HUNTER-GATHERER POTTERY AND CHARRED RESIDUE DATING: NEW RESULTS ON EARLY CERAMICS IN THE NORTH EURASIAN FOREST ZONE

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ABSTRACT. This article discusses 18 accelerator mass spectrometry (AMS) radiocarbon dates from the peat bog sites Sakhtysh 2a, Ozerki 5, and Ozerki 17 in the Upper Volga region. The aim is to contribute to a better understanding of the emergence and dispersal of early ceramic traditions in northern Eurasia and their connection to the Baltic. With 1 exception, all dates were obtained from charred residue adhering to the sherd. A possible reservoir effect was tested on 1 piece of pottery from Sakhtysh 2a by taking 1 sample from charred residue, and another sample from plant fiber remains. Although a reservoir effect was able to be ruled out in this particular case, 4 other dates from Sakhtysh 2a and Ozerki 5 seem too old on typological grounds and might have been affected by freshwater reservoir effects. Considering all other reliable dates, the Early Neolithic Upper Volga culture, and with it the adoption of ceramics, in the forest zone of European Russia started around 6000 cal BC.

BACKGROUND: HUNTER-GATHERER CERAMICS IN NORTHERN EURASIA

Early ceramic traditions of eastern Europe play a key role for our understanding of Stone Age cultural contacts and technological transfer between east and west. These traditions are characterized by a specific, often pointed-base pottery, and by the hunter-gatherer economy of their bearers. Pottery is seen as the main defining marker of the Neolithic period in this region (Oshibkina 2006), while in central and western Europe, a different definition of the Neolithic based on a food-producing economy is preferred (Scharl 2004). This article follows the local, "eastern" terminology. There is increasing evidence that ceramics from eastern Europe stimulated the onset of pottery production further west and that the new technology reached the southern Baltic coast in the 5th millennium cal BC. The appearance of this pottery was not, as has been previously thought, triggered by influences from Neolithic farming communities further south but rather represents an independent development, the roots of which must be sought further east in the vast expanses of the northern Eurasian landmass (Timofeev 1998; Klassen 2004:109–17; Gronenborn 2009; Jordan and Zvelebil 2009:33–7).

Starting in the first half of the 7th millennium cal BC, the early pottery of the Russian forest steppe in the lower Volga region belongs to the oldest ceramic traditions on the European continent, even predating the introduction of ceramics into mainland southeastern Europe (Zaitseva et al. 2008; Dolukhanov et al. 2009:239–40; Müller 2009:63–4). Towards the end of the 7th millennium cal BC, the new technology had dispersed into the forest zone where in central Russia an early center of ceramic production emerged (Nikitin 2008:257–8). In the region between the Volga and Oka rivers, the Mesolithic Butovo culture terminated around 6000 cal BC with the transition to the Early Neolithic Upper Volga culture, which was the first pottery-bearing culture in this region. The Upper Volga culture is divided into 3 stages and ended around 5000 cal BC with the transition to the Middle and Late Neolithic Lyalovo culture, which formed part of the larger entity of pit-comb ware cultures subsequently spreading across much of the eastern European forest zone (Engovatova et al.

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1998). This culture is subdivided into 4 stages (archaic, early, middle and late) and existed up until ~3900 cal BC (Zaretskaya and Kostyleva 2010:181–2). Our understanding of the absolute chronology of the dispersal and early development of the first ceramics in the Volga-Oka region, however, has been solely based on conventional radiocarbon dates, most of which derived from contextual material such as peat, worked wood, charcoal, and bone. Only very recently a number of conventional ^{14}C dates were received for pottery crust in exceptional cases where large amounts of charred residue adhering to the sherds made conventional dating possible (Zaretskaya and Kostyleva 2008, 2010). In a number of regions of European Russia, conventional ^{14}C dates are produced by using entire pottery fragments as samples (cf. Zaitseva et al. 2008:218). The reliability of these dates, however, is still under discussion because sometimes systematic differences compared to context dates have been noticed (Nikitin 2008:257). Altogether, the accelerator mass spectrometry (AMS) method with its small sample size provides a valuable opportunity to test, refine, and, where necessary, correct current ideas on pottery development on the basis of direct dates for individual ceramic vessel units.

A controversial debate concerns the introduction of the first ceramics further east as a result either of cultural contacts or of independent inventions (Kuzmin and Vetrov 2007:15–6; Jordan and Zvelebil 2009:68–75). In southern China, the earliest ceramic vessels were already produced between ~16,350 and 15,550 cal BC (Boaretto et al. 2009). In the Late Glacial, pottery began to be used on the Japanese archipelago between ~14,800 and 13,750 cal BC (Keally et al. 2004; Kudo 2004; Yoshida et al. 2004), and in the Amur Basin of the Russian Far East the new technology became known between ~14,550 and 12,150 cal BC (Kuzmin 2006, 2010).

The region east of Lake Baikal is claimed to provide some of the earliest assemblages with pottery outside these initial ceramic-producing centers (Kuzmin and Orlova 2000; Kuzmin 2006, 2010; Jordan and Zvelebil 2009:69). Among the most important sites are the monuments of the Ust-Karenga cluster at the confluence of the Vitim and Karenga rivers. These sites have produced a series of ^{14}C dates for the Early Neolithic layer that reach back into the Late Paleolithic (Kuzmin and Vetrov 2007). While the charcoal dates for layer 7 show a larger range of results, 3 dates on foodcrust samples indicate an onset of pottery production at Ust-Karenga in the late Allerød period (~11,000 cal BC). Comparatively early dates in the later 12th and the 11th millennium cal BC are also reported from pottery-bearing layers at Ust-Kyakhta on the right bank of the Selenga River close to the Russian-Mongolian border, and from Studenoe 1 on the right bank of the Chikoi River in the southern part of Transbaikalia (McKenzie 2009:181–3). However, the reliability of the early dates from Ust-Kyakhta and Studenoe 1 obtained on charcoal and soil samples is still subject to debate (Kuzmin and Vetrov 2007; McKenzie 2009:181, 183).

