

RADIOCARBON CHRONOLOGY OF THE SHIGIR AND GORBUNOVO ARCHAEOLOGICAL BOG SITES, MIDDLE URALS, RUSSIA

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ABSTRACT. Two well-known archaeological sites, the peat bogs of Shigir and Gorbunovo (Middle Urals, Russia), have been radiocarbon dated (61 conventional and accelerator mass spectrometry [AMS] dates from various natural and artifact samples). For the first time, a detailed chronology of Early to Late Mesolithic and Early Neolithic occupation for this region has been obtained, and a paleoenvironmental history reconstructed. Based on these results, we propose that the Mesolithic settlement of the Middle Urals region started in the early Holocene, at the same time as in central and eastern Europe.

INTRODUCTION

In the Middle Urals, archaeological finds from peat bogs have been well known since the end of the 19th century. The most famous sites are the Shigir and Gorbunovo peat bogs, located between the cities of Ekaterinburg and Nizhniy Tagil (Figure 1A). They are well known because of extraordinary Stone and Bronze Age artifacts, made from wood, bone, antler, and other organic materials. Until recently, almost no absolute dates for the earliest human settlement of these bogs were available. Before excavations at Gorbunovo were started in 2008 by Mikhail Zhilin and Svetlana Savchenko, all Mesolithic sites in the Eastern Urals region had been traditionally assigned to the late phase of this period. It was thought that during the Early and Middle Mesolithic the region was not suitable for settlement (Serikov 2000). However, there was no scientific proof for this assumption. Paleoenvironmental data (Khotinsky 1977) indicated that climatic and vegetational changes were very similar in eastern Europe and the Eastern Urals. Several published radiocarbon dates, including 3 dates from the Great Shigir idol (GIN-9467/1: 8680 ± 140 BP, GIN-9467/2: 8750 ± 60 BP, LE-5303: 8620 ± 70 BP; Savchenko 1999), indicate that settlement of the Eastern Urals area started much earlier than originally thought (Savchenko 2003). The chronology of the Early Neolithic of the region was also not well established, because most sites excavated from this period had admixtures originating from other periods. In addition, only few ¹⁴C dates were available. Some of these dates came from uncertain archaeological contexts; others are not consistent with the typological dating of the pottery assemblages. Here, we present the results of interdisciplinary research for 2 peat sites: Varga-2 at the Shigir peat bog, and Beregovaya-2 at the Gorbunovo mire. Varga-2 is located at the western part of the Shigir bog (Figure 1B) and produced an Early Neolithic layer. Beregovaya-2 is situated at the northeastern shore of the Gorbunovo paleolake (Figure 1C) and produced 5 cultural layers dating to, respectively, the Early, Middle, and Late Mesolithic, the Early Neolithic, and the Chalcolithic. Our investigations on these sites involved geochronology, archaeology, and paleoenvironmental studies. The main goal was to obtain reliable chronological data for the Mesolithic and Early Neolithic periods in this region, and to reconstruct the settlement history on the shores of the 2 lakes during the Early to Middle Holocene.

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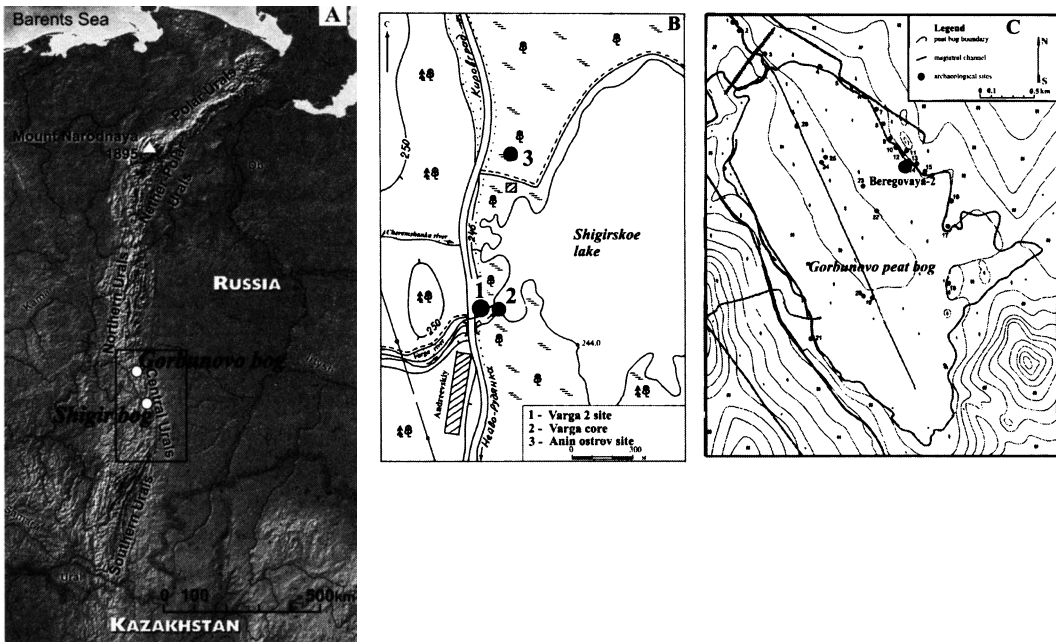


Figure 1 A) Study area: Central Ural Mountains with dots indicating Shigir and Gorbunovo peat bogs. B) map of the Shigir bog with sampling sites Varga-2, Varga core, and Anig ostrov indicated; C) map of the Gorbunovo peat bog with the Beregovaya-2 site indicated.

