Chronology of Early Neolithic materials from Sakhtysh IIa (Central Russia)

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ABSTRACT – *The Upper Volga culture (UVC) in the Volga and Oka basin is one of the earliest pottery cultures in Eastern Europe. The Sakhtysh IIa site is attributed to the core area of the UVC, with pottery encompassing all stages of this culture. A detailed analysis of artefact deposition in different layers allows the creation of chronological models of early pottery development in this region. A series of new radiocarbon dates of food crust on pottery sherds which typologically belong to different stages of UVC at Sakhtysh IIa, as well as an overview of the oldest pottery are presented in this article.*

KEY WORDS – *Early Neolithic; pottery; hunter-gatherers; Upper Volga culture; chronological modelling*

Kronologija zgodnje neolitskih najdb iz najdišča Sakhtysh IIa (centralna Rusija)

IZVLEČEK – *Kultura zgornje Volge (UVC) ob rekah Volga in Oka je ena najstarejših kultur z lončenino v vzhodni Evropi. Najdišče Sakhtysh IIa se nahaja v osrednjem območju njene razprostranjenosti in vsebuje keramične najdbe iz vseh stopenj kulture UVC. Z natančno analizo pozicije najdb v različnih plasteh smo izdelali kronološki model za razvoj najstarejše lončenine v regiji. V članku predstavljamo pregled najstarejše keramike ter serijo novih radiokarbonskih datumov, pridobljenih iz zoglenelih ostankov hrane na keramičnih črepinjah iz najdišča Sakhtysh IIa, ki jih lahko tipološko umestimo v različne stopnje kulture UVC.*

KLJUČNE BESEDE – *zgodnji neolitik; lončenina; lovci in nabiralci; kultura zgornje Volge; kronološko modeliranje*

Introduction

The Upper Volga culture is an archaeological culture with some of the earliest pottery in Eastern Europe. The culture influenced the development of the earliest ceramic assemblages in the neighbouring regions: Eastern Onega Lake, the Valday Hills, the Dnepr-Dvina basin, Northern Dvina, and the Pechora River basin (for descriptions of these regions and their chronology, see *Mazurkevich, Dolbunova 2015; Piezonka 2014; Zaitseva* et al. *2016; Nedomolkina 2014*). This culture was identified on the basis of particular ceramic assemblages found at well-stratified sites in the Upper Volga basin. Several stages of pottery de-

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velopment attributed to the UVC can be distinguished here based on different features, one of the most important being decorative characteristics (*Krainov 1996; Kostyleva 1986, 1994; Engovatova 1998; Engovatova* et al. *1998; Zhilin* et al. *2002*). The first stage can be divided into two parts: the pottery of stage I.1 is undecorated or decorated by occasional rows of pointed impressions. The pottery has flat or conical bottoms, with straight and flat rims (*Kostyleva 2003*). The materials attributed to the first stage of the UVC reflect the first appearance of pottery in this region, dated to the first half of the 6th millennium cal BC (*Zaretskaya, Kostyleva 2008. 13*). This tradition is supposed to have originated farther south, in the Volga River basin (*Engovatova 1997; Vybornov 2008*). Similarities have been noted with pottery of the Middle Volga culture, late Elshanian culture and Rakushechny Yar (*Kostyleva 2003. 215–216*). Several pottery types were found within the first stage of UVC (see below).

At the end of the first stage (I.2), pottery covered by 'false-cord' decoration, geometrical compositions consisting of drop-like and oval impressions, incised lines, or teeth-stamp impressions appeared (*Kostyleva 1994*). During stage II, pottery decorated by impressions of short-teeth stamps dominated. In stage III, vessels became bigger and were mostly decorated by impressions of different lengths of comb stamp. According to Elena L. Kostyleva, this evolution of the UVC might apply only to the central part of the Volga-Oka region, and may differ on its periphery (Fig. 1) (*Kostyleva 1994.56*). Early Neolithic pottery at the group of Sakhtysh sites is attributed to the core area of the UVC. Materials of all three stages of this culture are represented at these sites (*Kostyleva 1986.139*).

The chronology of different stages and pottery types of the Upper Volga area is still undecided, but can be clarified on the basis of materials from well-stratified sites such as Sakhtysh IIa. In order to refine the dating of this pottery, new dates were made on organic crust sampled from vessels attributed to different types and stages of the UVC from Sakhtysh IIa, combined with previously published dates, and these new and old dates will be discussed in this paper. The spatial distribution of all finds and dates was used to inform the interpretation of the dates, taking into account the complexity of dating organic crust on hunter-gatherer pottery, which is often suspected of being influenced by radiocarbon reservoir effects. A three-dimensional

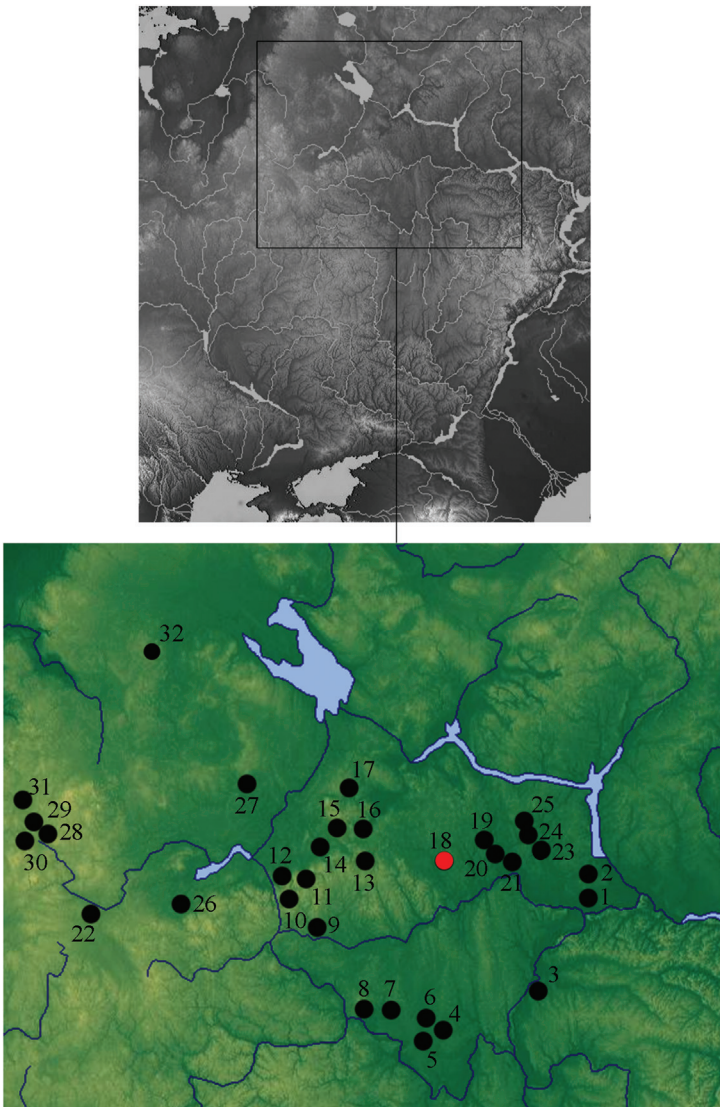

Fig. 1. Map of archaeological sites with the earliest pottery located in the Volga-Oka interfluve (1–27) and Valday Hills (28–32). 1 Seima I; 2 Shadrino IV; 3 Volosovo; 4 Korenec I; 5 Zhabki III; 6 Teren'kovo III; 7 Belivo II; 8 Maslovo boloto 8; 9 Davydkovo; 10 Davydkovskaya; 11 Zamostje 2; 12 Okaemovo 3, 5, 18; 13 Pol'co; 14 Somino II; 15 Ivanovskoe III, V, VII; 16 Kuhmar' 1; 17 Varos; 18 Sahktysh I, II, IIa, VIII; 19 Kosyachevo I, II; 20 Zav'yalka 1; 21 Bobrinka II; 22 Ozerki 5, layer III; 23 Alekseevskoe I; 24 Strelka I; 25 Malaya Lamna; 26 Al'ba I, III; 27 Yazykovo I; 28 Zales'e I, II, Nizhnie Koticy 5, Zehnovo III, IV, Lanino I; 29 Kotchishe 1,2, Shepochnik; 30 Dubovec (Peno 3); 31 ostrov Koshelev, Zabolot'e I; 32 Zabel'e.

analysis of artefacts distribution allows the reconstruction of relative chronology, which can be a reliable basis for different chronological models, that will be shown based on Sakhtysh IIa materials.