In western Siberia and the eastern Urals, the earliest pottery-bearing contexts date to the second half of the 7th millennium cal BC (Timofeev et al. 2004:47–8; Chairkina and Kosinskaya 2009).

AIMS AND METHODS

Recently, a Russian-German research team has started to take a systematic approach to improve the absolute chronology of the early hunter-gatherer ceramics. The authors initiated a program on direct AMS ^{14}C dating of organic objects and charred residue (foodcrust, soot coating) adhering to the pottery fragments themselves. It is the idea to establish series of AMS dates on pottery from key sites ranging from the eastern Baltic across the Upper Volga and the Urals area to the Transbaikal region in Siberia in the east. For the Baltic, important steps forward have been taken in this respect in recent years, resulting in a net of direct dates on early hunter-gatherer ceramics that has become already rather dense in regions such as Fennoscandia (Hallgren 2004; Skandfer 2005; Piezonka 2008;

Pesonen and Leskinen 2009). In Russia, too, efforts to produce direct ^{14}C dates for the earliest pottery have intensified (e.g. Kuzmin and Vetrov 2007; Zaretskaya and Kostyleva 2008, 2010; Karmanov et al., these proceedings). The AMS method is especially well suited to draw a more reliable and detailed picture of the typological and regional developments of early ceramics. At the same time, it provides the opportunity to combine the analysis of the samples for dating with the analysis of stable isotopes, thus furnishing additional information not only on pottery functions and on the diet and subsistence strategies of the manufacturers, but also on possible reservoir effects influencing the dating results (Philippsen et al. 2010).

In this paper, a series of 18 new AMS ^{14}C dates of organic residues on pottery from 3 central Russian sites are discussed against the background of the dispersal of ceramic technology in northern Eurasia and the further development of early hunter-gatherer pottery styles after its initial introduction (Table 1; Figures 1 and 2). Twelve samples from Sakhtysh 2a and Ozerki 17 were analyzed and dated at the Leibniz Laboratory for Age Determination and Isotope Analysis of Kiel University, Germany, and 6 samples from Ozerki 5 were dated at the AMS ^{14}C Dating Centre of Aarhus University, Denmark. Sample preparation followed international standards (e.g. Olsen et al. 2010). Only the $\delta^{13}C$ values for Ozerki 5 were determined by mass spectrometry.

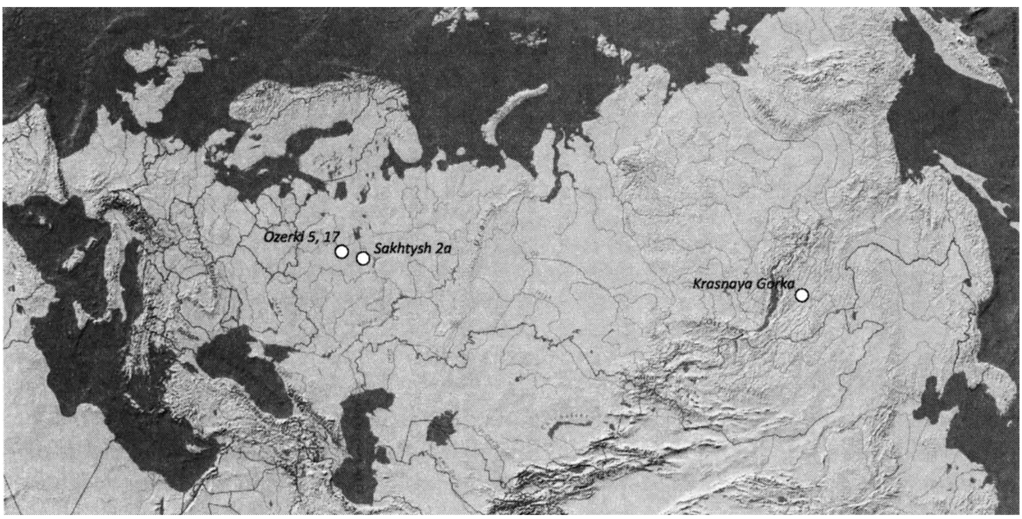

Figure 1 Eurasian sites with early ceramics from which residue on pottery was AMS dated during the project (map base: German Archaeological Institute, Eurasia Department).

NEW AMS DATES OF HUNTER-GATHERER POTTERY FROM THE UPPER VOLGA REGION

Sakhtysh 2a

The Sakhtysh peat bog is located in the Teikovo district of the Ivanovo region in the central part of European Russia (Figure 1). Thick accumulations of archaeological materials on several locations along an ancient lake shore attest to various chronological stages from the early Mesolithic to the early Iron Age. Scientific investigations of the Sakhtysh complex began in the 1960s and have since revealed large amounts of early pottery in close association with a rich flint industry and a variety of animal bones, charcoal, wood, and other organic finds. A series of conventional ^{14}C datings were conducted, including conventional dates from samples of charred crust adhering to pottery (Zaretskaya and Kostyleva 2008).

Table 1 AMS samples with context information and dating results.[a] Note: $\delta^{13}C$ values from Kiel laboratory (KIA dates): were obtained during AMS dating.