STUDY AREA

The Shigir and Gorbunovo peat bogs are both located in the Middle Urals region (Figure 1A).

Varga-2 Site

The Varga-2 site is situated in the western part of the Shigir peat bog, ~90 km to the north-northeast from Ekaterinburg (Figure 1B). The Shigir peat bog contains 68 archaeological sites, most of them distributed on the shores and “islands” of the Shigir paleolake, with cultural layers mainly accumulated in the coastal zone. Unfortunately, most of the Shigir peat bog had been destroyed during gold mining at the end of 19th century. A large number of beautiful wood and bone artifacts from the Stone Age were found at that time (Savchenko 1999). In 2004, M G Zhilin and S N Savchenko investigated part of the Varga-2 site, which is located about 120 m from the modern lake shore, and observed an undisturbed cultural layer. This was a good opportunity to obtain sample material for ^{14}C dating and paleoenvironmental studies (Zaretskaya 2007; Zaretskaya and Uspenskaya 2007).

The stratigraphy of the excavation trench at Varga-2 can be described from top to bottom as follows (Figure 2): 1) peaty turf (10–20 cm); 2) surface dump (20 cm); 3) brown peat with wood remnants (60–110 cm), in this layer old Varga River channels are identified; 4) dark-gray loam with quartz and slate-stone fragments (30 cm), Varga River deposits; 5) dark-brown peat with wood detritus, changing into peat containing cane (*Phragmites communis*) (20 cm); 6) dark-olive detrital gyttja (50–70 cm); 7) gray gyttja with wood detritus and dispersed charcoal (20–30 cm); 8) beige gyttja with small shells (20 cm); 9) blue-gray clay with gravel and stones, this is the bottom of the paleolake.

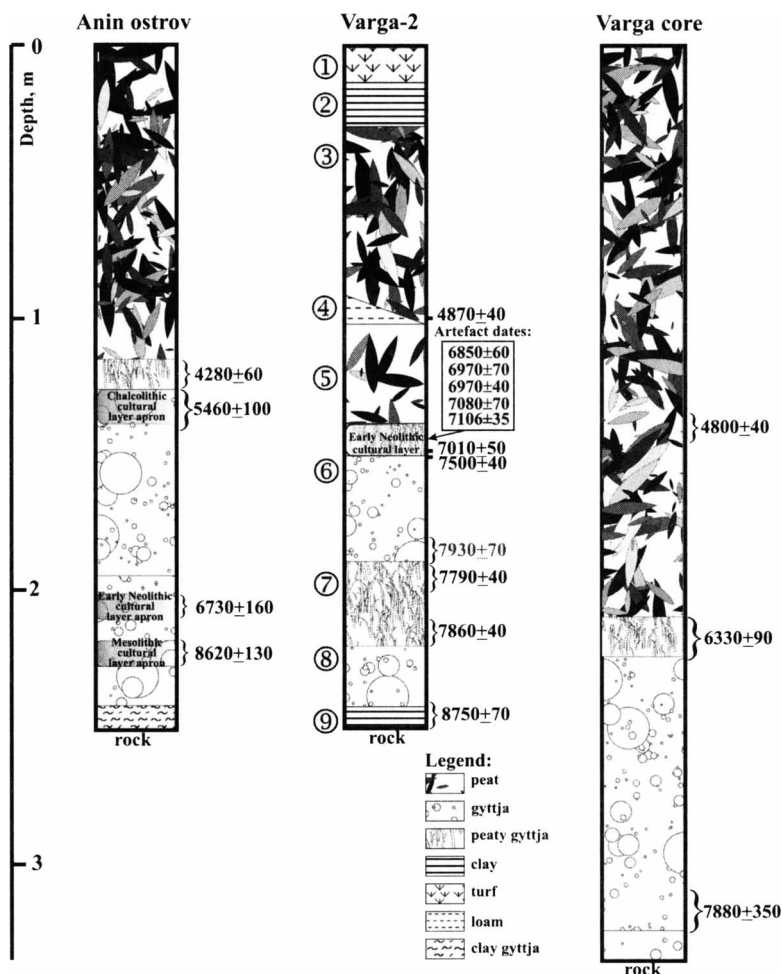


Figure 2 Dated sections at the Shigir peat bog: Anin ostrov, Varga-2 (within the excavation pit), and Varga core (near the excavation area). Dates obtained on artifacts from the cultural layer (bottom of layer 5) are indicated with a rectangle.

Only 1 cultural layer (Early Neolithic) occurs *in situ* in layer 5 (dark-brown peat) and contains fire-place remains, ceramic fragments of different types, stone and bone artifacts, and animal bones (Zhilin and Savchenko 2007). Five ¹⁴C dates for these artifacts are available, ranging from 6850 to 7106 BP (Table 1).

Table 1 Radiocarbon dates of the Shigir (Varga-2 site, Varga core, Anin ostrov site) and Gorbunovo (Beregovaya-2 site) peat bogs: sections and individual samples.