Spatial analysis of finds at Sakhtysh IIa

A previous spatial analysis of pottery attributed to different stages of the UVC and later cultures at various archaeological sites did not show any particular patterning (*Smirnov 2004*). Spatial patterning in pottery decorated by comb and undecorated pottery or ceramics decorated in a pin-pointed technique was identified only at the Ozerki 5 site (*Smirnov 2004.113*). UVC ceramic assemblages are very small at a number of sites, such as Ozerki 5 and 17, Okaemovo 5 and 18, Belivo 2, and Davydkovskaya. At Voimezhnoye, the ceramic assemblage includes 750 fragments, all belonging to one stage (I.2) of the UVC, and deposited in one layer (*Engovatova 1997. 56; Smirnov 2004.113*). Sakhtysh IIa appears to be a unique case, with a large ceramic assemblage, including pottery attributed to all stages of the UVC (797 sherds), Lyalovo culture (476 sherds), and Volosovo culture (48 sherds), as well as flint, bone, and wooden tools, faunal remains and remains of wooden objects, dated to the Mesolithic and Neolithic periods. Using Autocad 3D, a three-dimensional analysis was carried out for the Sakhtysh IIa site in order to refine the relative and absolute chronology of different stages of the UVC. The coordinates and attribution of the artefacts were indicated according to the field plans of 1999, 2004 and 2015, and a field inventory of 1999 made by Kostyleva.

The Sakhtysh group includes 15 sites located on the shore of Lake Sakhtysh and its outflow, the Koika River (Teykovsky district, Ivanovskaya oblast'). Sakhtysh IIa is located on a cape of the first floodplain terrace, on the left bank of the Koika River and in a waterlogged valley of a dried-up spring. The dry elevated part of the site is 3m above the modern water level. Some 700m^2 of the dry land area were excavated, where Lyalovo and Volosovo burials of the 4th–2nd millennium BC were found. A cultural layer 50cm thick contained finds from the Mesolithic to the Bronze Age (*Zaretskaya, Kostyleva 2008.6–7*). Thirty-six square metres of peat-bog were excavated, including 2m of sediments with cultural layers. Different layers with artefacts were uncovered here, located almost horizontally over the whole surface (Fig. 2).

Pottery of the Middle and Late Neolithic (Lyalovo and Volosovo culture) was found in the upper layer of black peaty loam (Ia) (Figs. 2, 4). Pottery decorated with long comb impressions attributed to the late (III) stage of the UVC was found in the underlying layer of grey clay loam (Ib) and in an ash layer (IIa) which was formed after a peat-bog fire here (*Zaretskaya, Kostyleva 2008.8*). Some downward movement of these fragments into the layer of dark brown peat with wood remains (IIb–IIv) can be also noted, but otherwise almost no finds were found in the upper part of this layer.

Another accumulation of material can be clearly distinguished – with fragments of pottery attributed to stage II of the UVC, early pottery decorated by oval impressions and false-cord decor (stage I.2) – in the lower part of the dark-brown peat layer with wood remains (IIv) and on its border with greenish-brown peat with wood remains (IIg). Different pottery types are deposited together (Fig. 4), which could be evidence that this place was occupied several times, or it could be explained by some other circumstances.

In the eastern part of the (2004) excavation, fragments of pottery decorated with roundish impressions and pottery attributed to stages II and III of the UVC are clearly separated from a layer of undecorated ceramic fragments (stage I.1; Figs. 2, 4) by a sterile gyttja interlayer. Single finds here could have penetrated as the result of some natural processes. Some of the undecorated ceramic fragments were found lying on the border of greenish-brown peat (IIg) and brown peat with wood remains (IIv), or in the lower part of the brown peat with wood remains (IIv). Some fragments could be parts of decorated vessels, as decorated fragments were also found here. Analysis of the finds' position suggests that there were two microstratigraphic horizons with pottery attributed to undecorated UVC pottery.

The final Mesolithic layer (IIIa) cannot be distinguished very easily in the lithology of the site (*Averin* et al. *2009.131*); it was distinguished on the basis of some materials found and ^{14}C dates. However, one can also suppose that some of the Mesolithic finds could have penetrated into layer IIIa. Taking into account that the Early Neolithic flint industry originated in the Mesolithic, it is also possible that the stone tools found in this layer might be attributed to the Neolithic period, *i.e.* when pottery appeared and other elements of material culture continued without significant changes. This layer was located in the bottom of greenish-brown peat layer, where sand lenses were identified (IIIa, squares 1–4) in the western part of the excavation, and deposited in a

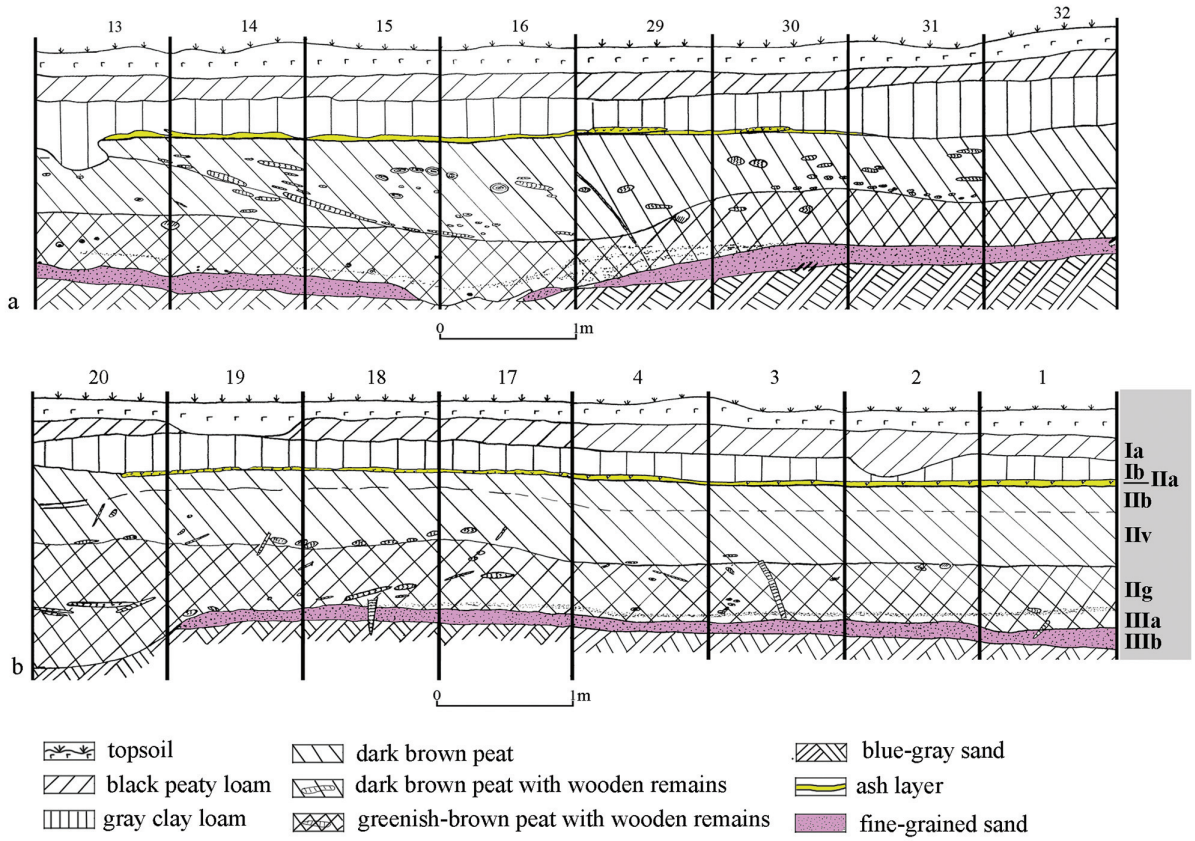

Fig. 2. Stratigraphy of the Sakhtysh IIa site with numbers of cultural layers indicated (b): a northern wall; b southern wall.