Site	Context	Material	Sample size (mg of C)	Lab nr	^{14}C age (BP)	$\delta^{13}C$ (‰)	Age cal BC (95.4%)
Sakhtysh 2a	Trench 2004, sq. 25, depth 2.94 m, layer IIg	Charred residue on pottery	10.2	KIA 39310	7356 ± 30	–29.03	6354–6089
	Trench 1999, sq. 14, depth 2.66 m, layer IIg	Charred residue on pottery	10.0	KIA 39311	7072 ± 36	–24.08	6020–5886
	Trench 2004, sq. 11, depth 2.44 m, layer IIg	Charred residue on pottery	7.2	KIA 39309	7037 ± 27	–20.10	5991–5846
	Trench 2004, sq. 18, depth 2.48 m, layer IIg	Charred residue on pottery	9.0	KIA 39308	7018 ± 45	–20.91	6000–5792
	Sq. 25, depth 2.49 m, layer IIg (same sherd as KIA 39301)	Plant (willow string) on pottery	4.7	KIA 39300	6847 ± 31	–26.88	5801–5662
	Sq. 25, depth 2.49 m, layer IIg (same sherd as KIA 39300)	Charred residue on pottery	12.1	KIA 39301	6860 ± 31	–24.43	5835–5668
	Trench 2004, sq. 29, depth 2.58 m, layer IIg	Charred residue on pottery	9.7	KIA 39312	6395 ± 28	–26.70	5469–5319
	Trench 2004, layer IIg	Charred residue on pottery	4.2	KIA 39313	6371 ± 30	–26.49	5468–5304
	Trench 2004, sq. 32, depth 2.23 m, layer IIb	Charred residue on pottery	9.7	KIA 39303	6348 ± 26	–23.37	5463–5226
	Trench 2004, sq. 32, depth 2.13 m, layer IIb	Charred residue on pottery	12.9	KIA 39302	6160 ± 27	–25.01	5213–5029
Ozerki 5	Trench 1994, sq. 150, depth 0.83 m, layer II	Charred residue on pottery	Not specified	AAR 14545	7412 ± 28	–30.05	6372–6231
	Trench 1990, layer II (western part)	Charred residue on pottery	Not specified	AAR 14542	7010 ± 33	–29.68	5987–5811
	Trench 1994, sq. 137, depth 1.18 m, layer IIa (II)	Charred residue on pottery	Not specified	AAR 14544	6528 ± 27	–27.09	5550–5468
	Trench 1994, sq. 137, depth 1.06 m, layer IIa	Charred residue on pottery	Not specified	AAR 14543	6479 ± 26	–27.40	5486–5373
	Trench 1993, sq. 103, depth 1.25 m, layer I	Charred residue on pottery	Not specified	AAR 14541	5971 ± 25	–27.96	4935–4791
	Trench 1993, sq. 105, depth 1.49 m, layer I	Charred residue on pottery	Not specified	AAR 14540	5898 ± 25	–31.62	4831–4715
Ozerki 17	Excavations 1991–1993, layer III	Charred residue on pottery	11.3	KIA 39306	6369 ± 27	–28.47	5466–5304
	Trench 1992, sq. 38, depth 2.30–2.32 m, layer II	Charred residue on pottery	11.9	KIA 39307	5693 ± 29	–25.55	4605–4457
Krasnaya Gorka	Trench 1, layer 2	Charred residue on pottery	0.7	KIA 42073	8345 ± 66	–25.08	7541–7187

[a]Dates calibrated using OxCal v 4.1 (Bronk Ramsey et al. 2009) and the IntCal09 curve data (Reimer et al. 2009).

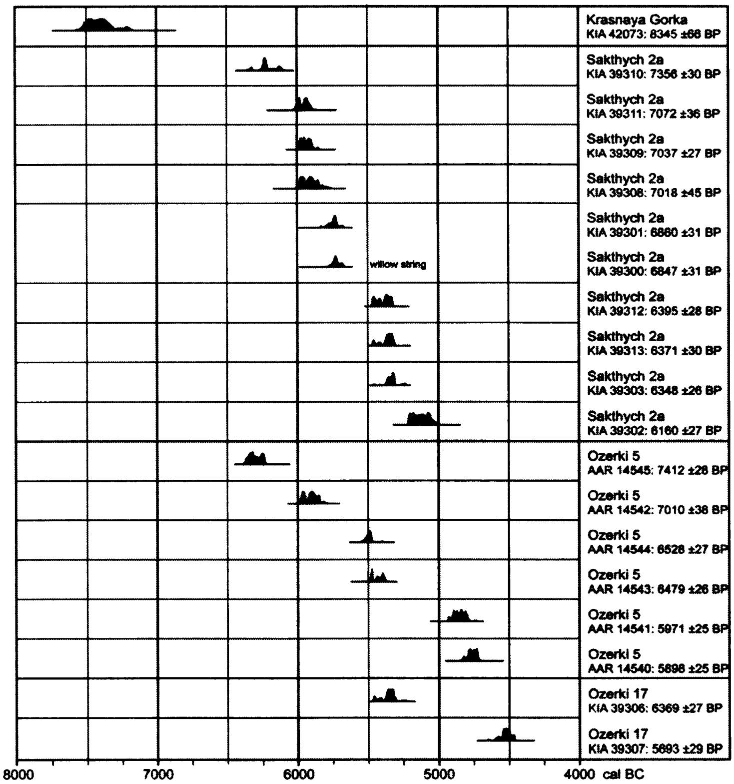

Figure 2 Calibrated AMS dating results of the samples from Sakhtysh 2a, Ozerki 5, Ozerki 17, and Krasnaya Gorka. Calibration was conducted using OxCal v 4.1 (Bronk Ramsey 2009) and IntCal09 data (Reimer et al. 2009).

Sakhtysh 2a is a Mesolithic-Neolithic settlement site with clearly stratified Neolithic layers in its peat bog part. The stratigraphy reaches a height of ~2 m (Zaretskaya and Kostyleva 2008:8–9). Eight lithological layers can be distinguished, 2 of which contain Early Neolithic cultural remains. In the brown peat of lithological layer 5, ceramics of the developed Upper Volga culture were found that are decorated with imprints of cord imitations, short comb stamps, and stitch-and-furrow lines. Slight differences between the top and the bottom part of this stratum were noticed. In the upper section (cultural horizon IIa and b), the ceramic fragments are characterized by chamotte temper and a dense arrangement of the decoration zones, while in the lower part (cultural horizon IIv), the ornaments are more widely spaced. Here, some unornamented pottery fragments have also been found. The earliest pottery belonging to the early phase of the Upper Volga culture is found in a layer of greenish-brown peat (cultural horizon IIg). In the top part of this stratum, the remains of 5 to 7 vessels with pricked decoration were discovered, while most of the pottery came from the middle and lower parts of the layer.

