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ANOTHER WAY OF EARLY POTTERY DISTRIBUTION IN EASTERN EUROPE? CASE STUDY OF THE PEZMOG 4 SITE, EUROPEAN FAR NORTHEAST

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ABSTRACT. A case study of the Neolithic comb ceramic site Pezmog 4 of the Kama culture presents a situation when results of radiocarbon dating change long-existing concepts concerning the development of archaeological events. Until the early 2000s, the chronology of the Kama culture, distributed mainly in the Kama and Vychegda River basins, has been based on comparative-typological analysis. Estimates of the age of this culture changed from the 3rd millennium BC in the 1950s to the 1st half of the 4th millennium BC by the 1990s. Research concerning the Pezmog 4 site in the central Vychegda River basin in 1999–2002 has abruptly changed this chronological understanding. The data obtained put the age of the early stage of Kama culture within the time range 5750–5620 cal BC and allowed us to propose the existence of another way of early pottery distribution in the forest zone of eastern Europe at the beginning of the 6th millennium BC. This innovation probably penetrated from the trans-Ural region.

INTRODUCTION

By the beginning of the 1990s, thanks to the studies by G M Burov (1967), L L Kosinskaya (1991), and E S Loginova (1989), 12 Neolithic sites containing comb ceramics had been known in the European northeast, mainly in the Vychegda River basin. It is widely accepted by now that these sites are related to the penetration of a population belonging to the Borovoozersky-khutorskoy stage or the Upper-Middle Kama local variant of the Kama Neolithic culture (Kosinskaya 1997:171–2; Karmanov 2008:96). This point of view is based on the obvious similarities in pottery from the Vychegda sites on one hand and from the sites Khutorskaya and Borovoye Ozero I of the Kama River basin on the other. It has been suggested that these migrants later took part in the formation of either the Vychegda-Vyatka culture (Burov 1967:167–8, 1986; Loginova 1989) or the Pechora-Dvina culture (Kosinskaya 1997:187; Vereshagina 2010), both of them being characterized by the syncretic (comb-pit) type of pottery. Until recently, the chronology of the comb pottery complexes had been established exclusively by the method of typological comparison. More reliable geochronological methods were difficult to apply due to certain peculiarities of the geochemistry of the forest soils, where the cultural level of most of the known sites is situated. This is true both for the Vychegda and Kama regions, and explains why both the chronology and the periodization of Kama culture complexes have been revised a number of times (Bader 1963, 1978; Halikov 1969). Importantly, these revisions mostly tended to increase the age of the complexes. Thus, in the 1960s, Burov, following O N Bader, dated their emergence to the middle of the 3rd millennia BC (Burov 1967:76). In the late 1990s, however, Kosinskaya (1997:159) proposed the end of the 5th to beginning of the 4th millennia BC as the date of their origin. Still, up to the early 2000s, all the attempts to date the complexes assigned them to the middle Neolithic. In the beginning of the 2000s, however, several archaeologists from Perm proposed that some of the complexes can belong to the Early Neolithic period (Mel'nichuk et al. 2001:160).

In this context, the recent studies of the site Pezmog 4 in the middle Vychegda basin (Figures 1 and 2) are of particular interest. ^{14}C dating of the charred food crust on one of pots found on this site (Figure 4) as well as that of the geoarchaeological context suggest a new significant revision of the established views on the chronology and origin of the oldest pottery in northeastern Europe.

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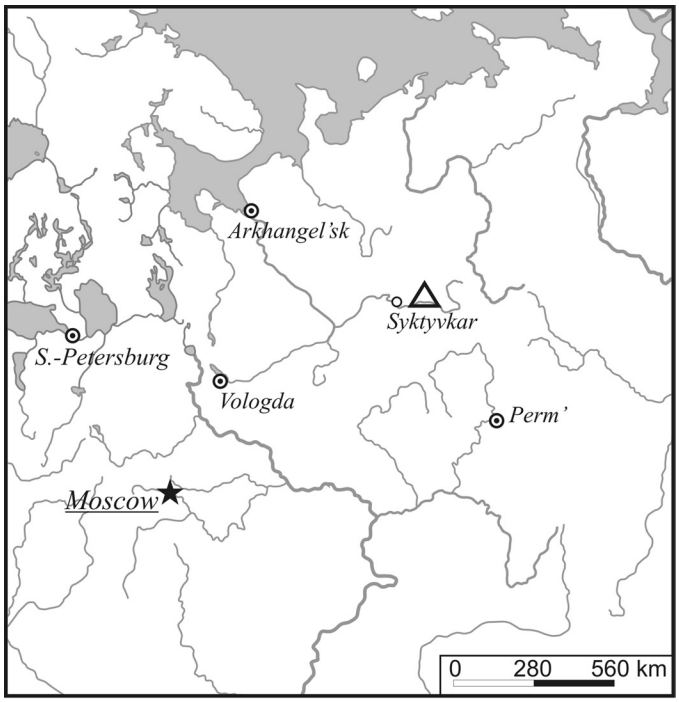