wellhead part of the stream, which can be traced in the modern relief (*Zaretskaya, Kostyleva 2008.8*). Some of the undecorated pottery fragments attributed, probably, to stage I.1 were found lying in the lower part of greenish-brown peat, in the darker, loose part, which was clearly distinguished during excavations (*Zaretskaya, Kostyleva 2008.9*). It complicates the delineation of the final Mesolithic layer IIIa in the lower part of greenish-brown peat.

The underlying cultural layer, IIIb, corresponds to a fine-grained sandy layer (*Averin* et al. *2009.133*) (Figs. 2, 4). The results of palynological analysis date it to the end of the Boreal, and wood from this layer was dated to 7170–6810 cal BC (GIN-10862, 8060± 50 BP) (*Averin* et al. *2009.133*).

The particularities of lithology and distribution of finds show that the littoral part of the site was located here, and was the base for household activity, including fishing and hunting. Short periods of drying did not lead to the formation of a thick layer of soil, and it cannot be identified now. The setting is a wetland, with sedimentation alternating between gyttja and peat (*i.e.* organogenic sediment) according to water level. Different levels of occupation are, therefore, recognised according to the layering of archaeological material. Frequent (for example, seasonal) washaways of soil might have led to compaction and even some mixing of finds dated to different periods, which are almost not divided by microlayers. The occupants of this site could have pushed some artefacts into deeper levels and mixed some artefacts in the course of household activities on the mud flat. Even taking into account these factors, Sakhtysh II is a particular case of the stratification of various pottery types, which permits a reconstruction of the pottery typo-chronological sequence and history of occupation in the Upper Volga area.

New ^{14}C dates

This paper includes a series of new radiocarbon dates of food crust on pottery sherds which typologically belong to different stages of the Upper Volga culture (SPb-1448–1457, KIA-51174). We also report radiocarbon results from three modern fish (KIA-51204–51206), and further measurements of three previously dated food crusts (KIA-39308–39310). In addition, the paper includes two previously unpublished dates for bone artefacts (KIA-39304–39305).

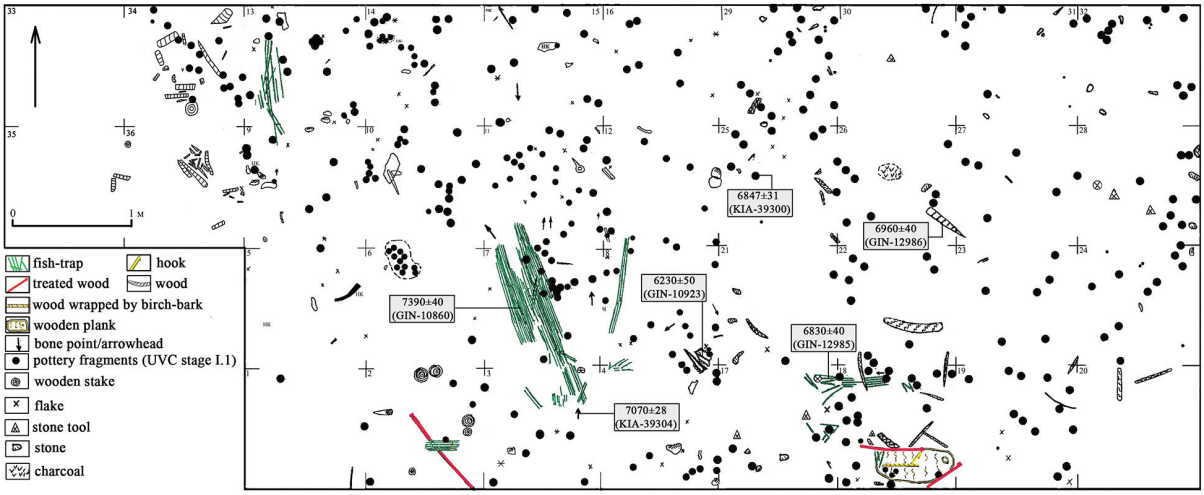

Fig. 3. Sakhtysh IIa. Plan of the layer IIg with finds and radiocarbon dates obtained for wooden and bone objects, and a willow string on pottery of UVC stage I.1.

Samples SPb-1448–1457 were pre-treated by the normal acid-base-acid procedure (*Nakamura* et al. *2001; Boudin* et al. *2010*), combusted and converted to benzene for liquid scintillation counting of ^{14}C activity, at the Herzen State Pedagogical University radiocarbon laboratory, St Petersburg, Russia. Their $\delta^{13}C$ values were measured by IRMS in the same laboratory by combusting another aliquot of the pre-treated extract. The IRMS-measured $\delta^{13}C$ values were then used to correct the measured ^{14}C activity for isotopic fractionation.

The other samples were dated by accelerator mass spectroscopy at Christian-Albrechts-University, Kiel, Germany, with $\delta^{13}C$ correction based on the $^{13}C/^{12}C$ ratio measured simultaneously by AMS. The fish were steamed for an hour on site, defleshed and stored in cooking salt (99.7% NaCl) for transport. In the laboratory, a fragment of flesh from each individual was frozen, freeze-dried and combusted, before reduction to graphite for AMS measurement (Tab. 2).

Archaeological samples were first extracted with a series of solvents to remove lipids and waxes, including possible conservation agents, before acid-base-acid pre-treatment (food crusts) or collagen extraction (bone) (*Grootes* et al. *2004*). Food crust extracts were typically 40–50% of the starting weights, with carbon contents >50%, which are characteristic values for well-preserved samples. The collagen yields for the bone artefacts were good to excellent (6–14% by weight). An aliquot of each extract was combusted and graphitised for AMS measurement.

Three of the new AMS results were from new combustions in 2016 of the same extracts which were dated in 2010 (*Hartz* et al. *2012*). These samples (KIA-39308–39310) gave the earliest known AMS dates for Upper Volga pottery, and they were regarded as important to confirm the original results (Tab. 3). In two cases, the new results are consistent with the 2010 measurements, and in this paper we use the weighted means of the 2010 and 2016 results as

Laboratory number	Sample	AMS $\delta^{13}C$(‰)	$F^{14}C$	Conventional ^{14}C Age*
KIA-51204	fresh fish flesh (cyprinid, probably young *Leuciscus cephalus*), caught summer 2015	–33.59	0.9822 ± 0.0024	144 ± 19 BP
KIA-51205	fresh fish flesh (cyprinid, probably young *Leuciscus cephalus*), caught summer 2015	–32.58	0.9789 ± 0.0023	171 ± 19 BP
KIA-51206	frozen freshwater carp flesh, caught 2014	–32.30	0.9851 ± 0.0024	121 ± 19 BP

* According to Hammer and Levin (2017) the average ^{14}C activity of atmospheric CO_2 during the May-August growing seasons in the Northern Hemisphere was 1.0193±0.0004 $F^{14}C$ in 2014 and 1.0134±0.0016 $F^{14}C$ in 2015. Apparent ^{14}C ages (more comparable to freshwater reservoir effects than conventional ^{14}C ages, which are calculated assuming an atmospheric ^{14}C activity of 1.000 $F^{14}C$)) are therefore 251±23 (KIA-51204), 278±23 (KIA-51205) and 274±19 (KIA-51206), the weighted mean of which is 269±13.

