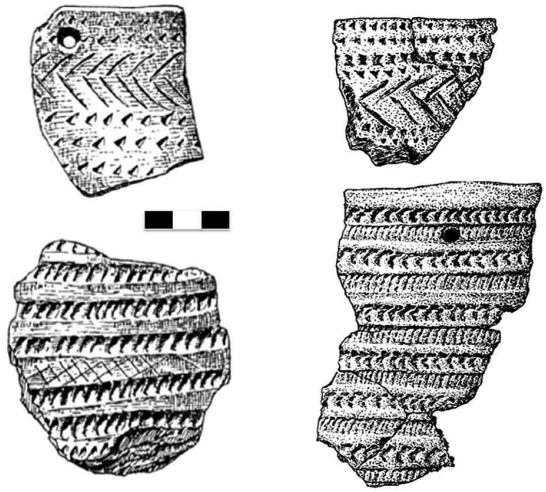

Fig. 7. A few examples of the similarities between Rakushechny Yar layer 10 (left column) (after,* Belanovskaya 1995.106*) and Novoselovka III (right column) pottery styles (V. Telizhenko drawing).

probably indicating some confusion in differentiating these threeanimal species from each other (*Tsybrii 2008*). A specimen from Semenovka site, identified by Kotova as sheep bone, from the lower layers of the settlement, was dated at the Beijing Radiocarbon Accelerator Unit for AMS radiocarbon dating. The date ranged between 5617–5482 calBC (BA–071462; 6595±40 BP) (Fig. 8). It was on the sheep/goat remains from the Semenovka site that N. Kotova based her theory of the Caucasian-Steppe origins of agriculture in eastern Ukraine (*Kotova 2009*). However, according to the opinion of a zooarchaeologist colleague from the University of Cambridge (*pers. comm. Katie Boyle, Ryan Rabett and Tony Legge*), this bone specimen is more likely to be that of *Saiga tatarica* than *Ovis aries orientalis*.

The presence of agriculture in the Lower Don and Donets basins has been detected by the author only in the Chalcolithic period. Cereal impressions in pottery were found at the Rakushechny Yar in site layers 4–2 and Zanovskoe's Chalcolithic layers. Rakushechny Yar and Zanovskoe are attributed to a very similar period of the Sredny-Stog culture and dated to the second half of the 5th and the 4th millennia calBC. The archaeobotanical investigation of the Rakushechny Yar site pottery has shown that the inhabitants were familiar with cultivating spelt wheat (*Triticum spelta*) and other wheat species, hulled barley (*cf. Hordeum vulgare*), probably flax (*cf. Linum usitatissimum*) and possibly broomcorn millet (*cf. Panicum miliaceum*). The Zanovskoe inhabitants were probably cultivating hulled and naked barley (*Hordeum vulgare*, *Hordeum vulgare* var. *nudum*) and wheat (*Triticum* spp.). Unfortunately, the cereal impressions in pottery from the Zanovskoe and the Rakushechny Yar sites do not have direct dates, but only dates of the layer and, therefore, constitute a less accurate piece of information than dates directly derived from dating charred cereal grains. It also should be pointed out that the dates from Rakushechnyi Yar were received from pottery consisting of a mollusc or humus temper – material not very appropriate for dating. The dates also have a very large error band of up to ±300 years, making these dates very inaccurate (see Tab. 1). Nevertheless, neither of the Zanovskoe or Rakushechny Yar

Site name	No of analysed pottery fragments	Archaeobotanical data (seed/grain impressions)
Orekhovo-Donetskoe–III	13	3 – wild plants
Olkhovaya–V	167	2 – wild plants
Starobelsk–I	379	3 – wild plants
Starobelsk–II	22	None
Zelena Gornitsya–I	22	None
Starobelsk–III	17	None
Zelena Gornitsya–V	24	1 – wild plant
Zelena Gornitsya–VI	1	None
Kleshnya–II	7	None
Podgorovka–I	573	3 – wild plants
Novoselovka–III	Over 1000	3 – wild plants
Novoselovka–I	1266	5 – wild plants
Tuba–II	24	10 – seeds imprinted in cluster, millets (?)
Zanovskoe	Not recorded	*Hordeum vulgare* var. *nudum*, *Hordeum vulgare*, *Triticim* spp.
Rakushechy-Yar	Over 1000	See Table 5.1–2 in this chapter
Total fragments	~4500	

Tab. 8. List of sites from where pottery sherds with cereal impressions were analysed.

sites are being excavated at present, which means that flotation or radiocarbon cannot be applied, and that the existing pottery impressions and dates constitute the only information about the presence of agriculture in the Donets and Don basins from around the 5–4th millennium calBC. During this period, an increase in the use of domestic animals in the region can be noted; a large quantity of domestic animal bones has been reported from the Zanovskoe and Rakushechny Yar sites and from other sites. For example, from the Chalcolithic layer at Zanovskoe (350m^2), O. P. Zuravlev identified bones from twenty-two individuals of domestic cattle, eight sheep, six goats, eight sheep/goat, twenty-two 'domestic' horses and eight dogs (*Zhuravlov, Telizhenko 2008*). Viktor Tsybrii (*2008.71*) notes that at the end of the Neolithic and Chalcolithic periods, the populations of the lower Don became predominately cattle and horse breeders. It is argued that during the 5th millennium calBC, some changes in the society of the Donets Basin can be seen, for example, an increase in population represented by the appearance of large burial grounds, such as Alexandria (*Manko 2003; Rassamakin 1999*); the development of metallurgy, where the first metal objects and crucibles were found at the Kleshnya site (*Manko 2006; Manko, Telizhenko 2002*), and others.