Figure 1 Pezmog 4 location denoted by triangle

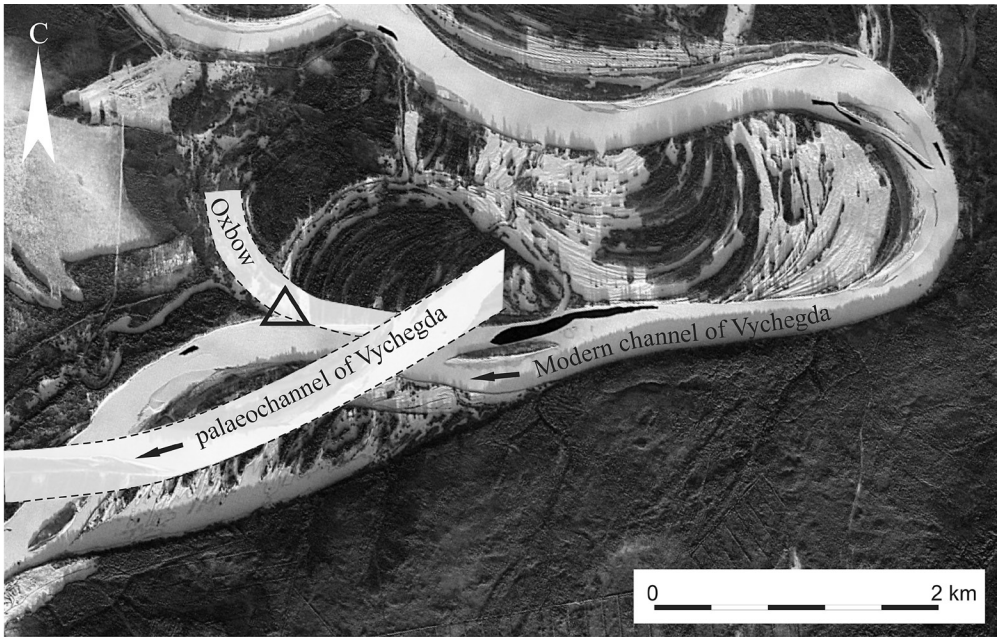

Figure 2 Pezmog 4 site in the context of the synchronous valley

PEZMOG 4: GEOARCHAEOLOGICAL CONTEXT

The Pezmog 4 archaeological site is situated on the right bank of Vychegda River (Republic of Komi; 61°48′15.10″N, 51°51′11.40″E). It was discovered in 1994 by researchers from the laboratory of Cenozoic Geology, Institute of Geology, Komi Science Center (Syktyvkar), as they collected samples for spore-pollen and diatomic analyses. In 1996, the archaeologist A V Volokitin cleaned the talus and determined the location and context of the culture-bearing deposits (Volokitin et al. 1998). From 1999 to 2001, the site was studied by Karmanov and Volokitin, with a total excavated area was ~30 m^2. Samples for radiocarbon and paleobotanic analyses were collected from the site in 2002 and 2009.

The artifacts found on the site are not numerous. They include 36 fragments of two pots (one of them had been reconstructed, see Figure 4), three flint artifacts (flake, debris, and retoucher), and two non-flint artifacts (flake and a preform). Since the geochemistry of the place allowed fair preservation of organic matter, ^{14}C dating had been performed.

The culture-bearing deposits (silty peat with sand) were associated with the bottom of the paleochannel infill, 3.6–3.8 m under the modern surface of the high floodplain (4–5 m above normal water level). According to archaeological and fluvial geomorphology data, the short-term (seasonal) camp had been located on the bank of an oxbow lake in the early Atlantic period, during the time of low water level in the river (Figure 3).