Tab. 2. Radiocarbon results of modern fish samples and combustion samples.

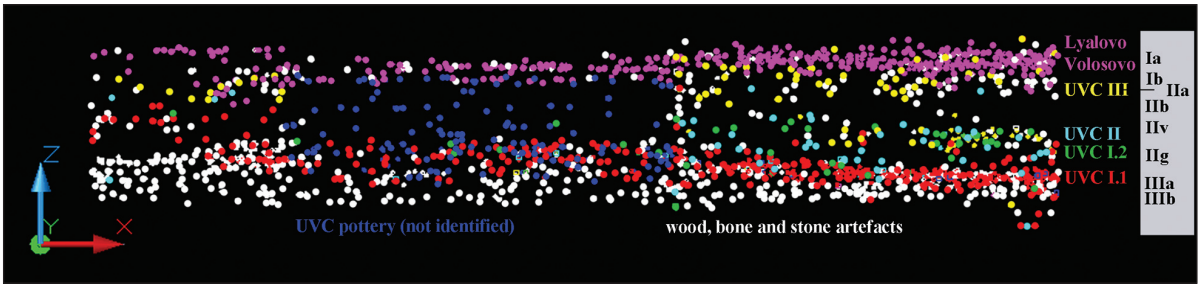

Fig. 4. Sakhtysh IIa. 3D reconstruction of finds from the Sakhtysh IIa site.

the best estimates of each sample's radiocarbon age. In the third case, KIA-39310, the 2016 result is even older than the 2010 result, suggesting some inhomogeneity in the extract. The 2010 result was already considered to be misleadingly old (*Hartz* et al. *2012*). Moreover, one of the new radiometric dates, SPb-1452, is from another sherd of the same vessel as KIA-39310, and there is a large discrepancy between the AMS and radiometric dates. We are currently unable to provide a satisfactory explanation for this pattern, but Henny Piezonka *et al.* (*2016*) showed that the KIA-39310 extract has stable isotope and elemental concentration values consistent with it being derived from fish, and the AMS results may therefore be heavily influenced by freshwater reservoir effects.

The modern fish, taken from the Koiko River close to the site, are all depleted in ^{14}C with respect to the atmosphere, by a similar amount, equivalent to an average apparent radiocarbon age of approx. 270 years (Tab. 2). If this relatively modest freshwater reservoir effect were applicable to fish caught at Sakhtysh during the Early Neolithic, we should not find large radiocarbon age offsets in food crusts consisting mainly of terrestrial ingredients, and even those dominated by aquatic ingredients should typically produce radiocarbon ages which are only 200–300 years too old. Although no detailed biomolecular analyses have yet been undertaken on pottery from Sakhtysh, EA-IRMS results suggest that most food crusts may have been predominantly composed of terrestrial ingredients (*Piezonka* et al. *2016*). We therefore assume that the food crust radiocarbon ages, with the exception of KIA-39310/SPb-1452, are generally reliable, although individual cases of significant reservoir effects cannot be excluded.

A series of new dates was available for different stages of UVC. Dates of the first half of the 6th millennium BC were obtained for different types of UVC vessels' fragments. Pottery attributed to UVC stage I.1 includes three flat, undecorated rim fragments (Fig. 5.1–3; Tab. 1.7–9). Perforated holes were put on each rim (except the fragments with a repair hole – Fig. 5.3). One of the rim sherds, covered partly by red ochre, also has a groove under the rim where the holes were made (Fig. 5.1). The pottery was made from shell-tempered paste (Fig. 5.1–2). A fragment of one vessel (Fig. 5.3) was made from a paste tempered by bones, sand and grog, according to the petrographic analysis (made by M. A. Kulkova). Organic crust from similar pottery was also dated previously (Tab. 1.11–18, 21) (*Zaretskaya, Kostyleva 2008.9–10; Hartz* et al. *2012.6.5–7*). Some of the dates were made on the total organic content of sherds of undecorated shell-tempered pottery (Tab. 1.25–27, 38) (*Vybornov, Kostyleva 2009.32*). One date, 5471–5046 cal BC (Ki-14555, 6290±90 BP; Table 1.38), which was made on the sherd of, probably, the same or a similar vessel, appeared to be much more recent than the others (Tab. 1.25–27).

Dated pottery attributed to stage I.2 includes one rim fragment decorated by impressions in diagonal rows (Fig. 5.4; Tab. 1.10), fragments decorated by

Sample	Measurement	AMS $\delta^{13}C$ (‰)	Conventional ^{14}C Age	weighted mean
KIA-39308	2010 combustion	–20.91	7018±45 BP	7008±28 BP
	2016 combustion	–22.19	7002±34 BP	
KIA-39309	2010 combustion	–20.10	7037±26 BP	7071±22 BP
	2016 combustion	–21.14	7125±34 BP	
KIA-39310	2010 combustion	–29.03	7356±29 BP	7427±23 BP
	2016 combustion	–29.85	7510±33 BP	

Tab. 3. AMS results from new combustions in 2016 of the same extracts which were dated in 2010.

drop-like impressions (Fig. 5.5, 11), small triangular impressions applied in a retreating manner (Fig. 5.7). Also, there is a date of 5877–5328 cal BC (SPb-1455, 6669±150 BP) obtained for a fragment decorated by large comb impressions (Fig. 5.9) (stage III). Such an early date for this vessel attributed to the late stage does not match the proposed scheme or period for such pottery. An age offset might be connected with a freshwater reservoir effect, which is suggested by $\delta^{13}C = -27.1‰$ for this sample; almost all the $\delta^{13}C$ values for the other samples are above –25‰.

Another group of dates lying within a time interval of the second half of the 6th millennium BC (Tab. 1.1–3) was obtained for vessels decorated by thin comb impressions (Fig. 5.10) in combination with rounded impressions (III stage) (Fig. 5.8). A similar fragment, decorated by thin comb impressions and rounded impressions (*Hartz* et al. *2012.Fig. 3.2*, similar to the fragment in Fig. 5.8), was dated to 5463–5227 cal BC (KIA-39303, 6348±26 BP).

Ceramic analysis – another question for chronological issues

Technological analysis of pottery can contribute a great deal to the chronological issues, especially when dealing with undecorated pottery, which appears not to be homogenous and can be divided into different types due to differences in the different stages of the *chaîne opératoire*. It is important to describe how these groups appear to be different and how these differences can be explained – by different potters, culture or chronology.

Undecorated UVC pottery from the Sakhtysh group of sites is of particular interest regarding this question. The 1091 pottery fragments attributed to the first stage of Upper Volga culture were found at Sakhtysh I, II, IIa, VIII. As already recognised (*Kostyleva 1984.51*), this is a small number of ancient undecorated pots. Some fragments could also be part of sparsely decorated vessels (of the I.1, I.2 and II stages of UVC), which complicates analyses of incomplete vessels.

Most undecorated pottery from the Sakhtysh group of sites had flat bottoms, flat rims and, rarely, roundish or pointed rims. Two types of the upper part of pottery can be reconstructed – globular and biconical – of different volumes.