Dated material	Sample position	Lab code	Age BP	Age cal BC 1 σ
Shigir peat bog				
1 Peat	Varga-2 sect., -100 cm	GIN-13858	4870 ± 40	3695–3677; 3673–3638
2 Peaty gyttja	Varga-2 sect., -148/–150 cm	GIN-13860	7010 ± 50	5980–5944; 5925–5844
3 Olive-colored gyttja	Varga-2 sect., -151/–152 cm	GIN-13861	7500 ± 40	6431–6359
4 Olive-colored gyttja	Varga-2 sect., -180/–190 cm	GIN-13862	7930 ± 70	7024–6967

Table 1 Radiocarbon dates of the Shigir (Varga-2 site, Varga core, Anin ostrov site) and Gorbunovo (Beregovaya-2 site) peat bogs: sections and individual samples. (*Continued*)

Dated material	Sample position	Lab code	Age BP	Age cal BC 1 σ
5 Peaty gyttja	Varga-2 sect., -190/-200 cm	GIN-13863	7790 \pm 40	6658-6589
6 Peat	Varga-2 sect., -210/-220 cm	GIN-13864	7860 \pm 40	6754-6718; 6712-6642
7 Olive-colored detrital gyttja	Varga-2 sect., -240/-250 cm	GIN-13865	8750 \pm 70	7940-7676
8 Peat	Varga core, -130/-140 cm	GIN-13866	4800 \pm 40	3587-3529
9 Peaty gyttja	Varga core, -210/-225 cm	GIN-13867	6330 \pm 90	5381-5216
10 Beige gyttja	Varga core, -310/-325 cm	GIN-13868	7880 \pm 350	7189-6426
11 Peaty gyttja	Anin ostrov, -115/-126 cm	GIN-13869	4280 \pm 60	3011-2977; 2943-2870
12 Algae gyttja	Anin ostrov, -126/-140 cm	GIN-13870	5460 \pm 100	4405-4230
13 <i>Cyanofycaea</i> gyttja	Anin ostrov, -198/-213 cm	GIN-13871	6730 \pm 160	5760-5486
14 Organo-mineral gyttja	Anin ostrov, -213/-228 cm	GIN-13872	8620 \pm 130	7830-7527
15 Chip	Varga-2 Sq.m. 14, c.l. II	GIN-12990	6850 \pm 60	5786-5667
16 Small charred plank	Varga-2 Sq.m. 9, c.l. II	GIN-13852	6970 \pm 40	5900-5789
17 Small charred plank	Varga-2 Sq.m. 5/9, c.l. I/II	GIN-13849	6970 \pm 70	5912-5772
18 charred half-timber	Varga-2 Sq.m. 8, c.l. II	GIN-13855	7080 \pm 70	6020-5892
19 Charred remain on a rim fragment	Vessel 3, c.l. II	AAR-14837	7106 \pm 35	6020-5980; 5945-5925
Gorbunovsky peat bog				
20 Pick-axe insert (elk antler)	Sq.m. 56, -278 cm, c.l. II	AAR-14548	7278 \pm 34	6211-6137; 6110-6083
21 Charred residue on a koshkino-type sherd	Sq.m. 60, -288 cm, c.l. II	KIA-42074	7325 \pm 40	6232-6203; 6146-6101
22 Charred remain on a rim sherd	Sq.m. 93, c.l.II, -284/-286 cm	AAR-14833	7320 \pm 38	6230-6100
23 Trackway, plank 3	Sq.m. 32, -322/-332 cm, c.l. III	GIN-14134	7960 \pm 30	7028-6930; 6921-6877
24 Elk scapula knife	Sq.m. 70, -294/-300 cm, c.l. III	AAR-14549	7989 \pm 36	6972-6911; 6884-6829
25 Trackway, plank 5	Sq.m. 58, -321/-325 cm, c.l. III	GIN-14133	7990 \pm 30	6971-6912; 6884-6830
26 Trackway, plank fragment	Sq.m. 40, -325/-330 cm, c.l. III	GIN-14087	7990 \pm 40	7042-6983; 6973-6911; 6885-6829
27 Thin burnt trunk	Sq.m. 5, -303/-309 cm, c.l. III	GIN-14085	8120 \pm 50	7144-7057
28 Burnt pine stake	Sq.m. 3-4, -309/-313 cm, bottom of c.l. III	GIN-14086	8350 \pm 40	7490-7446; 7414-7356
29 Binding of a net sinker, willow bark	Sq.m. 85, c.l. IV, -380 cm	AAR-14834	8405 \pm 40	7540-7460
30 Binding of a net sinker, willow bark	Sq.m. 46, -364/-373 cm, c.l. IV	KIA-42075	8445 \pm 50	7569-7494
31 Wooden stake	Sq.m. 24, horiz., -340/-346 cm, c.l. IV	GIN-14137	8490 \pm 40	7578-7535
32 Worked plank	Sq.m. 7, horiz., -368 cm, IV	GIN-14089	8670 \pm 40	7683-7601
33 Elk antler	Sq.m. 48-49, horiz., -373/-377 cm, c.l. IV	GIN-14207	8840 \pm 70	8198-8110; 8002-7821
34 Worked larch branch	Sq.m. 6, horiz., -358/-362 cm, c.l. IV	GIN-14090	8970 \pm 60	8278-8183; 8042-7994
35 Stake, larch	Sq.m. 43, horiz., -378 cm, IV	GIN-14136	9010 \pm 40	8278-8234
36 Red deer scapula	Sq.m. 41, horiz., -370 cm, c.l. IV	GIN-14208	10,200 \pm 100	10,140-9754
37 Stake, larch	Sq.m.7, sec.1, -371/-379 cm, horiz., lake bottom, c.l. V	GIN-14088	9800 \pm 40	9289-9253

Table 1 Radiocarbon dates of the Shigir (Varga-2 site, Varga core, Anin ostrov site) and Gorbunovo (Beregovaya-2 site) peat bogs: sections and individual samples. (Continued)