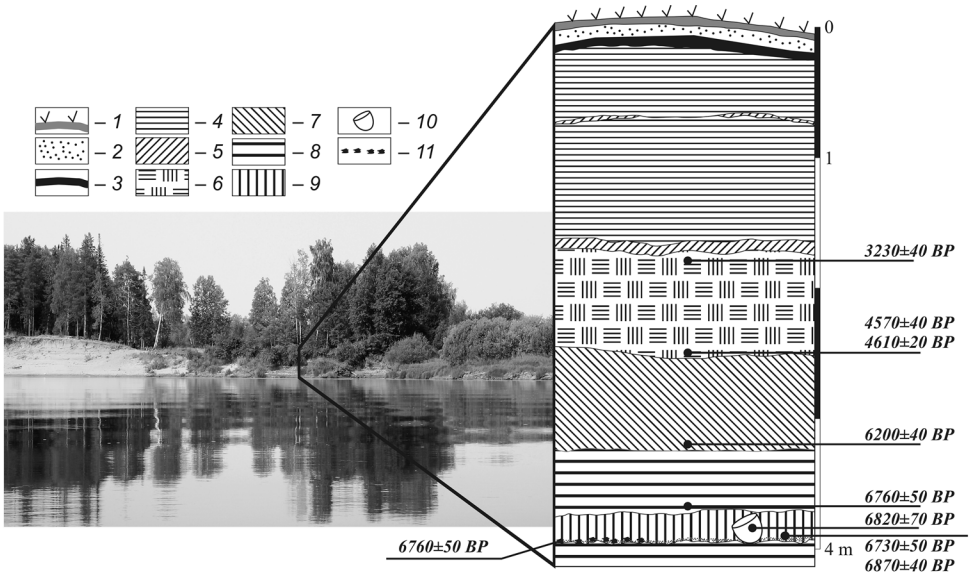

Figure 3 Pezmog 4: outcrop of first terrace and floodplain (view from the river); stratigraphy and radiocarbon dates: 1 – turf; 2 – sand (result of flood); 3 – buried soil; 4 – sandy loam; 5 – clay loam; 6 – peat; 7 – peaty loam; 8 – clay; 9 – silty peat with sand (culture-bearing deposits); 10 – potsherds; 11 – fragments of charcoal.

MATERIALS AND METHODS

A first attempt to date the cultural-bearing deposits of the Pezmog 4 site was performed in 1997; spore-pollen and diatom data showed the AT-3 age of this layer (6000–5000 ^{14}C BP). Thus, the artifacts of the site have been synchronized with this period (Volokitin et al. 1998:39). Later, ^{14}C dating became the main method to reconstruct the chronology of Pezmog 4. First, the charred foodcrust

was dated, then charcoal from the cultural layer. In 2002 and 2009, during the geological studies of the Vychegda paleochannel, the full section of the site was studied stratigraphically, and cultural-bearing deposits together with other overlying organic sediments were sampled for ^{14}C dating (Table 1). "Geological" samples have been taken as thin layers from the upper and lower parts of stratigraphic horizons.

Most of the samples were dated conventionally at the Geological Institute of the Russian Academy of Sciences in Moscow (laboratory code GIN), using standard pretreatment procedures (Zaretskaya 2005; Zaretskaya et al. 2005, 2012). Cultural-bearing deposits (silty peat) along with peat and charcoal samples were pretreated and dated according to the routine acid-alkali-acid (AAA) procedure: after cleansing of the sample in hot 5% HCl dilution, it was washed with distilled water, then boiled for 20 min in 2% dilution of NaOH. Foodcrust was pretreated in a cold NaOH dilution. After that, samples were once again pretreated in HCl and washed with distilled water.

All the dates are presented in the Table 1; those from the cultural layer (archaeological context) are in a very good agreement. The chronological data are supported by stratigraphic, paleobotanic, and paleochannel information, which excludes the redeposition. The dated section demonstrates the synchronicity of archaeological and paleoenvironmental events. The dates on foodcrust and charcoal, supported by dates on cultural-bearing deposits, allowed us to make a reasonable presumption on a significantly earlier age of the Kama Neolithic culture than that estimated by previous researchers.

Two dates have been obtained by direct dating of potsherds of one of the pots found within the cultural layer (Figure 4), performed in the Kiev ^{14}C Laboratory, Institute of Environmental Geochemistry. The method of sample preparation has been described previously in detail (Kovaliukh and Skrypkin 2007; Zaitseva et al. 2009). Briefly, pottery samples of 200–400 g with a carbon content of 1–3% were taken from the vessel walls. The ground samples (10–22 mm in diameter) were treated with 0.5N hydrofluoric acid in a Teflon® container for 2–5 hr under indoor temperature. At the initial and final pretreatment stages, the samples were subject to 10 min of ultrasonic exposure (Zaitseva et al. 2009).