Ten AMS dates resulted for samples taken from Sakhtysh 2a pottery (Table 1; Figures 2, 3, 4). Very valuable for the understanding of both the site stratigraphy and the early ceramic typology of the Upper Volga culture are 4 dates with ^{14}C ages older than 7000 BP (KIA 39310: 7356 ± 30 BP, Figure 3: 4; KIA 39311: 7072 ± 36, Figure 3: 3; KIA 39309: 7037 ± 27 BP, Figure 3: 5; KIA 39308: 7018 ± 45 BP, Figure 3: 6; Table 1). The samples stem from layer IIg, which is the earliest horizon with Neolithic materials on this site. Typologically, the 4 sherds represent characteristic examples of the early phase of the Upper Volga culture (cf. Kostyleva 1994): 2 rim sherds display simple ornaments comprised of small dots and notches, 1 rim sherd is undecorated, and the base sherd stems from a flat bottom. Three of the dates cover a narrow range from 6020 to 5792 cal BC. The fourth date (KIA 39310), however, is ~300 ^{14}C yr older. This potsherd produced the lowest δ^{13}C value of all Sakhtysh 2a samples (–29.03‰), and this might indicate a special vessel content involving fish or mollusks, resulting in a date too old for the pot due to a freshwater reservoir effect (Fischer et al. 2007; Olsen et al. 2010; Philippsen et al. 2010).

Figure 3 Sakhtysh 2a, Ivanovo region, Russia. Fragments of pottery from which AMS samples were taken: 1) KIA 39302 (6160 ± 27 BP); 2) KIA 39303 (6348 ± 26 BP); 3) KIA 39311 (7072 ± 36 BP); 4) KIA 39310 (7356 ± 30 BP); 5) KIA 39309 (7037 ± 27 BP); 6) KIA 39308 (7018 ± 45 BP); 7) KIA 30301 (6860 ± 31 BP) and KIA 39300 (6847 ± 31 BP); 8) KIA 39312 (6395 ± 28 BP); 9) KIA 39313 (6371 ± 30 BP) (photos: S Hartz).

The next 2 dates (KIA 30301: 6860 ± 31 BP; KIA 39300: 6847 ± 31 BP) stem from the same undecorated rim sherd also excavated in layer IIg (Figure 3: 7). One sample was taken from the charred residue adhering to the sherd, and the other from a piece of willow string that was embedded in the charred crust. This sampling strategy offered the opportunity to test a possible reservoir effect of the charred crust by the wood sample. In contrast to Fischer and Heinemeier (2003) and Boudin et al. (2009), who observed remarkable reservoir effects in foodcrust dates from Danish and Belgian

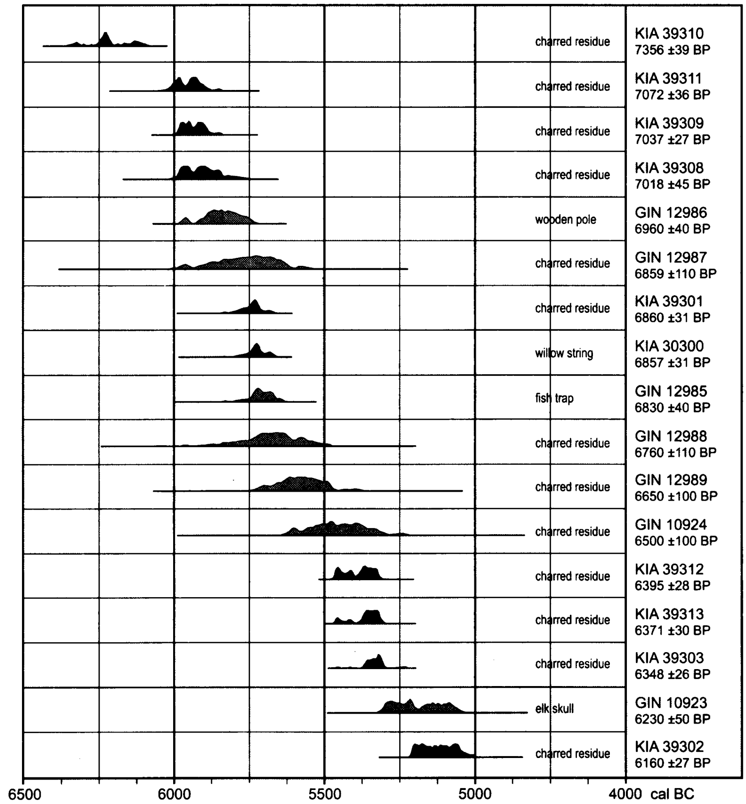

Figure 4 Sakhtysh 2a, Ivanovo region, Russia. New AMS dates against the background of existing conventional ^{14}C dates (GIN dates: after Zaretskaya and Kostyleva 2008: Table 2).

Stone Age pottery, the 2 dates from Sakhtysh 2a are very similar, showing no reservoir effect and dating the pottery fragment to a time bracket between 5835 and 5662 cal BC.

There are 3 dates (KIA 39312: 6395 ± 28 BP, Figure 3: 8; KIA 39313: 6371 ± 30 BP, Figure 3: 9; KIA 39303: 6348 ± 26 BP, Figure 3: 2) forming a younger cluster in the third quarter of the 6th millennium cal BC. The samples stem from charred residue on decorated rim sherds that display typological features of the developed Upper Volga culture such as rows of conical pits and other small impressions, and long as well as short comb stamps. While the 2 older samples were found in cultural layer IIg, the slightly younger specimen originated in layer IIb. From this stratum also stems the youngest sample in the AMS dating sequence from Sakhtysh 2a (KIA 39302: 6160 ± 27 BP, Figure 3: 1), which falls in the last quarter of the 6th millennium cal BC. This rim sherd displays the typical comb impression ornaments of the late Upper Volga culture pottery.

To sum up, the new AMS dates from Sakhtysh 2a cover the entire existence of the Upper Volga culture. The earliest date suggests the start of pottery production already at ~6300 cal BC. But because this date is isolated and related to the lowest $\delta^{13}C$ value, we give the younger cluster of 3 dates more confidence. The start of the initial pottery phase is thus dated to ~6000 cal BC. The reliability of these dates is corroborated by 2 results from the same pot, where a reservoir effect can definitely be ruled out. The subsequent AMS dates are in accordance with the pottery typology and help to describe the developments in more detail and precision.