	Dated material	Sample position	Lab code	Age BP	Age cal BC 1 σ
38	Two elk bones from the same sq. m.	Sq.m. 48, -385/-396 cm, horiz., lake bottom, c.l. V	GIN-14210	9830 ± 70	9356-9241
39	Elk scapula knife	Sq.m. 21, -404 cm, horiz., lake bottom, c.l. V	KIA-42076	9835 ± 50	9316-9255
40	Worked log, larch	Sq.m. 42-43, -378/-376 cm, horiz., lake bottom, c.l. V	GIN-14135	9850 ± 40	9317-9266
41	Red deer scapula knife preform	Sq.m. 60-72, -386/392 cm, horiz., lake bottom, c.l. V	GIN-14209	10,060 ± 80	9815-9446
42	Tool preform from a tubular bone	Sq.m. 20, -408 cm, horiz., lake bottom, c.l. V	KIA-42077	9215 ± 40	8474-8337
43	Stake, larch-1 (same construction)	Sq.m. 76, -412/-461 cm; c.l. V	GIN-14251	8980 ± 90	8285-8170; 8116-8053; 8047-7981
44	Stake, larch-2 (same construction)	Sq.m. 76, -397/-434 cm; c.l. V	GIN-14249	9230 ± 50	8489-8419; 8410-8346
45	Stake, larch-3 (same construction)	Sq.m. 76. -395/-430 cm; c.l. V	GIN-14250	9230 ± 60	8491-8417; 8414-8344
46	Sedge peat	Sec.1, layer 3, -230 cm, c.l.III, bottom	GIN-14080	8360 ± 40	7511-7449; 7410-7362
47	Gyttja	Sec.1, layer 4, between c.l. III and IV, -238 cm	GIN-14081	8620 ± 40	7654-7585
48	Gyttja	Sec.1, layer 5, c.l. IV, top	GIN-14082	8970 ± 40	8275-8202
49	Gyttja	Sec.1, layer 5, bottom, below c.l. IV, -370/-375 cm	GIN-14083	9140 ± 40	8349-8285
50	Peaty gyttja	Sec.1, layer 6, c.l. V -377/-380 cm	GIN-14084	9610 ± 40	9011-8912; 8904-8845
51	<i>Sphagnum</i> peat	Sec.2, layer 2, 20 cm above c.l. II, -261 cm	GIN-14124	6390 ± 110	5478-5295
52	<i>Sphagnum</i> peat	Sec.2, layer 2, 5 cm above c.l. II, -281 cm	GIN-14125	6990 ± 40	5975-5950; 5918-5837
54	Sedge peat	Sec.2, layer 3, -323 cm, c.l. III, 1 trackway level	GIN-14126	7990 ± 40	7042-6983; 6973-6911; 6885-6829
55	Sedge peat	Sec.2, layer 3, bottom below c.l. III, -335 cm	GIN-14127	8190 ± 40	7261-7225; 7193-7128
56	Cane peat	Sec.2, layer 3, bottom below -342 cm	GIN-14128	8200 ± 40	7301-7219; 7199-7139
57	Gyttja	Sec.2, layer 4, top, -345 cm	GIN-14129	8480 ± 40	7575-7530
58	Gyttja	Sec.2, layer 5, -368 cm, c.l. IV, top	GIN-14130	8520 ± 100	7651-7474
59	Gyttja	Sec.2, layer 5, -380 cm, c.l. IV, bottom	GIN-14131	9170 ± 90	8475-8289
60	Peaty gyttja	Sec.2, layer 6, -403 cm, c.l. V	GIN-14132	9210 ± 40	8469-8328
61	Peaty gyttja	Sq.m. 35, -371 cm, layer 6, c.l. V	GIN-14140	9390 ± 40	8724-8624

Beregovaya-2 Site

Beregovaya-2, discovered in 1944, is located on the rocky cape of the northeastern part of the Gorbunovo peat bog, 5 km southwest from the city of Nizhniy Tagil (Figure 1C). The Gorbunovo peat bog contains 38 archaeological sites along the paleolake shores and in the bog, dating from the Mesolithic to Early Iron Age periods. In 2008, M G Zhilin and S N Savchenko discovered a well-stratified “peat-bog” part below the rocky cape of Beregovaya-2, including 5 cultural layers (Zhilin and Savchenko 2009).

The stratigraphy of the excavation trench in this part of the peat bog encompasses the following layers (from top to bottom, Figure 3): 1) dark-brown decomposed peat (40 cm); 2) light-brown peat with wood logs (70–120 cm); 3) dark-brown decomposed peat (60–90 cm); 4) gray-brown olive-colored detrital loose gytija (10 cm); 5) gray-brown detrital sticky gytija (5–25 cm); 6) brownish peaty gytija with cane and typha leaves (2–3 cm); 7) blue-gray clay with sand and stones, this is the bottom of the paleolake (observed thickness 50 cm). We dated 2 continuous Holocene sections from the 2008 and 2009 excavation pits (Figure 3). Five cultural layers can be distinguished in the excavation trench, separated from each other by layers without artifacts (Figure 3).