Many vessels were made from paste, tempered with grog or coarse-grained sand (514 fragments) (technological group I). This pottery is similar to pottery of type 1 identified at Zamostje 2 (*Mazurkevich* et al. *2013*). Pottery was made from different types of coils, highly stretched, often with an S-junction of coils. The walls are usually 0.7–0.8cm thick, but there are also thin-walled vessels of 0.4cm thickness. Vessel surfaces are smoothed and polished, and in

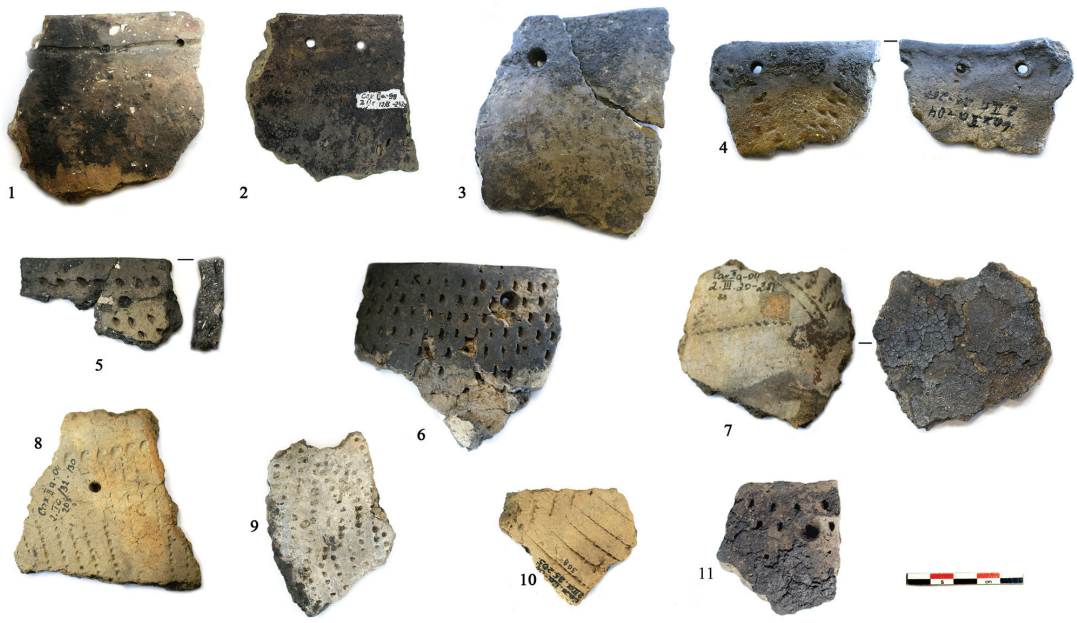

Fig. 5. Sakhtysh IIa. Pottery fragments, organic crust from which was dated: 1 – 6920±150 BP (SPb-1451); 2 – 7065±150 BP (SPb-1448); 3 – 6874±150 BP (SPb-1450); 4 – 7088±150 BP (SPb-1449); 5 – 6753±150 BP (SPb-1453); 6 – 6411±150 BP (SPb-1452); 7 – 6832±150 BP (SPb-1457); 8 – 6372±150 BP (SPb-1454); 9 – 6669±150 BP (SPb-1455); 10 – 6186±150 BP (SPb-1456); 11 – 6834±34 BP (KIA-51174).

many cases traces of polishing with a pebble are visible. Fourteen fragments of undecorated pottery flat rims can be attributed to this group. The upper parts of the vessels are closed; biconical forms can be reconstructed, as well as a globular form. Eight flat bases (Fig. 6.1) are attributed to this group; flat bases are typical of the earliest UVC complexes, including those found at Sakhtysh, as was indicated by a previous analysis (*Kostyleva 1986; 1994*). A subgroup of pottery (108 fragments), tempered by shell, could be distinguished. In this case, grog and coarse-grained sand is absent (Fig. 5.1).

Pottery fragments decorated by different impressions made with different techniques (by triangular and oval impressions) (Fig. 6.6), incisions, as well as in retreating manner (stage I.2), by different comb stamps, and by denticulated stamp (stage II) can also be attributed to this group (236 fragments; *Kostyleva 1986*). Decorative compositions include simple horizontal rows and one geometrical (see *Kostyleva 1984; 1986*). Also, a particular pottery fragment was found, which was decorated in a very specific way: with triangular impressions in a retreating manner and single triangular impressions nearby, and a fragment decorated by incised lines with triangular impressions nearby (Fig. 6.8). This decoration is similar to that on pottery from the Lower Volga region (*e.g.*, Varfolomeevka, layer 3). Poorly decorated vessels could have been made from coils with N-technique and with stretched coils (Fig. 6.4–5).

Vessels attributed to the second technological group (202 fragments) were made from paste tempered with organics (traces of burnt vegetation can be seen); the laminated structure of the paste and elaborate polishing (traceable on some fragments) are typical (Fig. 6.9). Most of these vessels have thin walls (0.4–0.6cm), and were made from slabs/short coils, greatly stretched, with an N-junction. Five flat rim fragments and a fragment of a flat base can be attributed to this group. Vessel forms are closed or straight. One vessel was decorated with an incised line.

A particular type consists of fragments of several vessels (27 fragments) made from small coils of sandy paste, with a smoothed or polished surface (Fig. 6.3, 7) (group 3). This group includes 18 fragments of undecorated walls, one fragment decorated by small triangular impressions – not typical of the complex of UVC pottery as a whole – and 2 fragments decorated in a retreat-traced manner. Similar pottery can be found at Zamostje 2 (types 4 and 7, according to *Mazurkevich* et al. *2013*), as well as in materials from the Dnepr-Dvina region (phases 'a', 'b', and probably 'a-1'). This pottery is not abundant at sites in the Upper Volga region, or at sites in other regions. for example, in the Dnepr-Dvina basin and Valday Hills. The absence of organic crust on pottery of some technological types makes refining their chronological position more difficult.

Chronological modelling

We used the Bayesian chronological modelling package OxCal v.4.3.2, with the IntCal13 calibration curve (*Bronk Ramsey 2009a; Reimer* et al. *2013*) to interpret the Sakhtysh IIa radiocarbon results (Fig. 7). Our model does not rely on stratigraphic relationships between samples, as most of the dated material is from a single layer, IIg; sample depths within this layer are potentially misleading, as the samples were scattered across the excavation area. Instead, our model incorporates the proposed typo-chronological sequence for UVC pottery, in which undecorated or sparsely decorate pottery and pottery decorated with rare oval impressions (I.1 stage) was gradually replaced by pottery decorated by false-cord impressions and traced lines (I.2 stage), then by pottery decorated by short teeth impressions (II stage), which was in turn gradually replaced by pottery decorated by comb-stamp impressions (III stage). Most of the dated food crusts and total organic carbon (TOC) contents were from sherds that could be attributed to one of these stages. OxCal's Trapezium model function (*Lee, Bronk Ramsey 2012*) was developed for this type of sequence. Our model also addresses the risk that some food crust dates may be too old, due to freshwater reservoir effects, and that TOC results could be misleading (*Bronk Ramsey 2009a*). Details of the model structure are shown in Figure 7.

The model output indicates that pottery probably first appeared at Sakhtysh IIa in 6040–5950 cal BC (start of the Early Neolithic start, 68% probability) and that the Early Neolithic phase ended in 5200–5070 cal BC (end of the Early Neolithic, 68%), and therefore lasted 750–890 years (68%). It is difficult to detect any gaps in the calibrated dates, but the large uncertainties in many of the dates do not allow us to exclude significant hiatuses. Undecorated pottery (stage (I.1) predominated until 5840–5640 cal BC (first transition, 68%) and comb-stamp decorated pottery (stage III) predominated after 5460–5330 cal BC (second transition, 68%). The model output suggests a very gradual transition between stages

I.1 and I.2. The relatively sudden transition indicated between stage I.2 and stage III may be misleading, as there are no dates from stage II sherds.

Nevertheless, the model demonstrates that the stratigraphic division of Upper Volga pottery into typochronological phases is justified by radiocarbon ages from food crusts. TOC radiocarbon results are often consistent with these phases, but can also appear to be too old or too recent. Stratigraphic associations between stage I.1 sherds and three organic artefacts (KIA-39304, GIN-12985, GIN-12986) support the attribution of undecorated UVC pottery to the first third of the 6th millennium cal BC, and the date of an elk skull (GIN-10923) is consistent with the dating of most stage III sherds, from the same layer or later, to the last quarter of the 6th millennium cal BC. It is important to note that future chronological models may be different, both because more radiocarbon dates will be available, and because the archaeological-typological information included in models might change.