Ozerki 5

The Ozerki peat bog in the Konakovo district of the Tver region is situated in the western part of the Upper Volga area (Figure 1). It has yielded numerous multilayered archaeological sites, among them more than 20 with Stone Age evidence. On 3 of them, Ozerki 5, 16, and 17, layers of the Early Neolithic Upper Volga culture have been discovered. These sites were excavated from 1990 to 1995 (Zhilin 1994, 1996, 2006). They had been occupied during regression phases of an ancient lake that later turned into the peat bog. The cultural layers had been originally covered by more than 5 m of peat, which was only in modern times partly removed during peat cutting.

A trench of ~200 m^2 was excavated at Ozerki 5 in 1990–1995, and 4 cultural layers were distinguished at the site. The uppermost layer (I), which has been severely disturbed during peat cutting, contained Middle Neolithic materials including pit-and-comb pottery. The second cultural layer (II) belongs to the middle Atlantic period according to pollen analysis and conventional ^{14}C dates (Zhilin et al. 1998). In this horizon, traces of fireplaces and clusters of finds were discovered, consisting mainly of a rich flint inventory and ceramic fragments. In the upper part of horizon II, pottery tempered with ground granite of the early Lyalovo culture was found together with ceramics and other cultural remains of the late phase of the Upper Volga culture. The lower part of this cultural layer (IIa) produced pottery of the middle stage of the Upper Volga culture, which is tempered with fine sand, chamotte, and organic admixture and decorated with horizontal rows and oblique lines of imprints. The third cultural layer (III) was distributed in the eastern part of the excavation, where cultural layer II was absent. It is dated to the first half of the Atlantic by pollen analysis. The abundant ceramic fragments from this stratum are tempered with ground sherds, sand, and organic matter; their outer surface has been polished. While most of the fragments were unornamented, some had been decorated with back-stepped imprints typical for the early stage of the Upper Volga culture. However, the most ancient pottery of the Upper Volga culture, similar to the type discovered at Sakhtysh 2a (see above), was not found. Cultural layer III overlies layer IV of the Mesolithic Butovo culture without any sterile streak in between.

One of the 6 AMS samples from Ozerki 5 (AAR 14545: 7412 ± 28 BP, Figure 5: 2) has produced a similarly old date as the oldest sample from Sakhtysh 2a (see Figure 2; Table 1). The dated potsherd stems from layer II and would on typological (long oblique comb stamps) and stratigraphic grounds be attributed to a more developed phase of the Upper Volga culture. The next result was retrieved for a large potsherd from the same layer, decorated with multidirectional comb stamps and pit-like impressions, and is remarkably younger (AAR 14542: 7010 ± 33 BP, Figure 5: 4). While the ^{14}C date places this sample in the group with the 3 early Upper Volga culture sherds from Sakhtysh 2a dated to the beginning of the 6th millennium cal BC (see above), typologically it resembles late Upper Volga culture ceramics, an attribution that is also confirmed by its stratigraphic position. Two dates around the middle of the 6th millennium cal BC were retrieved from charred residue on potsherds from layer IIa, which are also ornamented with oblique comb impressions (AAR 14544: 6528 ± 27 BP, Figure 5: 3; AAR 14543: 6479 ± 26 BP, Figure 5: 1). The results are in accordance with the expected age for this type of developed Upper Volga culture pottery and also with a conventional ^{14}C date that was retrieved from layer IIa (GIN 7215: 6450 ± 160 BP; Engovatova et al. 1998:17). Two dates of the Ozerki samples yielded results in the first half of the 5th millennium cal BC. Both of the sampled sherds were found in layer I, which is associated with middle to late Neolithic Lyalovo culture materials. The pit-comb decorated fragment that produced the slightly older result (AAR 14541: 5971 ± 25 BP, Figure 5: 5) represents a typical example of early Lyalovo pottery. The other sherd is ornamented with widely spaced pits (AAR 14540: 5898 ± 25 BP, Figure 5: 6) and typologically belongs to the late Lyalovo culture.

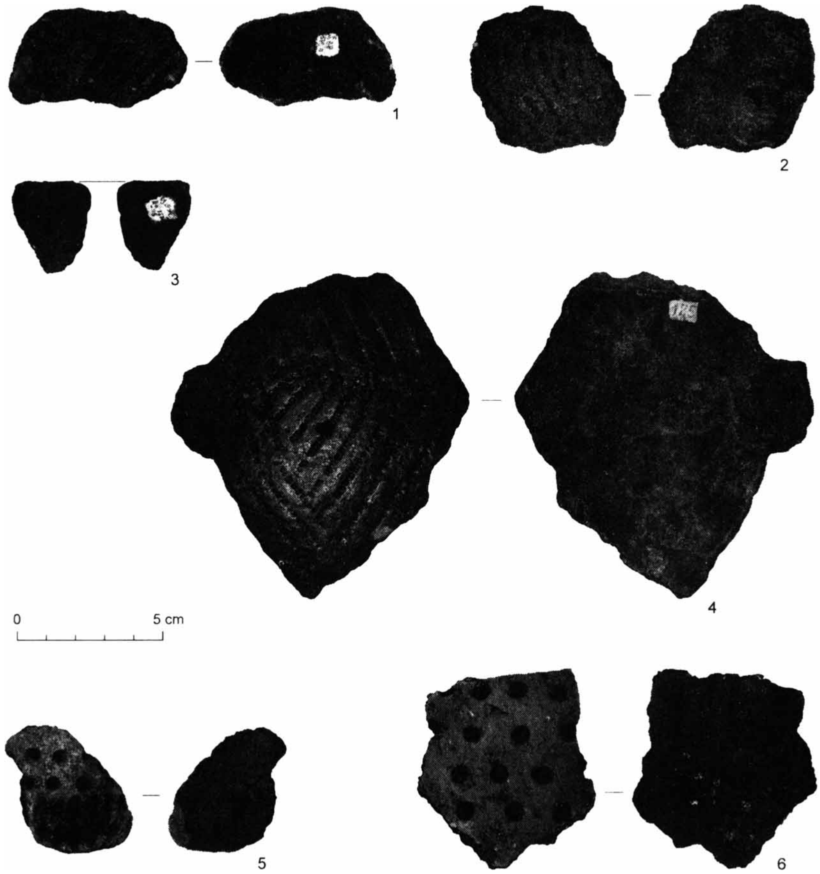

Figure 5 Ozerki 5, Tver region, Russia. Fragments of pottery from which AMS samples were taken: 1) AAR 14543 (6479 ± 26 BP); 2) AAR 14545 (7412 ± 28 BP); 3) AAR 14544 (6528 ± 27 BP); 4) AAR 14542 (7010 ± 33 BP); 5) AAR 14541 (5971 ± 25 BP); 6) AAR 14540 (5898 ± 5 BP) (photos: S Hartz).