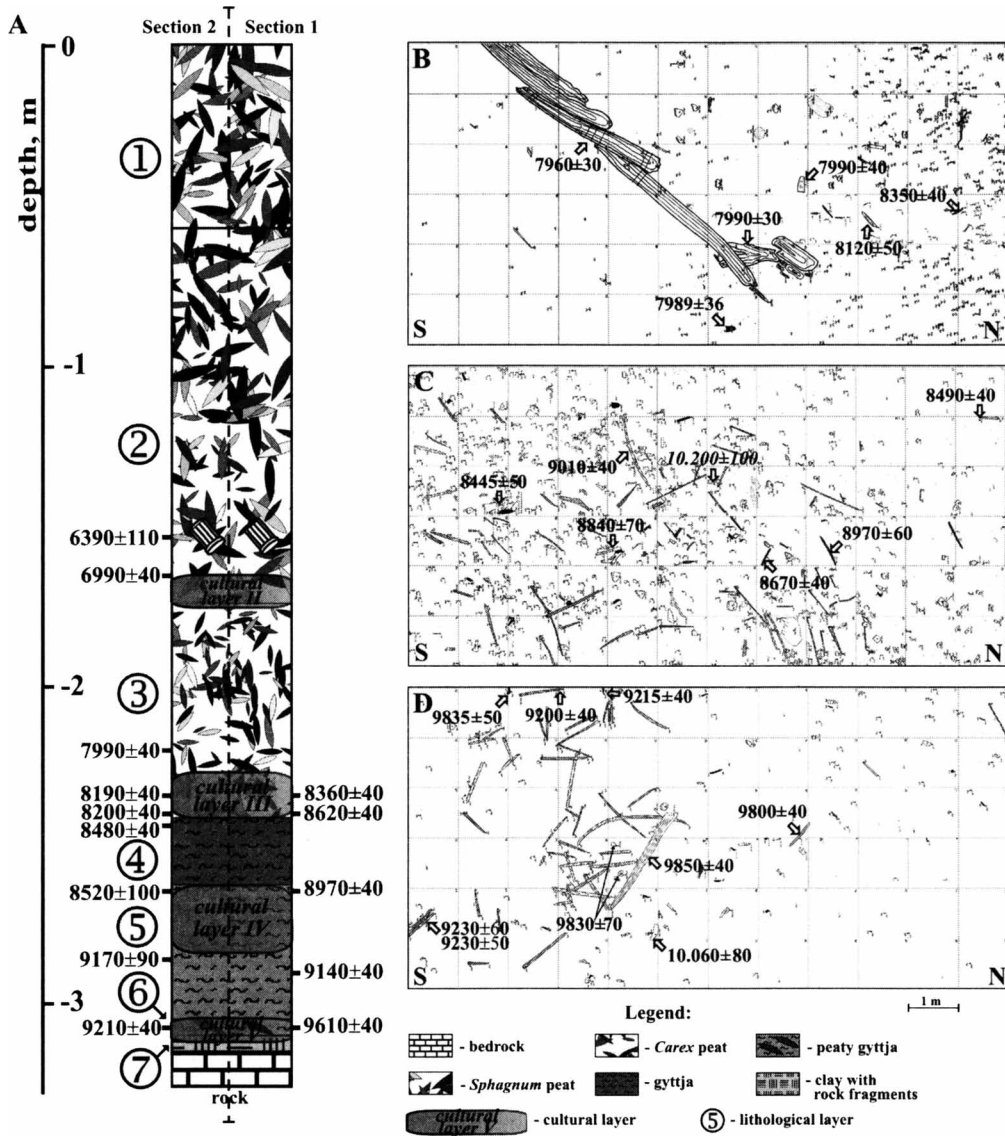


Figure 3 Beregovaya-2 site (Gorburново peat bog): A) summary section with dates on wetland deposits and lithology; dashed line is dividing sections 1 and 2. Stratigraphy description is presented in the text; B) plan of cultural layer III with dates on artifacts; C) plan of cultural layer IV with dates on artifacts; D) plan of cultural layer V with dates on artifacts.

Cultural layer I is located at the bottom part of layer 1 and contains few stone tools, animal bones, and fragments of ceramic of the Chalcolithic Ayat culture. We suppose that the layer represents the shoreline part of a Chalcolithic settlement existing on the rocky cape.

Cultural layer II is associated with the upper part of layer 3 in the northern part of the trench and with the bottom part of layer 2 in the southern part of the trench. It contains Early Neolithic ceramic fragments, stone, bone and antler tools, and animal bones. This represents the shoreline area of a settlement where some economic activities took place at the peaty, but rather dry, meadow-like shore in the northern part of the trench. Some refuse was discarded further into the swamp in the southern part of the trench, while the main settlement site occupied the rocky peninsula above it.

Cultural layer III is located in the bottom part of layer 3 and is related to Late Mesolithic activities. The lithic industry is typical for Eastern Urals Mesolithic sites; bone and antler tools are also present, but no ceramic fragments. The most interesting find is a well-preserved trackway (Figure 3B), composed of partly charred larch planks, placed on the mire surface.

Cultural layer IV is located in the upper part of layer 5 (Figure 3A) and is associated with the Middle Mesolithic period. Many stone artifacts (among them net sinkers with bark tapes) and bone and antler tools (arrowheads, knives, harpoons, even a pack containing 11 arrows) were found as well as many mammal, bird, and fish bones. In the southern part of the excavation trench, sharpened wooden stakes driven into lake bottom were discovered.

Cultural layer V is the oldest archaeological complex at this site. It is located directly on the bedrock (layer 7), partly in and under layer 6 (Figure 3A). Here, many sticks, 1 worked log, stone artifacts, and bone and antler artifacts (knives and harpoon fragments) were found. We suppose that this layer represents the earliest stage of Mesolithic settlement of this region.