Pottery as a material for ^{14}C dating has been widely studied since the mid-1980s. Earlier studies (Gabasio et al. 1986; Evin et al. 1989; Hedges et al. 1992; Delque Količ 1995; Gomes and Vega 1999; O'Malley et al. 1999; Bonsall et al. 2002) focused on the components of carbon in the pottery; different fractions of pottery organic matter have been determined and estimated from the point of view of their reliability for ^{14}C dating (coating, temper, lipids, humics, residue, HF digest). Interior/exterior parts of pottery samples have been dated and compared, and different combustion temperatures applied. Coating and surviving organic temper have been shown to be more reliable pottery samples.

Carbon components in potsherds are quite complicated. They include (1) carbon in the clay used by the potter (can significantly increase the age); (2) carbon from the temper added to the clay (grass, straw, chaff, dung, and ground shells); (3) carbon from the fuel of the kiln; (4) carbon from resins or other substances applied on pots; (5) carbon derived from domestic use of pots (food residues); and (6) carbon from geochemical contamination of the site. The main problem of pottery ^{14}C dating is that many different carbon sources of different ^{14}C age may contribute to the potsherd carbon content; also the process of firing is liable to destroy information that might help to differentiate between possible sources (Hedges et al. 1992). All these statements and problems have been reflected in the potsherds dating results at Pezmog 4 (see next section).

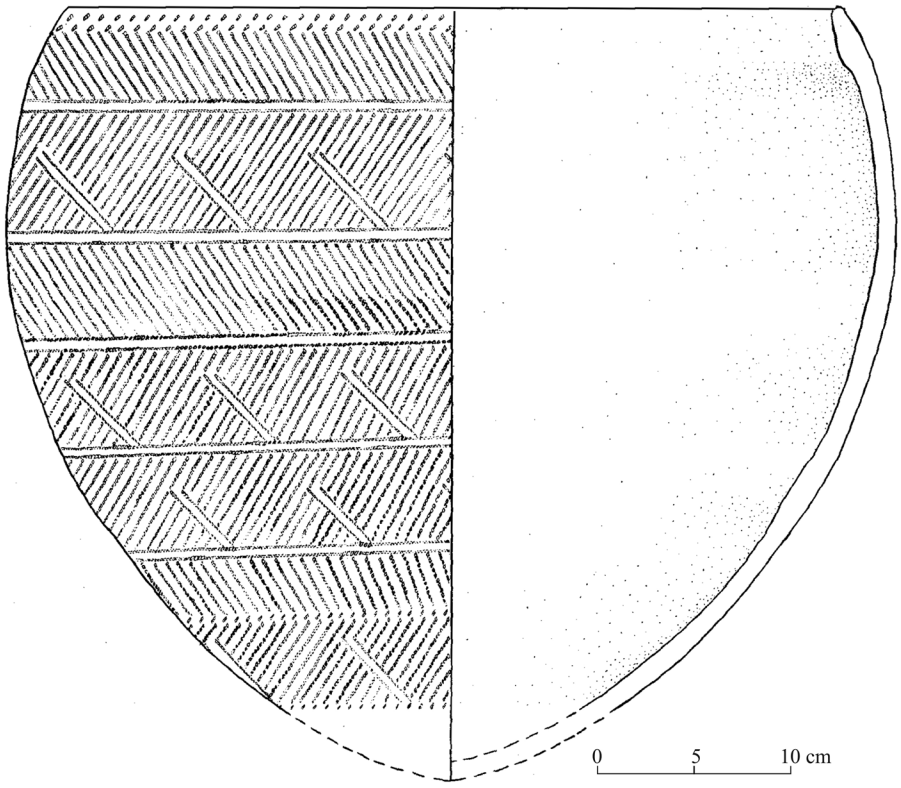

Figure 4 Pezmog 4: ceramic pot (reconstruction)

Calibration of all dates presented herein was performed using the OxCal program v 3.10 (Bronk Ramsey 1995, 2001) and the IntCal04 calibration curve (Reimer et al. 2004). The Ward and Wilson chi-squared test was provided using CALIB 6.11 (Reimer et al. 2009).