Among the new AMS results from Ozerki 5, the 2 oldest dates (AAR 14545, AAR 14542) appear problematic with respect to the site stratigraphy and the established ideas on pottery development in the Upper Volga culture. On typological grounds, both fragments would be attributed to the later phases of the Upper Volga culture. Especially far off the expected value is the result of sample AAR 14545, which seems centuries too old even for the early Upper Volga culture. Furthermore, it contradicts the conventional ^{14}C evidence for the final stage of the Mesolithic Butovo culture from the lower layer of the same site (Zhilin 2006). The δ^{13}C values of both samples are among the lowest of the Ozerki 5 assemblage (AAR 14545: –30.05‰; AAR 14542: –29.68‰); thus, the apparent age offsets of ~1000 and ~500 yr, respectively, are probably caused by a freshwater reservoir effect (Fischer et al. 2007; Olsen et al. 2010). For the late Lyalovo sherd AAR 14540, the dating result is also not in accordance with the expected age but ~500 ^{14}C yr too old (cf. Zaretskaya and Kostyleva 2010). As this sample produced the lowest δ^{13}C value in the Ozerki 5 series (–31.62‰), this is another case where a freshwater reservoir effect has to be taken into consideration.

Ozerki 17

Ozerki 17 is located ~30 m east of Ozerki 5 and at this site a trench of 41 m^2 was excavated. The stratigraphical sequence consists of clay sediments at the base (former lake bottom) covered by sand and thick layers of peat. In the southern part of the excavation, the stratigraphy also included a limnic gyttja. Three Neolithic and 1 Mesolithic cultural horizon were identified during excavation. The uppermost layer (I) is situated in the lower part of a brown forest mire peat and contained some bones and flint flakes as well as 2 fragments of Middle Neolithic pit-and-comb pottery of the Lyalovo culture. The second cultural layer (II) is embedded in the lower part of an underlying forest mire peat and provided a number of animal bones, a bone point, flint flakes, and fragments of comb pottery of early Lyalovo type. Cultural horizon III coincides with a lens of forest mire sediments mixed with sand and peat. It produced numerous animal bones, some flint artifacts and bone arrowheads, various fishing equipment such as net floats and sinkers, and several pottery sherds of the middle Upper Volga culture. Pollen analysis dated the layer to the early Atlantic (Zhilin et al. 1998). Cultural horizon IV is connected to peat and gyttja layers further below and contains Mesolithic materials of the Butovo culture.

Until recently, ^{14}C dates were only available for the Mesolithic cultural layer of Ozerki 17 (Zhilin 1994). Two AMS samples taken from charred residue on potsherds thus provide the first absolute dates for the Neolithic layers of the site (Table 1; Figures 6 and 2). The older date (KIA 39306: 6369 ± 27 BP) was retrieved for a large decorated rim sherd from cultural layer III. This ceramic fragment represents a typical example of middle Upper Volga culture ware decorated by rows of elongated notches superimposed by oblique striations (Engovatova et al. 1998:13, Figure 1). The

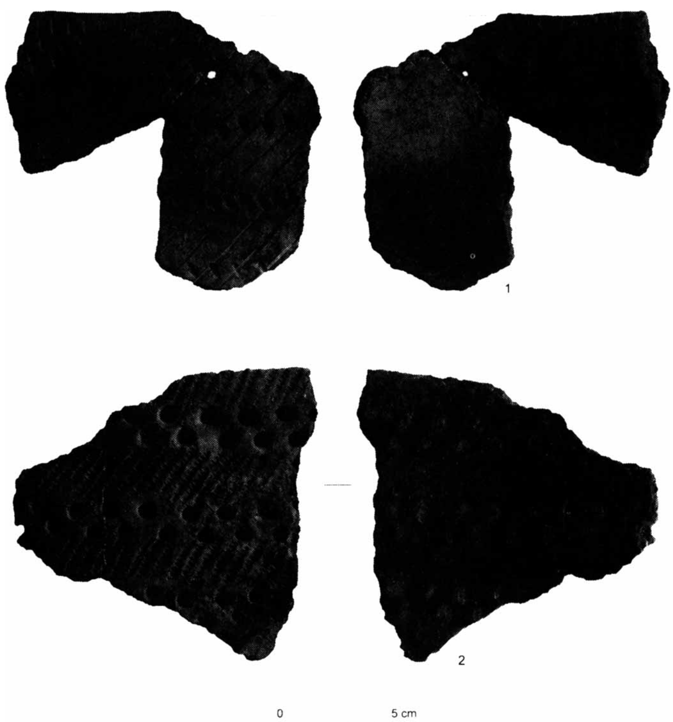

Figure 6 Ozerki 17, Tver region, Russia. Fragments of pottery from which AMS samples were taken: 1) KIA 39306 (6369 ± 27 BP); 2) KIA 39307 (5693 ± 29 BP) (photos: S Hartz).

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second date (KIA 39307: 5693 ± 29 BP) stems from charred organic residue on a typical early Lyalovo potsherd found in layer II. Its date in the middle of the 5th millennium cal BC is in accordance both with the expected typological position of such ware and its stratigraphic location.