METHODS: RADIOCARBON DATING AND MACROFOSSIL ANALYSIS

We used both conventional and accelerator mass spectrometry (AMS) methods for ¹⁴C dating of wetland deposits (peat and gyttja) containing artifacts, and of the artifacts themselves (bones and bone tools, worked wood, sticks, log fragments, and charred crust adhering to pottery). All dates are presented in Table 1, with a selected number shown in Figures 2 and 3.

In the field, we sampled 3 sections from the Shigir peat bog (1 section from the Varga-2 excavation trench, 1 core nearby, and 1 core near Anin Ostrov site ~1 km from Varga-2) and 2 sections from the Gorbunovo peat bog (both from the Beregovaya-2 excavation trench). Artifacts for dating have been collected from the entire excavation area from all Mesolithic and Neolithic cultural levels.

Most of the samples were dated conventionally at the Geological Institute of the Russian Academy of Sciences in Moscow (laboratory code GIN), using a standard pretreatment procedure (Zaretskaya et al. 2001, 2005; Zaretskaya 2005, 2007). Wood, peat, and gyttja samples were pretreated and dated according to routine (AAA) procedure: after the cleaning of the sample in hot 5% HCl dilution, it was washed with distilled water and then boiled for 20 min in 10% dilution of NaOH. After that, samples were once again pretreated in HCl (hot 5% dilution or cold concentrated depending on sample type) and washed with distilled water.

Gyttjas provide reliable dates for estimating age of deposits enclosing Mesolithic and Neolithic cultural remains. The pretreatment procedure was just the same as for peat samples, except that the boiling in NaOH was longer (25–30 min). The $\delta^{13}\text{C}$ values of gyttja samples range from 28‰ to 22‰, and the gyttja dates mostly match with artifact dates from the same stratigraphic layer. There-

fore, we consider that no freshwater reservoir effect is observed in the Middle Ural bogs even at >3 m depth.

The method of collagen extraction from bone samples consists mainly of long sample cleansing in HCl dilution under cold conditions. After the HCl pretreatment, the collagen was diluted and then centrifuged and dried out. Details of the procedure are described in Sulerzhitsky and Romanenko (1999).

A number of small samples were dated by AMS in Kiel, Germany (lab code KIA) and Aarhus, Denmark (lab code AAR). For calibration, we used OxCal v 3.10 (Bronk Ramsey 1995, 2001) and the IntCal04 calibration curve data (Reimer et al. 2004). The complex formation and chronology of the early Holocene layers of Beregovaya 2 caused problems in building an age-depth model; here we used the sum probability distribution calculated by OxCal to work with this data set. The results are shown in Figure 4.

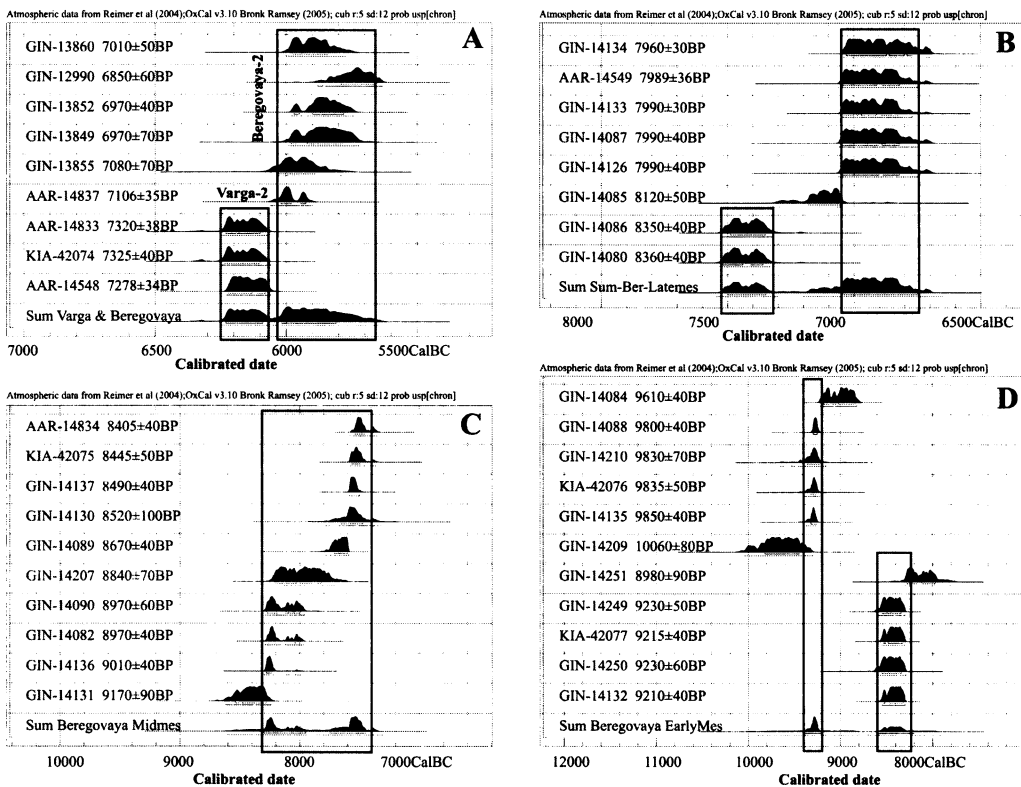


Figure 4 Calibrated ages and sum probability distribution of dates for cultural layers; blocks are bordering main cultural stages: A) Early Neolithic: Varga-2 site (6020–5800 cal BC) and Beregovaya-2 site (6230–6100 cal BC); B) Beregovaya-2 site, 2 stages of Late Mesolithic (7500–7350 and 7050–6750 cal BC); C) Beregovaya-2 site, Middle Mesolithic (8300–7450 cal BC); D) Beregovaya-2 site, Early Mesolithic, 2 stages (9400–9200 and 8600–8200 cal BC).