RESULTS AND DISCUSSION

^{14}C results of the floodplain deposits and archaeological contexts are represented in Table 1 and Figure 5. The 6820 ± 70 BP date on the foodcrust (GIN-11915) was obtained first (Volokitin and Karmanov 2004:11) and it seems to be the most reliable date both for the pot itself and for the cultural deposits in general. Indeed, the charred foodcrust is the only organic material available from the site for which its synchrony to the pottery is beyond any doubt. The dates obtained later from the culture-bearing deposits (6760 ± 50 BP, GIN-12324 and 6870 ± 40 BP, GIN-14202) as well as from the charcoal (6730 ± 50 BP, GIN-12322) were essentially similar to that obtained from the foodcrust. This agreement can exclude the possibility of reservoir effect influence on the age of the foodcrust sample. Samples are statistically the same at the 95% level; the *t* test statistic is 5.735121, χ^2 (.05) = 7.81, *df* = 3 (Reimer et al. 2009).

The results of potsherd dating at Pezmog 4 are as follows: the two different dates 6130 ± 100 BP (Ki-15428-2) and 6410 ± 90 BP (Ki-15428-1) were obtained from a single archaeological object (pot). The samples are significantly different at the 95% level (t = 4.331492, χ^2 (0.05) = 3.84, *df* = 1; Reimer et al. 2009), and both dates are considerably younger than the date on foodcrust. All this allowed us to date the site to the first half of the 6th millennium BC (Figure 5), with 5840–5610 BC being the most likely range of dates.

Table 1 Radiocarbon dates from the Pezmog 4 site and section.

Nr	Sample	Context	Layer	Depth (m)	Lab code	Date (BP)
1	Pezmog 4, section, 2002	Paleochannel infill, upper part	Brownish peat	1.75–1.8	GIN-12326	3230 ± 40
2	Pezmog 4, section, 2002	Paleochannel infill, upper part	Brownish peat	2.50–2.55	GIN-12325	4570 ± 40
3	Pezmog 4, section, 2009	Paleochannel infill, upper part	Peaty loam	2.54–2.57	GIN-14200	4610 ± 20
4	Pezmog 4, section, 2009	Paleochannel infill, lower part	Peaty loam	3.25–3.28	GIN-14201	6200 ± 40
5	Pezmog 4, cultural layer, 2002	Paleochannel infill, bottom part – cultural-bearing deposits	Peaty loam: culture-bearing deposits	3.62–3.65	GIN-12324	6760 ± 50
6	Pezmog 4, ceramic pot, 1996, 1999	Archaeological context	Food crust on the inner side of pot	3.6–3.8	GIN-11915	6820 ± 70
8	Pezmog 4, culture-bearing deposits, 2009	Paleochannel infill, bottom part – cultural-bearing deposits	Peaty loam: culture-bearing deposits	3.58–3.90	GIN-14202	6870 ± 40
9	Pezmog 4, culture-bearing deposits, 1999	Archaeological context	Charcoal fragments	3.70	GIN-12322	6730 ± 50
10	Pezmog 4, ceramic pot, 1996, 1999	Archaeological context	Potsherds (direct dating)	3.6–3.7	Ki-15428-2	6130 ± 100
11	Pezmog 4, ceramic pot, 1996, 1999	Archaeological context	Potsherds (direct dating)	3.6–3.7	Ki-15428-1	6410 ± 90