Outlook: Neolithic Pottery of the Transbaikal Region

In the course of our dating program of early pottery of the forest zone, a first sample from the multilayer settlement site of Krasnaya Gorka in Buryatia, Transbaikalia, was obtained (Figure 1). The AMS date was received for charred residue from an undecorated wall sherd found in cultural layer 2 (Table 1. The result of 7541–7187 cal BC (KIA-42073: 8345 ± 66 BP) verifies the general (Early) Neolithic context of the complex. The date is substantially younger than the direct dates obtained on early pottery from Ust-Karenga (~11,000 cal BC), thus illustrating the chronological depth of Early Neolithic developments in this region (Tsydenova 2010). At the same time, the date from Krasnaya Gorka suggests the existence of an established pottery production in the Transbaikal region in a period when further west, ceramic technology had not yet been introduced. The earliest dates for pottery complexes in the Cis-Baikal region stem from the 6th millennium cal BC and are associated with the Kitoi mortuary tradition (McKenzie 2009:184–5). Further investigations are necessary to elaborate the understanding of the Late Glacial initial phase of pottery production in the Transbaikal area and to characterize the subsequent early Holocene pottery development. Direct AMS dating of charred remains adhering to ceramics provides the important opportunity to include previously undated complexes into a developing chronological framework of Eurasian hunter-gatherer pottery.

DISCUSSION

AMS dating of charred residues adhering to pottery fragments is a very valuable tool for understanding early hunter-gatherer ceramics in the Eurasian forest zone. The first results of the Russian-German dating program contribute to a better understanding of the spreading of pottery production, the regional developments, and typological changes.

In the Upper Volga region in central European Russia, results for typologically early ceramics from Sakhtysh 2a form a cluster and date the start of pottery production to the beginning of the 6th millennium cal BC (Figure 2). One sample from Sakthysh 2a and another one from Ozerki 5, which are both dated to ~6300 cal BC, might indicate an even earlier start of pottery use. For typological and stratigraphic reasons, however, the reliability of these dates must be questioned and the authors favor an interpretation of these 2 dates as outliers caused by freshwater reservoir effects. An indication for this scenario could be seen in the low $\delta^{13}C$ values (Table 1; Figure 7a).

A certain amount of variation can be possible even in direct AMS dating (Fischer and Heinemeier 2003) as is also illustrated, for example, by 2 dates from 1 Early Neolithic vessel from Kalmozero 11 in Karelia (Piezonka 2008:96–8). In this case, the sample taken from charred residue adhering to the outer surface produced a date 265 ^{14}C yr older than the sample from the inside of the pot. The rather low $\delta^{13}C$ values are almost identical in this case (outer sample: –28.82‰; inner sample: 27.75‰). In contrast to this example, the 2 samples obtained from the same pottery fragment from Sakthysh 2a (foodcrust and willow string: KIA 39300 and KIA 39301) are in very good agreement and argue against a (regular) reservoir effect for the foodcrust samples from this site. For further discussion, it is very important to find out what was cooked in the sampled pots. Altogether, our results confirm earlier ideas on the transition from the Mesolithic to the early Neolithic (Engovatova et al. 1998; Zhilin 2000; Zaretskaya and Kostyleva 2008) and date the onset of pottery production in the Upper Volga region to ~6000 cal BC. Further investigations are necessary to test this 6000 cal BC boundary and to better characterize the earliest pottery phase in the Upper Volga region.

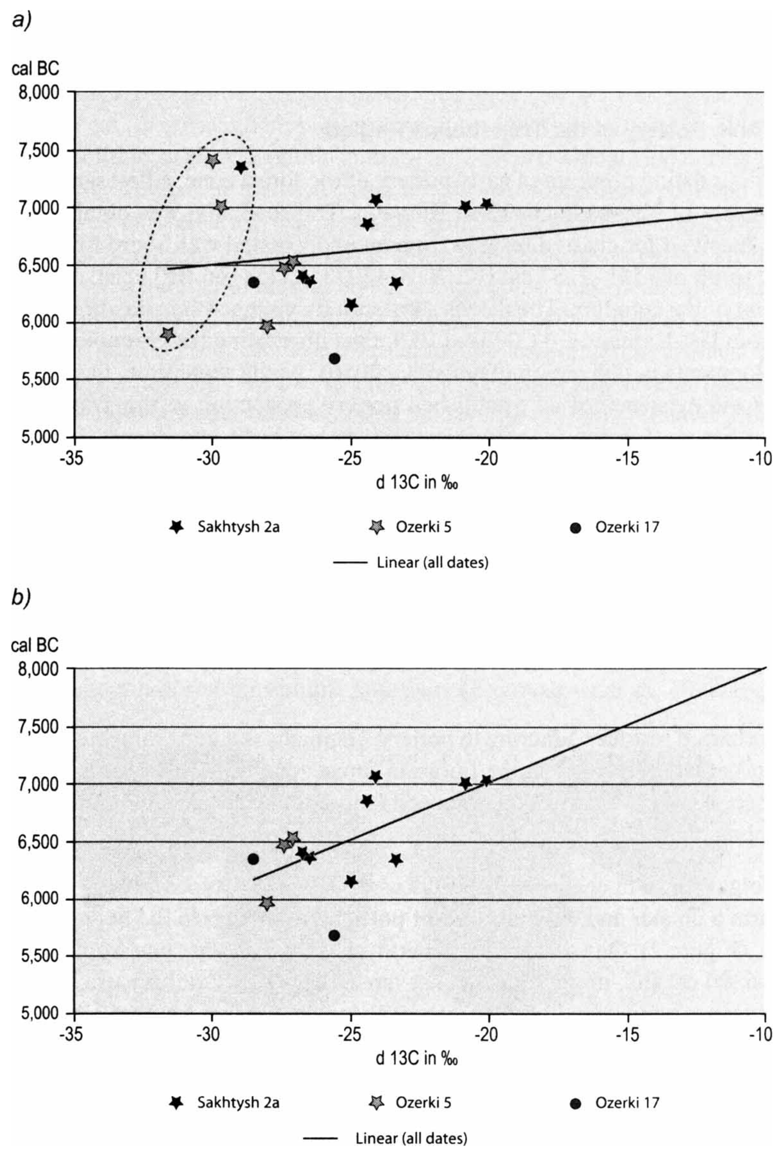

Figure 7 a) $\delta^{13}C$ values (in ‰) of all foodcrust AMS dates from Sakhtysh 2a, Ozerki 5, and Ozerki 17 (see Table 1) including the ones too old on typological and stratigraphical grounds (dotted line). b) $\delta^{13}C$ values (in ‰) of selected AMS dates excluding dates rejected on typological and stratigraphical grounds. Note: $\delta^{13}C$ values from Sakhtysh 2a and Ozerki 17 were measured during AMS dating and are not comparable in detail to specific isotope analyses.