For paleoenvironmental reconstruction, we carried out plant macrofossil analysis for all dated peat and gytja samples. This analysis provided not only the plant composition for the samples, but also the ecological conditions of sediment accumulation (depth, disturbance, cooling or still water, etc.), and the organic/mineral ratio of the sample. This enabled the reconstruction of the history of wetland

sedimentation (accumulation of cultural and lithological layers) and local paleoenvironmental conditions (lake transgressions and regressions) at the archaeological sites (Zaretskaya and Uspenskaya 2007; Zaretskaya 2010).

RESULTS AND DISCUSSION

We obtained 19 ¹⁴C dates for the Shigir peat bog and 42 ¹⁴C dates for the Gorbunovo peat bog.

Shigir Peat Bog

The results from Shigir peat bog (Varga and Anin Ostrov) are shown in Figures 2 and 4 and Table 1. The dates for the wetland deposits represent almost in all cases the normal sequence from top to bottom. One inversion in the Varga-2 section (samples GIN-13862 and -13863) is possibly caused by redeposition during the paleolake transgression. The date obtained from the peaty gyttja enclosing artifacts is 7010 ± 50 BP (GIN-13860); the 5 artifact dates are 7080 ± 70 BP (GIN-13855, charred half-timber under the Early Neolithic vessel remains), 6970 ± 40 BP (GIN-13852, charred plank), 6970 ± 70 BP (GIN-13849, charred plank), 6850 ± 60 BP (GIN-12290, chip), and 7106 ± 35 BP (AAR-14837, crust on early Neolithic sherd). All dates are in good agreement and demonstrate a short period of settlement of the Varga-2 site. The calibrated age of the Early Neolithic settlement of Varga-2 is 6020–5800 cal BC, which is almost identical to the age of the early phase of the Upper Volga Early Neolithic culture (Zaretskaya and Kostyliova 2008; Hartz et al. 2012). In the Anin Ostrov site core, a date of 6730 ± 160 BP (GIN-13871, mixed algae gyttja) has been obtained for the level with Neolithic ceramics, which is younger than the Varga-2 set of dates. The ceramic sherd found there also appears later on typological grounds than pottery from Varga-2.

Gorbunovo Peat Bog

Results obtained for the Gorbunovo peat bog are shown in Figures 3 and 4 and Table 1. All dates obtained from wetland deposits show a normal sequence; no inversion has been observed. Most of the dates directly obtained on artifacts are in good agreement with the dates of the enclosing deposits. Nevertheless, there are some discrepancies and interesting peculiarities of site formation, which will be discussed below.

There are 3 AMS dates for the Early Neolithic layer II: 7278 ± 34 BP (AAR-14548, pick-axe insert made from elk antler); 7325 ± 40 BP (KIA-42074, charred crust from a ceramic fragment); and 7320 ± 38 BP (AAR-14833, charred crust from another ceramic fragment). The dates are in good agreement, so apparently no significant reservoir effect has affected the charred crust samples. The date from peat overlying this layer is 6990 ± 40 BP (GIN-14125). The calibrated age of the Early Neolithic occupation of Beregovaya-2 site is 6230–6100 cal BC, which is significantly earlier than the Early Neolithic age of Varga-2 (Figure 4A). This indicates that here an earlier phase of the local Early Neolithic culture was excavated.

Nine dates, both conventional and AMS, were obtained for the Late Mesolithic layer III, 6 dates on artifacts and 3 on sedge peats (Table 1), which show quite a long duration of the habitation. The lowest dated peat sample from section 1, which is close to the shore, provided an age of 8360 ± 40 BP (GIN-14080); the date of a burnt pine stake found at the same level is 8350 ± 40 BP (GIN-14086). The date of a thin tree trunk ~10 cm above is 8120 ± 50 BP (GIN-14085). The dates encompassing the chronological position of the layer III in section 2 are 8200 ± 40 BP (GIN-14128) and 7990 ± 40 BP (GIN-14126). There is a remarkable agreement between all dates for the wooden trackway fragments: 7960 ± 30 , 7990 ± 30 , and 7990 ± 40 BP (GIN-14134, -14133, and -14087, respectively); an elk scapula knife: 7989 ± 36 BP (AAR-14549); and the upper part of the sedge

peat: 7990 ± 40 BP (GIN-14128). This set of results also proves excellent agreement between the conventional and AMS dates, indicating that no reservoir effect influenced the peat sample. The calendar age of the Late Mesolithic occupation corresponds to 2 periods: 7500–7350 and 7050–6750 cal BC (Figure 4B).

Twelve dates were obtained for cultural layer IV: 4 dates on pinkish *Cyanophyceae* gyttja; 7 dates on larch stakes, elk and red deer bones (conventional dates); and 2 on willow bark bindings of stone sinkers (AMS dates). Samples and dates of cultural layer IV from all age ranges and materials are evenly distributed over the excavation area (Figure 3A and C, Table 1). Therefore, we conclude that the habitation was continuous during the Middle Mesolithic. There is 1 outlier in the dates: $10,200 \pm 100$ BP (GIN-14208), which stems from a red deer scapula. This might be the case of reuse of an older animal bone found by Middle Mesolithic people. The dates from the base of the gyttja layer without finds are older than those from the artifacts, indicating that habitation occurred when this layer had already partly formed, and people performed various economic activities above the shallow water near the lake shore, most probably using rafts or floating platforms. The calendar age of the Middle Mesolithic layer corresponds to the time range 8300–7450 cal BC.