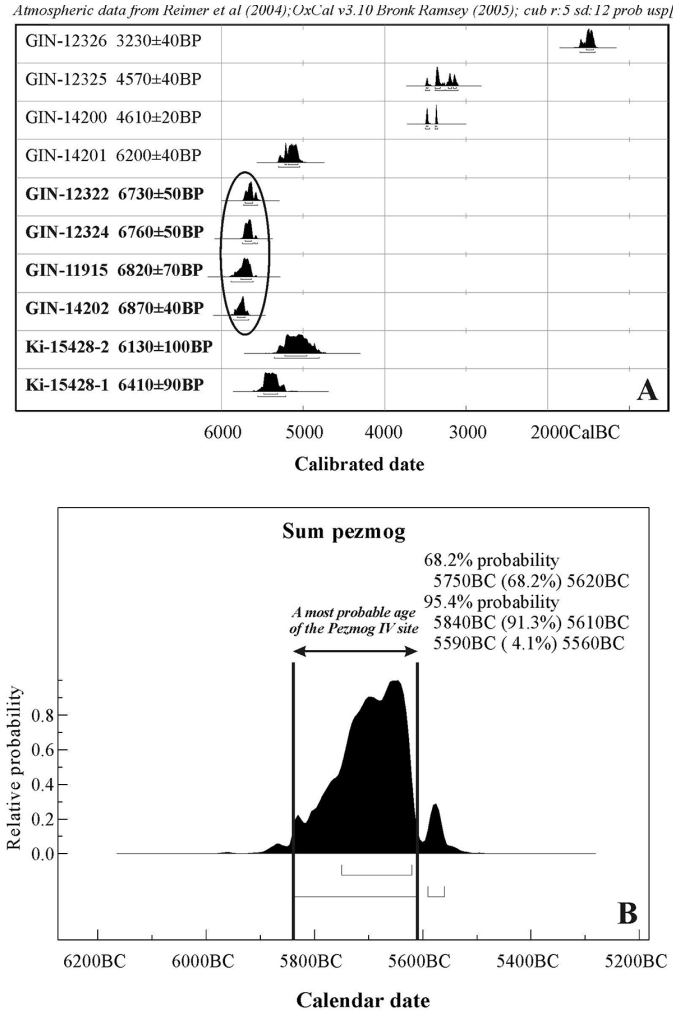

Figure 5 Pezmog 4: (A) chronology (dates related to geoarchaeological context are marked by bold type); (B) Sum probability distribution of reliable dates (see text).

The ^{14}C dating results of the organic remains from the Pezmog 4 site therefore suggest that the spread of comb ware pottery in NE Europe occurred earlier than previously thought, starting already at the beginning of the 6th millennium BC. The material from the site as well as from other sites of the Vychegda basin show that the groups having comb ware pottery started settling in the region in this period. These most probably were small hunting bands that had left behind only temporary camps. Their stay in the region was most probably short, so no further development of their traditions can be detected. Still, the comb ware pottery from the Pezmog 4 site, together with unornamented and pricked ceramic, represents the oldest ceramic tradition in this part of Europe. The rich materials available from the central part of the Russian Valley suggest that the oldest comb ware pottery here dates back to the second half of the 6th millennium BC (Engovatova 2000). However, this pottery is completely different in respect to its type and technology (Kostyleva 1994). The only source of comb ware tradition in NE Europe known up to date in the region is the Kama Neolithic culture. However, all available ^{14}C dates from this culture fall into the range of 5060–3300 BC (Ly-

chagina 2011; Karmanov et al. 2012). This inconsistency can be explained as follows. The studies of synchronic complexes show that the oldest pottery is scarce and fragmented. Therefore, it easily gets lost in the massive material from long-time settlements of the Kama basin. On the other hand, the oldest layer of the Kama culture, documented by materials from the Mokino and Ust'-Bukorok sites, does not have corresponding ^{14}C dates (Mel'nichuk et al. 2001). In this context, the study of the Pezmog 4 site opens new perspectives for studying the spread of early pottery traditions in northern Eurasia. Thus, on the basis of the chronological data related to known cultures (Upper Volga, Yet-to type, etc.) as well as to the sites of eastern Europe and the trans-Uralic region, one can propose that the origin of the comb ware traditions in NE Europe (including the territory of Kama culture) is situated further to the east, past the Urals. Indeed, the comb ware pottery traditions have quite similar ^{14}C dates to those reported here: both date to the beginning of the 6th millennium BC (Zakh 2009:199). However, the exact region of their origin is difficult to tell; this would involve a careful analysis of materials from a number of trans-Uralic sites.

CONCLUSIONS

The new chronological and paleoenvironmental data obtained shifts the early stage of Neolithic Kama culture into the time range of 5840–5610 cal BC and allows us to propose that early pottery in the forest zone of eastern Europe started to spread in the beginning of the 6th millennium BC. The most reliable and consistent dates have been obtained on foodcrust, charcoal, and cultural-bearing (paleochannel infill) samples. The most probable source of this innovation was situated east of the Ural Mountains. Further research should focus on finding materials in the trans-Ural Neolithic assemblages that would be comparable to those from the Pezmog 4 site.

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REFERENCES

Bader ON. 1963. *Drevneishaia istoriya Prikam'ya* [The most ancient history of the Kama region]. Moscow: Nauka. 156 p.

Bader ON. 1978. Hronologicheskie ramki neolita Prikam'ia i metody' ikh ustanovleniia [Chronology of Neolithic of the Kama region and methods of its determination]. *Kratkie soobshcheniia instituta arkheologii AN SSSR* 153:72–4.