Chronology of Upper Volga culture (UVC) pottery

The relative and absolute chronology of UVC represented on the basis of Sakhtysh IIa materials, can be also supported by the dates from other sites in the Upper Volga region. Similar stratigraphic conditions were described at different sites of the Volga-Oka basin, where a sterile Preboreal-Boreal layer of blue-grey sand (clay) was recorded at Sakhtysh IIa, and Ivanovskoe III and VII. It is important to note that underlying Mesolithic layers have been recorded at many sites in the Upper Volga region.

At Ivanovskoe III, the lower part of a blue-grey sandy layer was dated to 7470–6825 cal BC (Le-3096, 8150 ±100 BP) and 7516–7069 cal BC (Le-3099, 8260± 100 BP) (*Krainov* et al. *1990.30*). It was followed by a layer of grey, peaty sand with Mesolithic finds (bone, wood and flint artefacts), followed by the UVC layer. The Mesolithic layers – III (in dark-olive gyttja and peaty sand) and IV (in the ginger-brown peat layer with an admixture of sand and peaty sand) – were dated to the Boreal period. Pollen analysis showed that the earliest cultural layer (IV) was formed at the beginning of the Boreal period (charcoal from this layer was dated to 8351–8221 cal BC (GIN-7475a, 9070±50 BP), and cultural layer III – to the end of the Boreal period. The trunk of a deciduous tree in square 177, found in the layer of light gyttja which covered cultural layer III, was dated to 7049–6687 cal BC (GIN-8858, 7960±60 BP) (*Sulerzhitskiy* et al. *1998.27*). UVC pottery fragments were found in clearly distinguished buried soil at Ivanovskoe VII (cultural layer II), and were absent beneath it (in cultural layer IIa) (*Zhilin 1998.14*). Part of the site where this layer was deposited had been flooded, which can be attested by an admixture of gyttja in the layer (*Zhilin 1998.14*). Cultural layers II and IIa are attributed to the Atlantic period (*Zhilin 1998. 21*). Samples of peat from cultural layer IIa were dated to 6535–6088 cal BC (Le-1260, 7490±120 BP) and 6590–5918 cal BC (Le-1261, 7375±170 BP). Thus pottery of the UVC found in overlying layer II must be younger than these dates.

At Sakhtysh IIa, the date of a fish trap (#1) (GIN-10 860, 7390±40 BP, 6392–6208 cal BC) (Tab. 1.32) left in a littoral part of the site (Fig. 3), located slightly lower than undecorated UVC pottery in the western part of the trench, could indicate the first stages of site use, probably at the very end of the Mesolithic. It corresponds to the accumulation of a low part of a greenish-brown peat layer (IIg). Pottery use probably began at around 6000 cal BC (see Chronological modelling). It is more difficult to separate the appearance of early pottery decorated with roundish impressions (UVC stage I.1) and falsecord impressions (UVC stage I.2). An elk skull at the Okaemovo 18 site, found at the base of a layer with an accumulation of UVC pottery fragments, decorated by drop-like impressions (UVC stage I.1), was dated to 5813–5617 cal BC (GIN-6416, 6800±60 BP) (*Engovatova* et al. *1998.14*).

One must also take into account the active use of this part of Sakhtysh IIa over a long period, which is evidenced by the dates of several archaeological finds stratified with UVC pottery. Another fish trap no. 2, located slightly higher, in the same layer, IIg, rather close to fish trap no. 1 (Fig. 3) is dated to 5790–5639 cal BC (GIN-12985, 6830±40 BP; Tab. 1.28).

A wooden pile or stake was dated to 5974–5741 cal BC (GIN-12986, 6960±40 BP; Tab. 1.29). It was lying almost horizontally above a layer with undecorated UVC pottery fragments (Fig. 3). This stake is supposed to be more recent than the undecorated UVC pottery fragments, as it lay above them. We might suppose that it was deposited on the level of the ancient land surface, serving as a marker of an upper border of this microstratigraphic horizon. Several dates made on organic crust on pottery fragments found in this level appeared to be slightly

older or synchronous with this date. Also, a bone arrowhead (at -240cm) (Fig. 3) was dated to 6010–5890 cal BC (KIA-39304, 7070±28 BP; Tab. 1.37). It was found just on the border of greenish-brown peat (IIg) and dark-brown peat (IIv) and is dated to the same time as early undecorated UVC deposited here.

A three-dimensional analysis of pottery attributed to stages I.2 and II at Sakhtysh IIa does not clarify their chronological position, as some layers might have been washed away, and possible different periods of occupation were not marked by accumulations of layers or interlayers. A young elk cow skull, dated to 5311–5054 cal BC (GIN-10923, 6230±50 BP; Tab. 1.30), was found in a lower part of the dark-brown peat layer (layer IIv; -227cm – upper part of a skull, deposited at a depth of -241cm; the upper part of the skull is indicated on a 3D model; Figs. 3–4). It could be synchronous with pottery of UVC stage III, which was also found in this part of the layer.

Fig. 6. Sakhtysh IIa (1–4, 6–9), Sakhtysh II (5, 10). Macrotraces on pottery fragments: 1, 3, 6 different types of bottom construction; 2, 4a, 5, 8b, 7a coils junction; 4c, 5c, 7b N-junction of coils with different degree of coil stretching; 4b, 8a surface treatment; 9b coil/slab technique; 10b S-junction of coils; 9a traces of finger pinching.

Charcoal from a fire-place with an accumulation of UVC ceramic fragments (I.2 stage) at Voimezhnoe 1 was dated to 5646–5320 cal BC (GIN-6868, 6550±100 BP). Worked wood from this layer was dated to 5476–5327 cal BC (GIN-5926, 6430±40 BP) (*Engovatova* et al. *1998.12*).

At Ozerki 5, wood chip waste from the deeper part of the layer with pottery decorated by long comb impressions and oblique traced lines with oval impressions and short impressions of comb stamp (III stage) was dated to 5674–5044 cal BC (GIN-7215, 6450±160 BP) (*Engovatova* et al. *1998.17*).

Conclusion

Different chronological schemes have been proposed for the UVC (see *e.g., Engovatova 1998; Zaretskaya, Kostyleva 2008*). The first were based on all the available radiocarbon dates obtained both for archaeological materials and for the deposits where these materials were found. In both cases, these dates might be deemed as not completely adequate, particularly for the case of multiple occupations of the same site (see *Mazurkevich 2009*). This could have created an illusion of the long-term existence of different stages and the evolutionary character of their development. A chronological time scale for different stages of the UVC can now be reconstructed based on the analysis of the radiocarbon dates from Sakhtysh IIa, and their correlation with dates from other sites that correspond precisely with a definite type of UVC. As radiocarbon dates made on organic crust seem to be controversial due to possible reservoir effects, dates made on bones and wood can be regarded as points of reference, assuming these samples were found relatively in situ.

