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RADIOCARBON DATING SITES OF NORTHWEST RUSSIA AND LATVIA

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ABSTRACT. We describe applications of radiocarbon dating used for establishing a chronology of archaeological sites of the Novgorod region at the end of the first millennium AD. We have ^{14}C-dated known-age tree rings from sites in Latvia and ancient Novgorod, northwest Russia, as well as charcoal and wood from Novgorod. Calendar ages of ^{14}C-dated tree rings span the interval, AD 765–999. We used the Groningen calibration program, CAL15 (van der Plicht 1993) to calibrate ^{14}C ages to calendar years. Comparisons between ^{14}C results and archaeological data show good agreement, and enable us to narrow the calendar interval of calibrated ^{14}C determinations.

INTRODUCTION

Systematic excavations of old cities in northwest Russia, mainly Novgorod, have led to the construction of an archaeological chronology of the 10th–15th centuries. Lesman (1984, 1990) has linked Russian burial sites in northwest Russia with the well-dated dendrochronological scale of ancient Novgorod. This enables us to place the origin of many burial complexes at the beginning to the middle of the second millennium AD.

Pre-Christian Slavic settlement of northwest Russia has attracted much attention since the end of the 19th century. Recently excavated material from related settlements supplements the information retrieved from burial sites of long-barrow and high mound (*sopki*) cultures. However, chronological data are scarce (Popov, Svezhentsev and Zaitseva 1993).

The ancient city of Novgorod provides a well-documented archaeological chronology for northwest Russia. Dendrochronologically dated wood samples (Chernykh 1985) and the reconstruction of pavement-level stratigraphy at the Troitskii-VIII site (Bassalygo, Sorokin and Khoroshev 1988) indicate that the settlement at Novgorod extends from the mid-9th to the early 15th centuries. Our research on ^{14}C-dating tree rings has narrowed the period of occupation to AD 765–1000. Figure 1 shows the archaeological sites of the Novgorod region.

METHODS

We used dendrochronologically dated pine wood samples for ^{14}C-dating 14 samples from the sites of Ushuri and Araishiu, Latvia (which belong to the western European forest zone and are synchronous with some layers of ancient Novgorod), and 25 samples from the Troitskii-VIII excavation in Novgorod (Chernykh 1985a,b, 1987; Urieva 1989).

Wood samples were pretreated by using benzene/alcohol 2:1 for resin removal and acid-alkali-acid (AAA) solutions. The sequence follows: extraction of resins for 5–6 h; 1% HCl solution at room temperature for 1–2 h; 0.5% NaOH solution at 80°C for 1 h; washing with hot water; 1% HCl solution at 80°C for 1 h; and finally, rinsing with hot water to pH 7. The yield of this procedure is *ca.* 60–70% by weight. The samples were then carbonized by the dry distillation method (anoxic). We reacted the carbonized samples with lithium, then used standard procedures to convert Li_2C_2 to C_6H_6. The ^{14}C activity was measured using liquid scintillation spectrometry. We used a two-channel analyzer with quartz vials of 3.2- and 6.8-ml capacities. We did not correct for isotopic fractionation. The ratio of our calibration standard to the international standard, SRM-4990 (Arslanov

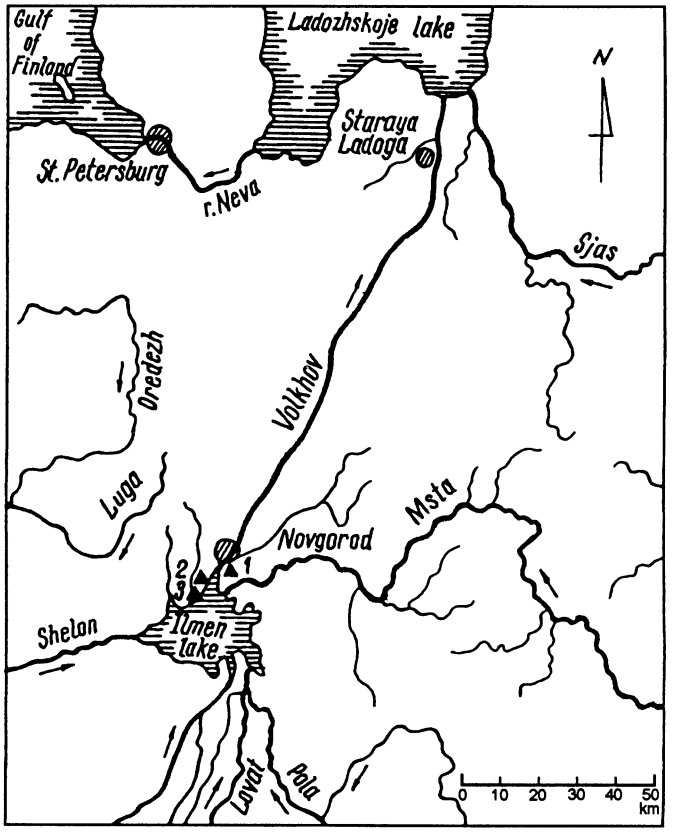

Fig. 1. Map of the Novgorod region and archaeological sites mentioned in the text: 1. Ryurikovo Gorodishche; 2. Gorodishche Georgii; 3. Vasiljevskoe-I settlement

1987) was 4.993 ± 0.011. The statistical error depended on the number of counts accumulated. Generally, the 1 σ error was between 30 and 60 yr, sometimes 70 and 90 yr.