Bonsall C, Cook G, Manson JL, Sanderson D. 2002. Direct dating of Neolithic pottery: progress and prospects. *Documenta Praehistorica* 29:47–59.

Bronk Ramsey C. 1995 Radiocarbon calibration and analysis of stratigraphy: the OxCal program. *Radiocarbon* 37(2):425–30.

Bronk Ramsey C. 2001. Development of the radiocarbon calibration program. *Radiocarbon* 43(2A):355–63.

Burov GM. 1967. *Drevnii Sindor (iz istorii plemen Evropeiskogo Severo-Vostoka v VII tysiacheletii do n.e. – I tysyacheletii n.e.)* [Ancient Sindor (History of Tribes of European Northeast in VII m. BC – I m. AD)]. Moscow: Nauka. 220 p.

Burov GM. 1986. Krainii Severo-Vostok Evropy v epohu mezolita, neolita i rannego metalla [Far Northeast of Europe in Mesolithic, Neolithic and Palaeometal]. Summary of PhD thesis. Novosibirsk. 18 p.

Delqué Količ E. 1995. Direct radiocarbon dating of pottery: selective heat treatment to retrieve smoke-derived carbon. *Radiocarbon* 37(2):275–84.

Engovatova AV. 2000. Hronologiya epohi neolita Volgo-Okskogo Mezhdurech'ya [Chronology of Neolithic of Volga-Oka interfluve]. In: *Hronologiya neolita Vostochnoi Evropy. Tezisy dokladov mezhdunarodnoi konferentsii, posviashchennoi pamyati N.N. Gurinoi*. Sankt-Peterburg, 27 noyabrya – 2 dekabrya 2000 g. Saint Petersburg: Institut Istorii Material'noy kultury RAN. p 94.

Evin J, Gabasio M, Lefevre JC. 1989. Preparation techniques for radiocarbon dating of potsherds. *Radiocarbon* 31(3):276–83.

Gabasio M, Evin J, Arnal GB, Andrieux P. 1986. Origins of carbon in potsherds. *Radiocarbon* 28(2A):711–8.

Gomes DC, Vega O. 1999. Dating organic temper of ceramics by AMS: sample preparation and carbon evaluation. *Radiocarbon* 41(3):315–20.

Halikov AH. 1969. *Drevniaia istoriya Srednego Povolzh'ya* [Ancient history of the Volga region]. Moscow: Nauka. 395 p. In Russian.

Hedges REM, Tiemei C, Housley RA. 1992. Results and methods in the radiocarbon dating of pottery. *Radiocarbon* 34(3):906–15.

Karmanov VN. 2008. *Neolit Evropei'skogo Severo-Vostoka* [Neolithic of European Northeast]. Syktyvkar: Komi nauchnyi centr. 226 p.

Karmanov VN, Zaretskaya NE, Lychagiha EL. 2012. Neolithic dispersal in Far Northeast Europe: ways and chronology. *Radiocarbon* 54(3):331–9.

Kosinskaya LL. 1991. Neoliticheskaia stoianka Kochmas na nizhnei' Vy'chegde [The Neolithic site Kochmas in the Lower Course of Vychegda river]. In: *Neoliticheskie pamiatniki Urala*. Sverdlovsk: UrO AN SSSR. p 4–20.

Kosinskaya LL. 1997. Neolit [Neolithic]. In: *Arheologiya Respubliki Komi*. Moscow: DiK. p 146–213.

Kostylyova EL. 1994. Ranneneoliticheskaia verkhnevolzhskaia kul'tura [The Early Neolithic Verhnevolzhskaya culture]. In: *Tverskoi arkheologicheskii sbornik* 1. Tver'. p 53–8.

Kovaliukh N, Skrypkin V. 2007. Radiocarbon dating of the archaeological pottery by liquid scintillation technique. In: *Proceedings of the Conference "Radiocarbon in Archaeological and Palaeoecological Studies*." Moscow: SpB. p 120–5.

Loginova ES. 1989. Poseleniya epohi neolita na Srednei Vychegde [Neolithic settlements in the Middle course of Vychegda river]. In: *Materialy VI mezhdunarodnogo kongressa finno-ugrovedov*. Volume 1. Moscow. p 66. In Russian.

Lychagina EL. 2011. Chronology and periodization of the Neolithic in the Upper and Middle Kama region. *Archaeology, Ethnology and Anthropology of Eurasia* 39(1):28–33.