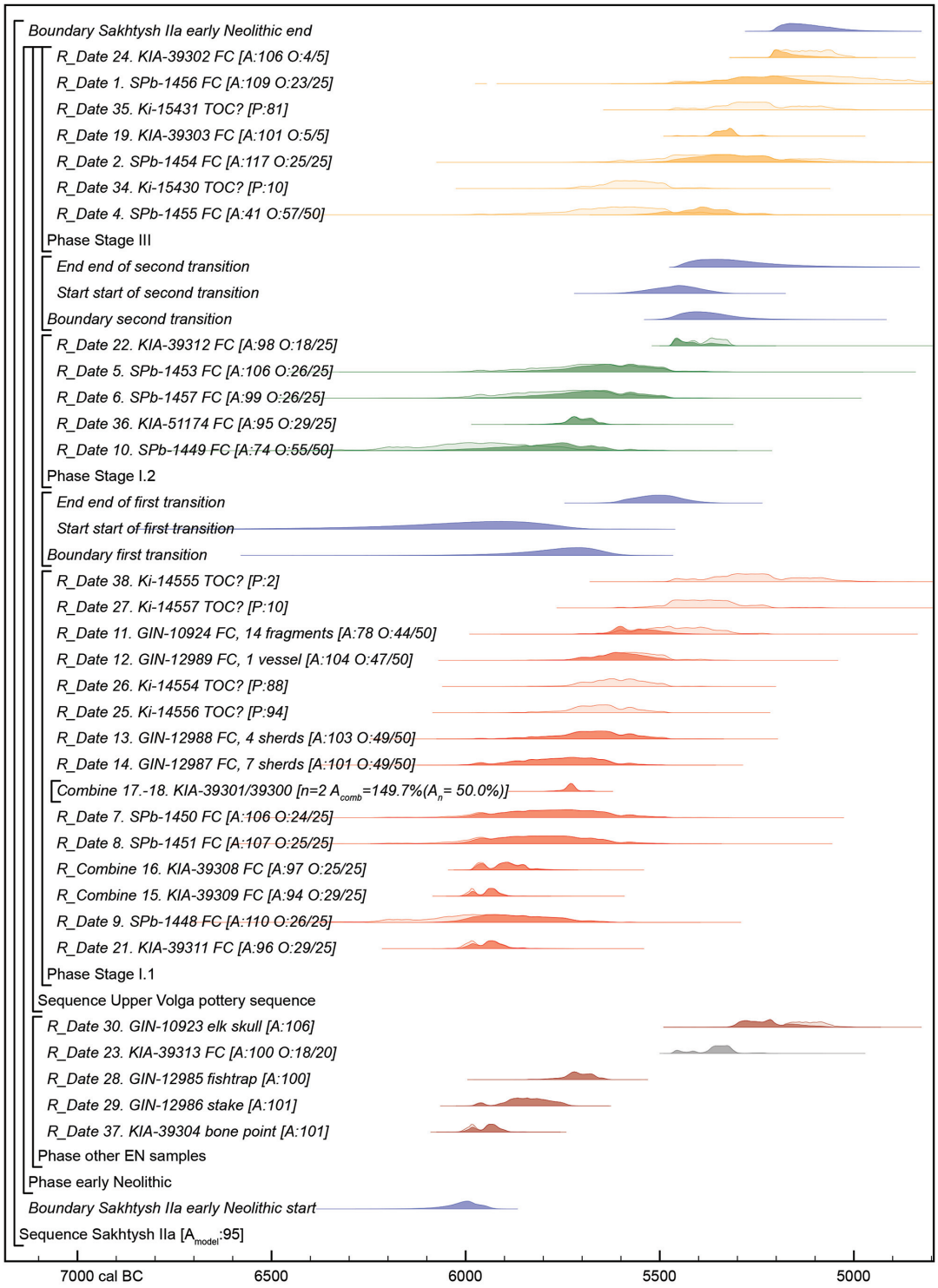

Fig. 7. Bayesian chronological model of radiocarbon results from Sakhtysh IIa. The model structure shown assumes that there was a typo-chronological sequence of three stages, with gradual transitions between stages (*Lee, Bronk Ramsey 2012*). TOC results are not used in the model, while food crust results have been modelled using a one-tailed type-r Outlier Model that allows for the possibility of freshwater reservoir effects, but is biased towards minimal offsets (*Bronk Ramsey 2009b*; parameters: –Exp(1,–10,0), U(0,2); the chronology obtained without the Outlier Model is almost identical). Pale distributions are simple calibrated dates; intense distributions are modelled dates (posterior density estimates of the dates of samples and associated events). Legend: FC = food crust, TOC = total organic carbon content of pottery; A = OxCal index of agreement between calibrated and modelled date of each sample; P = probability that calibrated date fits this phase in the model; O = posterior/prior % probability that a date is an outlier, given the Outlier Model parameters.

Sakhtysh II is a particular case of stratification of various pottery types attributed to all stages of UVC, which permits a reconstruction of the pottery typo-chronological sequence and occupation history in the Upper Volga area. The spatial distribution of all finds and dates was used to inform the interpretation of the dates, taking into account the complexity of dating organic crust on hunter-gatherer pottery. Thus, different levels of occupation were therefore recognised according to the layering of archaeological material. Various levels with pottery attributed to different stages of the UVC, evidenced at Sakhtysh IIa, could indicate definite chronological periods of this occupation connected with periodic regressions of paleolakes. Some downward movement of later ceramic fragments might be supposed, based on general patterns of find distribution and single artefacts which are found below their corresponding layers. Further on relative and absolute chronology created for different stages of UVC were interrelated, allowing an independent typo-chronological scheme to be created.

The proposed typo-chronological sequence for UVC pottery implies that undecorated or sparsely decorate pottery and pottery decorated with rare oval impressions (I.1 stage) was gradually replaced by, or co-existed with, pottery decorated by false-cord impressions and traced lines (I.2 stage), then by pottery decorated with short teeth impressions (II stage), and, probably, after some hiatus pottery decorated with comb-stamp impressions (III stage) was deposited here. The proposed model indicates that pottery probably first appeared at Sakhtysh IIa in 6040–5950 cal BC and that the Early Neolithic phase ended in 5200–5070 cal BC. It is difficult at present to separate the appearance of early pottery decorated by roundish impressions (UVC stage I.1) and false-cord impressions (UVC stage I.2). Three-dimensional analysis of pottery attributed to stages I.2 and II at Sakhtysh IIa does not clarify their chronological position, as some layers might have been washed away and possible different periods of occupation were not marked by an accumulation of layers or interlayers. It might be supposed that pottery attributed to stage I.2 could also have existed during the middle of the 6th millennium BC. The second half of the 6th millennium BC is when stage III appeared and further developed. It is difficult to detect any gaps in the calibrated dates, but the large uncertainties in many of the dates do not allow us to exclude significant hiatuses. The model demonstrates that the stratigraphic division of Upper Volga pottery into typo-chronological phases is justified by radiocarbon ages from food crusts. These dates combined with three-dimensional analysis refine the absolute and relative chronological three-stage scheme of Upper Volga culture. Also, some dates of pottery decorated in different traditions – by triangular impressions and long comb stamp – appear to overlap. This must be explained, and further research is needed that includes not only radiocarbon dating, but also analysis of decoration, the technology of pottery making, three-dimensional analysis of pottery distribution, and chemical composition of organic crust that has been dated.

Similarities between the pottery from the Upper Volga region and other ceramic collections found at sites located far away (due to specific decoration and technological features) may be evidence of contact with other cultural traditions. It is important to date these distinct ceramic types and events, which could improve the chronology of ceramic stages of the UVC. We might assume long-distance contacts with communities from other regions either by demic diffusion or diffusion of ideas, reflected in different pottery types that appeared here. Obviously, local 'Mesolithic' inhabitants played an important role in this process.

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Tab. 1. Radiocarbon dates for materials from Sakhtysh IIa.