For the Early Mesolithic cultural layer V, 12 ^{14}C dates were obtained. They correspond to 2 chronological groups (Figure 3A and D, Table 1). Most of the younger dates were laid farther away from the shore of the paleolake, while the older dates are situated closer to the shore. Another problem concerns the relationship between direct dates on artifacts and dates of the enclosing deposits: in the younger group, the dates are quite similar, but in the older group the enclosing peaty gyttja date is younger by about 200 ^{14}C yr. However, within each group, the dates agree well with each other.

Here, we propose the following paleogeographic scenario to explain the observed peculiarities of layer formation and chronology. During 9400–9200 cal BC, an Early Mesolithic settlement existed in the Beregovaya-2 area, on a dry surface of the shore of the paleolake. This is confirmed by data published earlier (Khotinsky 1977): in a core in the middle of the Gorbunovo peat bog a peat horizon underlying pinkish gyttja was identified between the early Holocene layers, i.e. there was a dry period in the history of the bog. After that, about 9000–8900 cal BC, a lake transgression started to flood the settlement area, and the peaty gyttja with abundant cane (*Phragmites communis*) remnants was deposited. At this time, there was a hiatus in the Early Mesolithic settling of Beregovaya-2. Then, a regression of the lake took place, and during the second stage of the Early Mesolithic occupation, about 8600–8200 cal BC, people most probably lived on the shore, and the cultural layer deposited in the littoral zone. Subsequently, a large transgression flooded the coastal area, which explains the archaeologically sterile layer (the lower part of pinkish gyttja) covering the cultural level V. After that, people came back again during the Middle Mesolithic, and the settlement of Beregovaya-2 continued from 8300 to 7450 cal BC (see above). The next lake transgression flooded the coastal area of the site and deposited a layer of olive-colored gyttja. The following settlement phase occurred during the late Mesolithic in 7500–6750 cal BC. Since that time, the transformation of the lake into a swamp started. Another gap in the settlement history coincides with the final Mesolithic period, and in the very beginning of the Neolithic, ~6230–6100 cal BC, when people again occupied both the rocky promontory and the dry peat surface below it.

CONCLUSIONS

Interdisciplinary studies at 2 peat bog archaeological sites in the Middle Urals, Varga-2 and Beregovaya-2, including ^{14}C dating, archaeological and plant macrofossil analysis, enabled for the first time to determine the age of several stages of the Mesolithic and the early stage of the Neolithic of this region. An absence of reliable ^{14}C dates had, by the end of the 20th century, led to a wrong con-

clusion that the initial Holocene settlement of the region occurred only during the Late Mesolithic (Serikov 2000). As our study was able to show the Mesolithic occupation of the Middle Urals area started already from the very beginning of the Holocene, contemporaneous with the forest zone of eastern Europe. A well-developed Mesolithic stone and bone industry, characterized by wise use of all available raw materials and by a high technological level, existed here already during the first half of the Holocene. Lithic tools are accompanied by various bone and antler tools and weapons, as well as wooden artifacts, including spears, javelins, arrow shafts, leister points, and others. Various bone arrowheads, harpoons, daggers, knives, perforators, and other tools from all 3 Mesolithic phases indicate a very high level of bone working. Composite weapons with slots for flint insets are present, supplemented with microblade insets and cores for their production. Many bone weapons are ornamented. The trackway to the lake shore over swamp from the upper Mesolithic layer at Beregovaya-2 is a perfect example of highly sophisticated woodwork and adaptation to local environment. Also of special interest is a large series of polished stone tools probably used for wood cutting, observed in the Middle Mesolithic layer. Such tools from mineral soil sites were usually treated as Neolithic artifacts (Serikov 2000), but they turned out to be much older. Fragments and preforms of such tools from the lowermost Mesolithic layer indicate the presence of this technology in the Middle Urals area at the very beginning of the Holocene. Such a phenomenon was earlier observed on the Upper Volga (Zhilin 2006, 2009), while in central and northern Europe polished wood cutting tools emerge much later.

According to our results, the introduction of pottery, which marks the transition from the Mesolithic to the Neolithic (Eastern terminology) in the region under study, started slightly earlier than in the forest zone of eastern Europe. This important result needs further investigation (Hartz et al. 2012). It is also interesting to note that ceramics of different types were found in the same layer and dated to a very short chronological interval at both sites. There are discussions about the chronological and typological relations of both pottery styles. Our study shows that 4 types of early Neolithic ceramics occur more or less synchronous in the Middle Urals area. A further important conclusion is the positive evidence for the use of composite projectile points with slots for flint insets in the Early Neolithic of the region, as indicated by finds of fragments of such bone artifacts at both sites. Earlier it was considered (without any dates available) that all composite weapons and microblade insets belong to the Mesolithic (Serikov 2000). The problem of the transition from the Mesolithic to the Neolithic in the Urals region is presently a subject of discussion, and the new reliable series of ¹⁴C dates presented here provide a good framework for further research. The consistency of dates obtained from various organic materials (wood, herbivorous bones, charred remains from sherds) shows that there is no reservoir effect affecting the studied samples.

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