Mel'nichuk AF, Bordinskikh GA, Mokrushin VP, Degtiareva MI, Lychagina EL. 2001. Novye pozdnemezoliticheskie i ranneneoliticheskie pamiatniki v verkhnem i srednem Prikam'e [New Late Mesolithic and Early Neolithic sites at the Upper and Middle courses of Kama river]. In: *Arkheologiia i etnografiia Srednego Priural'ya* 1. Berezniki: Permskii gos. p 142–62.

O'Malley JM, Kuzmin YV, Burr GS, Donahue DJ, Jull AJT. 1999. Direct radiocarbon AMS dating of the earliest pottery from the Russian Far East and Transbaikal. *Memoires de la Societe Prehistorique Francaise* 26:19–24.

Reimer PJ, Baillie MGL, Bard E, Bayliss A, Beck JW, Bertrand JH, Blackwell PG, Buck CE, Burr GS, Cutler KB, Damon PE, Edwards RL, Fairbanks RG, Friedrich M, Guilderson TP, Hogg AG, Hughen KA, Kromer B, McCormac G, Manning S, Bronk Ramsey C, Reimer RW, Remmele S, Southon JR, Stuiver M, Talamo S, Taylor FW, van der Plicht J, Weyhenmeyer CE. 2004. IntCal04 terrestrial radiocarbon age calibration, 0–26 cal kyr BP. *Radiocarbon* 46(3):1029–58.

Reimer PJ, Baillie MGL, Bard E, Bayliss A, Beck JW, Blackwell PG, Bronk Ramsey C, Buck CE, Burr GS, Edwards RL, Friedrich M, Grootes PM, Guilderson TP, Hajdas I, Heaton TJ, Hogg AG, Hughen KA, Kaiser KF, Kromer B, McCormac FG, Manning SW, Reimer RW, Richards DA, Southon JR, Talamo S, Turney CSM, van der Plicht J, Weyhenmeyer CE. 2009. IntCal09 and Marine09 radiocarbon age calibration curves, 0–50,000 years cal BP. *Radiocarbon* 51(4):1111–50.

Vereshagina IV. 2010. *Mezolit i neolit krai'nego evropei'skogo Severo-Vostoka* [Mesolithic and Neolithic of Far European Northeast]. Saint Petersburg: Peterburgskoe Vostokovedenie. 232 p.

Volokitin AV, Karmanov VN. 2004. Rannii neolit Evropeiskogo Severo-Vostoka [Early Neolithic of European Northeast]. *Rossiiskaya Arkheologiya* 2:5–14. In Russian with English abstract.

Volokitin AV, Karmanov VN, Marchenko TI, Duryagina DA. 1998. Pezmog IV – novyi pamyatnik grebenchatogo neolita na Vychegde [Pezmog IV – New Site of Comb Neolithic at Vychegda river]. In: *Severnoe Priural'e v epohu kamnya i metalla (Materialy po arheologii Evropeiskogo Severo-Vostoka 15)*. Syktyvkar: Komi nauchnyi centr. p 31–40.

Zaitseva G, Skripkin V, Kovaliukh N, Possnert G, Dolukhanov P, Vybornov A. 2009. Radiocarbon dating of Neolithic pottery. *Radiocarbon* 51(2):795–801.

Zakh VA. 2009. *Hronostratigrafiia neolita i rannego metalla lesnogo Tobolo-Ishim'ya* [Chronostratigraphy of Neolithic of Tobol-Ishim region]. Novosibirsk: Nauka. 320 p.

Zaretskaya NE. 2005. Radiouglerodnaya i kalendarnaya khronologiia mnogosloi'ny'kh torfianikovy'kh poselenii' Volgo-Okskogo mezhdurech'ia [Radiocarbon and calendar chronology of multilayer peat sites within the Upper Volga]. In: Zhilin MG, editor. *Stone Age of the Eastern Europe and Trans-Ural Forest Zone*. Moscow: Academia. p 113–29. In Russian.

Zaretskaya NE, Zhilin MG, Karmanov VN, Uspenskaia ON. 2005. Radiocarbon dating of wetland archeological sites. *Geochronometria* 24:117–32.

Zaretskaya NE, Hartz S, Terberger T, Savchenko SN, Zhilin MG. 2012. Radiocarbon chronology of the Shigir and Gorbunovo archaeological bog sites, Middle Urals, Russia. *Radiocarbon* 54(3):783–94.