The new dates illuminate also the further typological development: AMS results of charred residue samples assign the developed and late types of Upper Volga culture ceramics from Sakhtysh 2a, Ozerki 5, and Ozerki 17 to the period shortly after the middle of the 6th millennium cal BC. Three dates from Ozerki 5 and Ozerki 17 help to elaborate the chronology of the subsequent Middle to Late Neolithic Lyalovo horizon (Figure 2). All 3 samples produced dates in the first half of the 5th millennium cal BC and fall into the late archaic to early stages of the Lyalovo culture according to the framework established based on stratigraphy and conventional ^{14}C dating (Engovatova et al.

1998:19; Zaretskaya and Kostyleva 2010:180–2). For sherd AAR 14540, which typologically represents the late Lyalovo style, the result is ~500 ^{14}C yr too old. The reason for this might be a freshwater reservoir effect (see Figure 7a). It is important to note that in the new dates presented in this article, there is no overlap between the dates of Upper Volga culture sherds and those of Lyalovo ceramics, and only 1 late Upper Volga culture date from Sakhtysh 2a fills the large gap between ~5300 and ~4900 cal BC. The question whether the latest Upper Volga culture and the archaic Lyalovo culture existed concurrently for some time, and how the transition between the 2 traditions took place, has not yet been solved. The current state of conventional ^{14}C chronology places the end of the late Upper Volga culture around 4900 cal BC (~6000 BP) and the onset of the archaic phase of the Lyalovo culture around 5150 cal BC (~6200 BP) (Engovatova et al. 1998:19; Zaretskaya and Kostyleva 2010:180–2). The problem must be investigated by AMS dating of pottery from reliable contexts (peat bog sites especially) where both late Upper Volga and archaic Lyalovo ceramics occur together.

Isotope measurements including ^{15}N as well as biochemical analyses of the charred residue are planned in order to receive more information on diet and subsistence strategies of the pottery makers in the forest zone. This will also better address the problem of possible freshwater reservoir effects in the ^{14}C dates.

Studies of central and north European material have shown that tissue of freshwater species such as fish and mollusks is characterized by low $\delta^{13}C$ values overlapping with the typical terrestrial range around –26‰, but sometimes reaching values around –30‰ and lower. In contrast, marine fish is characterized by higher $\delta^{13}C$ values (Fischer and Heinemeier 2003; Philippsen 2010; for systematic $\delta^{13}C$ value differences in fatty acids of freshwater fish and marine fish and mammal species, see also Craig et al. 2011: Figure 4A). Bone collagen of Stone Age humans and animals with a high freshwater animal protein portion in their diet display comparatively higher $\delta^{13}C$ values due to the trophic level shift. Thus, the very low $\delta^{13}C$ values measured in 4 charred residue samples might be connected to the preparation of fish or mollusks in the respective pots. However, it is more reliable to identify consumption of aquatic resources and possible reservoir effects by the combination of $\delta^{13}C$ and $\delta^{15}N$ values (Fischer and Heinemeier 2003; Fischer et al. 2007; Olsen et al. 2010; Philippsen et al. 2010).

Our isotope results from Sakhtysh 2a, Ozerki 5, and Ozerki 17 obtained so far display interesting correlations of the $\delta^{13}C$ data and the ^{14}C ages, even though only the values from Ozerki 5 stem from mass spectrometry. The series of the 18 Upper Volga region samples shows generally higher $\delta^{13}C$ values for Sakhtysh 2a than for the Ozerki sites (Figure 7a). The 4 samples whose dates are several centuries older than expected by typological and stratigraphic observations display the lowest $\delta^{13}C$ values of the entire data set (Figure 7a). If these samples are removed, the graph displays a distinct coherence between younger dates and lower $\delta^{13}C$ values (Figure 7b). As low $\delta^{13}C$ isotopic values are characteristic for freshwater species (see above), an increasing exploitation of aquatic resources might be a reasonable explanation for this picture. Systematic investigations of the ^{13}C and ^{15}N isotopes from foodcrust and human samples therefore represent an important future task to obtain more information on the development of the diet of Mesolithic and Neolithic people.

CONCLUSIONS AND FUTURE PERSPECTIVES

The new AMS dating results presented in this article provide a more reliable basis to discuss the supraregional developments and the respective cultural contexts of early ceramic traditions in Eurasia. Eighteen samples of charred organic residues of pottery fragments from 3 sites in the central Russian Upper Volga region indicate the beginning of Early Neolithic pottery production at 6020 to

5792 cal BC; 2 earlier dates (~6300 cal BC) are interpreted as possible outliers due to freshwater reservoir effects. The developed phase of the Upper Volga culture is dated to 5550 and 5468 cal BC, and 3 dates assign pottery of the subsequent Lyalovo culture to ~4935 and 4457 cal BC. Our results strongly suggest an earlier start of pottery production in the Upper Volga than in the Baltic region. They are in accordance with the idea that influences of the east European forest zone have played an important role in the formation of Mesolithic societies in the Baltic region in the early Holocene and stimulated the adoption of pottery production in the Atlantic period (Timofeev 1998; Piezonka 2008; Hartz et al. 2010, 2011).

Pottery production in the Upper Volga region was probably stimulated from communities of the middle and lower Volga (Nikitin 2008; Vybornov 2008:202–5; Zaitseva et al. 2008). At the moment, however, it remains unclear to what extent communities further east might have influenced the emergence of pottery production in European Russia (Vybornov 2008:197–202). Currently, there are only a limited number of ^{14}C dates available, for example, for early pottery complexes of the Urals regions and western Siberia. Work is in progress to obtain a series of AMS dates to develop a more reliable chronology for the late Mesolithic and the Early Neolithic of the Urals and Trans-Urals. Further research is necessary to discuss the question of possible early trajectories from east to west or independent innovations of pottery production in different regions on a more extended database.

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