It can be only speculated about the geographical origins of domesticated plant species in the region. The arrival of agriculture in the territory of Ukraine could be seen as taking place not only following the branched Danubian route, but also by following the later steppe and Caucasian route. The broomcorn millet found at the Rakushechny Yar was probably introduced via the steppe corridor from the populations at the present territories of China. Unfortunately, not much is known about millet cultivation in central Asia. So far, the earliest ^{14}C dated (end of the 3rd millennium calBC) *Panicum miliaceum* grain was found in eastern Kazakhstan (*Frachetti* et al. *2010*).

The wheat and barley agriculture of the sites in eastern Ukraine and southwest Russian could have arrived from the northern Caucasus region. There is substantial evidence of agriculture in the northern Caucasus region during the early stages of the Chalcolithic period. The best-known site in the northern Caucasus, the Chokh settlement in the Dagestan region, is probably dated to Chalcolithic-Bronze Age (*pers. comm. Nadia Kotova*). Khizri Amirkhanov (*1987*) reports cultivars of barley (*Hordeum vulgare* var. *polystichum*, *Hordeum* var. nudum), millet (*Panicum* spp.), and wheat (*Triticum monococcum, Triticum dicoccum, Triticum aestivo-compactum*) from the site, retrieved by applying flotation methods to the settlement layers. Besides the Chokh site, more Early Chalcolithic sites in the northern Caucasus provide evidence for agriculture, such as Svobodnoe, Yasenovaya Polya, Meshoko, Zamok, Khadzhokh, *etc*. Archaeobotanical data from the Chalcolithic fortified Svobodnoe site; macro report the remains of grain and chaff of *Triticum monococcum*, *Triticum dicoccum*, and *Hordeum vulgare* were found from the flotation samples (*Lebedeva 2011*). At the fortified Svobodnoe site, 39% of all tools discovered were attributed to cereal cultivation and processing activities (*Nekhaev 1992*). The Svobodnoe site was radiocarbon dated to the second half of the 5th millennium calBC (*Rassamakin 1999*). Authors have reported the presence of farming village establishments along the River Kuban, where large granite cereal grinding stones and flint sickles for cereal cultivation were recovered (*Formozov 1965; Korenevskii 2004*).

Fig. 8. The fragment of* Ovis aries*/* Saiga tatarica *metatarsal from the lower cultural layer at the Semenovka site dated at the Beijing Radiocarbon Accelerator Unit for AMS.

To the north Caucasus, agriculture spread from the central and southern Caucasus, where it existed during the Shulaveri-Shomutepe Culture, dated to the 6–5th millennia calBC (*Lisitsina, Prishchepenko 1977; Lisitsina 1978; Nebieridze 1978; Lisitsina 1984*). Irrigation channels were found at the Arukhlo–I, Imiris-gora, Chakh-tepe, Kiul-tepe and Alikemek-Pepesi sites (*Korobkova 1999*). The sites with domesticated animal and plant remains that have seen the best investigation of archaeobotanical data are the Aratashen and Aknashen Neolithic sites in Armenia, where the majority of radiocarbon dates fall into the period of the first half of the 6th millennium calBC (*Hovsepyan 2004; Hovsepyan, Willcox 2008*). Early cultivars started to spread north, reaching the northern territories of the Caucasus pro-

bably only during the early metal period around the 5th millennium calBC. The discovery of a stratified Late Mesolithic-Early Neolithic-Bronze Age site, such as Tsmi (7th to the 3rd millennia calBC) at an elevation of 1700m in the northern Caucasus shows "*the importance of the traverse across the nearby passes in the longue durée of Caucasian communication network*" (*Rostunov* et al. *2009.73*) and the possibility that the Neolithic populations of northern Caucasus had contact with the agricultural societies to the south.

According to Yuri Rassamakin (*1999*), in the Chalcolithic period, the route of a bi-directional network of interaction via the steppe belt stretched from the Prut River all the way to the north-west Caucasus. Imported items from the food producing pre-Maykop populations of the Kuban River region in the northern Caucasus are distributed through Sredny-Stog and Tripolye sites (*Rassamakin 2004*). For example, serpentinite bracelets from the Caucasus were found at the Novye-Ruseshti site in Moldova, green serpentinite axes also from the Caucasus, and pottery typical of the fortified agricultural village of Svobodnoe (north Caucasus) were found in the Sredny-Stog sites. This demonstrates the existence of interactions between the northern Caucasus region and the Ukrainian steppe already during the Early Chalcolithic period, which continued all the way through to the Maykop culture period (*Rassamakin 1999; Anthony 2007*). Rassamakin (*1999*) also emphasises the close similarity in the pottery making traditions of the northern Caucasus region with the Lower Don region during the Chalcolithic. The similarities in the material cultures of the steppe populations in Russia and Ukraine and northern Caucasus populations have also been noted by Nikolay Merpert (*1994*).

To conclude, the archaeobotanical investigations conducted by the author have provided evidence that cereal cultivation began in eastern Ukraine and south-west Russia around the second half of the 5th millennium calBC, as demonstrated by the analysis of pottery impressions from the Zanovskoe and Rakushechny Yar sites. The earliest evidence of cereal cultivation in eastern Ukraine and southwest Russia comes from the Sredny-Stog culture sites at Zanovskoe and Rakushechny Yar, where cereals and their chaff impressions were identified by the author in the layers dated to the second half of the 5th to the first half of the 4th millennium calBC. A variety of cereal species were identified from the grain and chaff impressions, comprising hulled and naked barley, spelt wheat, probably flax, and broomcorn millet species.

The archaeobotanical and archaeological evidence has shown that the possibility cannot be excluded that the spread of cereal cultivation into the eastern regions of Ukraine and south-western Russia may have arrived from the Caucasian corridor and the Eurasian steppe, but only during the Chalcolithic period.

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