No.	^{14}C (BP)	cal BC (2σ)	lab-index	dated material	δ^{13}C	information about dated material
1	6186±150	5469–4796	SPb-1456	food crust	–21.3‰	excavation of 2004, layer IIa,
2	6372±150	5617–5001	SPb-1454	food crust	–23.4‰	excavation of 2004, No. 205,
3	6411±150	5632–5033	SPb-1452	food crust	–27.7‰	excavation of 1999, layer IIg,
4	6669±150	5877–5328	SPb-1455	food crust	–27.1‰	excavation of 2004, layer IIb,
5	6753±150	5986–5389	SPb-1453	food crust	–24.7‰	excavation of 2004, No. 223,
6	6832±150	6001–5491	SPb-1457	food crust	–25.2‰	excavation of 2004, layer III,
7	6874±150	6033–5522	SPb-1450	food crust	–20‰	excavation of 2004, layer IIg,
8	6920±150	6074–5554	SPb-1451	food crust	–19.1‰	excavation of 2004, layer IIg,
9	7065±150	6231–5667	SPb-1448	food crust	–22.45‰	excavation of 1999, layer IIg,
10	7088±150	6246–5669	SPb-1449	food crust	–22.4‰	excavation of 2004, layer IIg,
11	6500±100	5632–5300	GIN-10924	food crust		organic crust from 14 fragments shell-tempered), layer IIg
12	6650±100	5738–5382	GIN-12989	food crust		organic crust from 4 fragments
13	6760±110	5877–5486	GIN-12988	food crust		organic crust from 4 fragments,
14	6850±110	5983–5564	GIN-12987	food crust		organic crust from 7 fragments,
15	7037±27	5991–5849	KIA-39309	food crust	–20.1‰	excavation of 2004, layer Iig,
16	7018±45	5999–5794	KIA-39308	food crust	–20.91‰	excavation of 2004, layer Iig,
17	6860±31	5833–5669	KIA-39301	food crust	–24.43‰	sq. 25, depth –249cm, layer IIg
18	6847±31	5798–5662	KIA-39300	Plant (willow string) on pottery (KIA-39301)	–26.88‰	sq. 25, depth –249cm, layer IIg
19	6348±26	5463–5227	KIA-39303	food crust	–23.37‰	excavation of 2004, sq. 32,
20	7356±30	6353–6090	KIA-39310	food crust	–29.03‰	excavation of 2004, sq. 25, impressionsput in gemotric
21	7072±36	6019–5887	KIA-39311	food crust	–24.08‰	excavation of 1999, sq. 14,
22	6395±28	5468–5319	KIA-39312	food crust	–26.70‰	excavation of 2004, sq. 29, depth
23	6371±30	5467–5305	KIA-39313	food crust	–26.49‰	excavation of 2004, layer IIg
24	6160±27	5213–5030	KIA-39302	food crust	–25.01‰	excavation of 2004, sq. 32,
25	6740±90	5802–5488	Ži-14556	total organic content in sherd		excavation of 2004, sq. 26,
26	6690±90	5739–5478	Ži-14554	total organic content in sherd		excavation of 2004, sq. 24,
27	6410±90	5544–5214	Ži-14557	total organic content in sherd		excavation of 2004, layer IIg,
28	6830±40	5790–5639	GIN-12985	wood (part of the fish-trap #2)		excavation of 2004, sq. 17/18,
29	6960±40	5974–5741	GIN-12986	wood (stake)		excavation of 2004, sq. 26,
30	6230±50	5311–5054	GIN-10923	bone (skull of a young elk cow)		excavation of 1999, sq. 4/8,
31	7220±70	6231–5986	GIN-12984	peat, where a fish-trap #2 (GIN-12985) was found		excavation of 2004, sq. 17/18,
32	7390±40	6392–6106	GIN-10860	wood (part of the fish-trap #1)		excavation of 1999, sq. 7,
33	7530±60	6471–6248	GIN-10861	peat, where a fish-trap #1 was found (GIN-10860)		excavation of 1999, peat where lithological layer, where cultural
34	6640±90	5726–5389	Ki-15430	total organic content in sherd		pottery fragment decorated
35	6280±80	5467–5047	Ki-15431	total organic content in sherd		pottery fragment decorated
36	6834±34	5780–5640	KIA-51174	food crust (95mg)	–25.0‰; δ^{15}N 5.6‰	excavation of 2015; sq. 6,
37	7070±28	6010–5890	KIA-39304	piece with oblique truncation	–19.93‰	excavation of 1999, layer IIg,
38	6290±90	5471–5046	Ki-14555	total organic content in sherd		excavation of 2004, layer IIg,
39	9500±33	8872–8710	KIA-39305	bone knife		excavation of 2004, layer III,

	cultural context	publication
square 25, depth –155cm	Upper Volga culture (III stage)	
layer Ia, square 32, depth –130cm	Upper Volga culture (III stage)	
square 4, depth –229cm	Upper Volga culture (I.2 stage)	
square 27, depth –229cm	Upper Volga culture (III stage)	
layer IIg, sq. 28, depth –261cm	Upper Volga culture (I.2 stage)	
square 20, depth –281cm	Upper Volga culture (I.2 stage)	
square 23, depth –265cm	Upper Volga culture (I.1 stage)	
square 26, depth –262cm	Upper Volga culture (I.1 stage)	
square 12/8, depth –242cm	Upper Volga culture (I.1 stage)	
square 27, depth –257cm	Upper Volga culture (I.2 stage)	
of undecorated pottery (with flat bottom and straight rims,	Upper Volga culture (I.1 stage)	*Zaretskaya, Kostyleva 2008*
of one vessel, border of the squares 19/23, layer IIg	Upper Volga culture (I.1 stage)	*Zaretskaya, Kostyleva 2008*
square 22–24 and 32	Upper Volga culture (I.1 stage)	*Zaretskaya, Kostyleva 2008*
square 23, 18, 19, 24	Upper Volga culture (I.1 stage)	*Zaretskaya, Kostyleva 2008*
sq. 11, depth –244cm (flat bottom)	Upper Volga culture (I.1 stage)	*Hartz* et al. *2012*
sq. 18, depth –248cm (undecorated rim sherd)	Upper Volga culture (I.1 stage)	*Hartz* et al. *2012*
(same sherd as KIA-39300) (undecorated rim sherd)	Upper Volga culture (I.1 stage)	*Hartz* et al. *2012*
(same sherd as KIA-39301)	Upper Volga culture (I.1 stage)	*Hartz* et al. *2012*
depth –223cm, layer IIb	Upper Volga culture (III stage)	*Hartz* et al. *2012*
depth –294cm, layer IIg (rim fragment decorated by oval compositions)	Upper Volga culture (I.2 stage)	*Hartz* et al. *2012*
depth –266cm, layer IIg	Upper Volga culture (I.1 stage)	*Hartz* et al. *2012*
–258cm, layer IIg (fragment decorated by a false-cord decor)	Upper Volga culture (I.2 stage)	*Hartz* et al. *2012*
	Upper Volga culture	*Hartz* et al. *2012*
depth –213cm, layer IIb	Upper Volga culture (III stage)	*Hartz* et al. *2012*
depth –262cm, layer IIg	Upper Volga culture (I.1 stage)	Vybornov, Kostyleva 2009
depth –263cm, layer IIg	Upper Volga culture (I.1 stage)	Vybornov, Kostyleva 2009
sq. 28, depth –263cm	Upper Volga culture (I.1 stage)	Vybornov, Kostyleva 2009
layer IIg	Upper Volga culture	*Zaretskaya, Kostyleva 2008*
layer IIg	Upper Volga culture	*Zaretskaya, Kostyleva 2008*
depth –227 up to 241cm, layer IIv	Upper Volga culture	*Zaretskaya, Kostyleva 2008*
layer IIg	–	*Zaretskaya, Kostyleva 2008*
–260cm, layer IIIa	final Mesolithic (?)	*Zaretskaya, Kostyleva 2008.10*
a fish-trap (GIN-10860) was found, low part of the layer IIg and IIIa are deposited	–	*Zaretskaya, Kostyleva 2008*
by a long comb stamp and roundish impressions	Upper Volga culture (III stage)	*Vybornov 2012*
by a long comb stamp and roundish impressions	Upper Volga culture (III stage)	*Vybornov 2012*
depth –236cm	Upper Volga culture (I.2 stage)	
square 3, depth –240cm	Upper Volga culture	
sq. 28, depth –263cm	Upper Volga culture (I.1 stage)	*Vybornov, Kostyleva 2009*
sq. 30, depth –263cm	Mesolithic	

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