Results

Earlier excavations yielded ^{14}C data sets for dendrochronologically dated wood samples from the 25th level of the Troitskii-VIII site in ancient Novgorod: TC-VIII-25–78, felling date: AD 968; and TC-VIII-25–63, felling date: AD 960 (Table 1, Fig. 2: III–IV). In the three years since we wrote our last report (Popov, Svezhentsev and Zaitseva 1993), we have obtained more data from Layers 22, 26 and 27 of the same excavation: TC-VIII-22–50—wood from the framework, felling date: AD 1002; TC-VIII-26–88—wood from planking, felling date: AD 960; and TC-VIII-27–130—wood from a wall, felling date: AD 958 (Table 1, Fig. 2: V–VII). Further, we have obtained dating results of dendrochronologically dated wood from Latvia: Ushuri—wood from planking, felling date: AD846; and Araishiu—wood from planking, felling date: AD 920–930 (Table 1, Fig. 2: I, II)

We have also reconsidered previous conclusions (Popov, Svezhentsev and Zaitseva 1993) based on new results and recent calibration information (Stuiver and Pearson 1993). We used the calibration program CAL15 (van der Plicht 1993) to convert ^{14}C determinations to calendar ages. We report

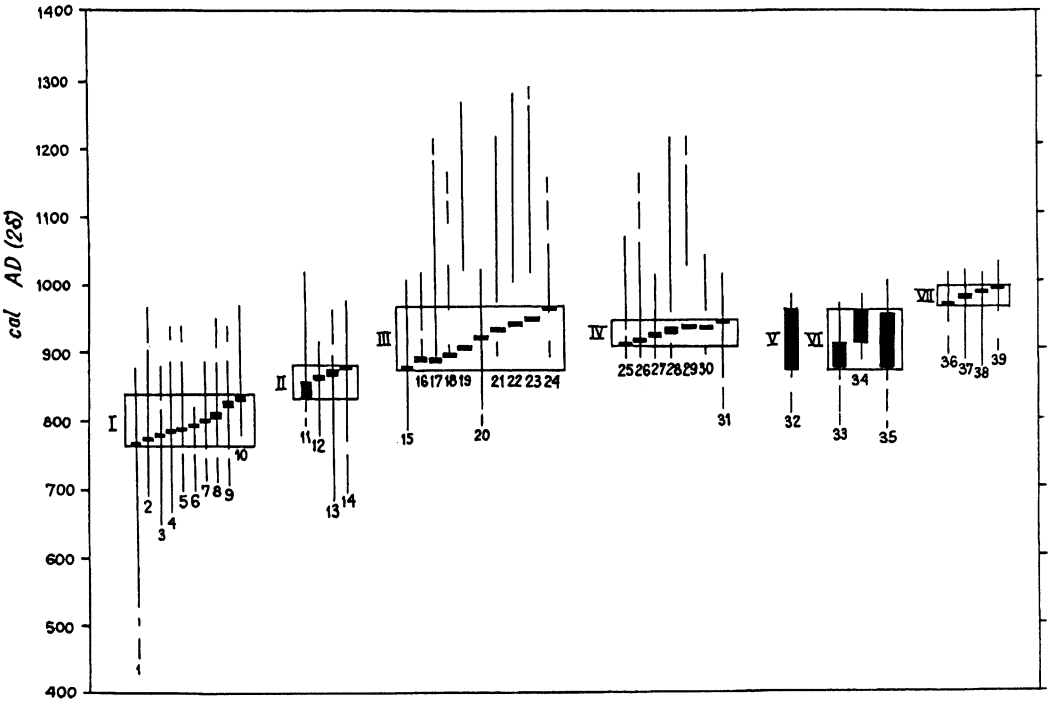

Fig. 2. Calibrated ^{14}C dates (2 σ) of tree-ring-dated wood samples: I–VII = blocks of tree-ring-dated wood samples; ▮ = range of tree-ring dates; Nos. 1–39 = sample numbers correlated to Table 1.

our results in Table 1 and in Figures 2 and 3. Figure 3 shows a rapid decline in ^{14}C concentration in Section 3 of the curve at *ca.* cal AD 900. Some samples of dendrochronologically dated wood lie within this period.

Table 1 compares calendar ages for wood (determined dendrochronologically) with calibrated ^{14}C ages (Fig. 2: Blocks I–VII). Generally, the two data sets agree, particularly where the ^{14}C concentration changes smoothly (Fig. 3: 1, 2, 4). Blocks I, II and IV (Fig. 2) correspond to these sections

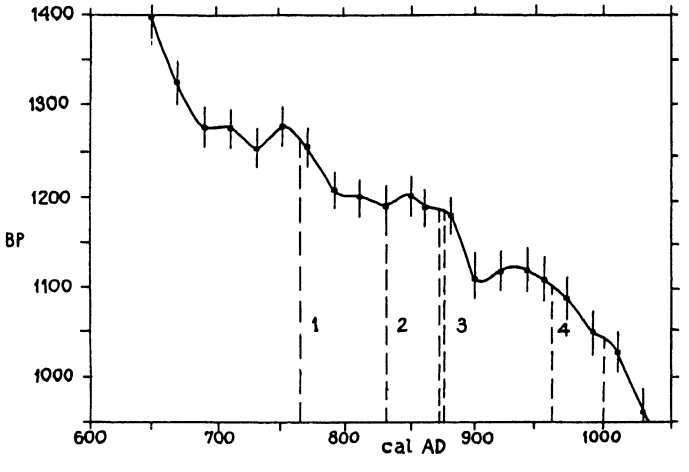

Fig. 3. The Stuiver and Pearson (1993) calibration curve for AD 600–1050 according to the range of ^{14}C-dated tree-ring dates

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and tree-ring dates lie inside the calibrated range of ^{14}C ages. Blocks III and IV show some differences between calibrated and tree-ring dates, which may be connected with the section of the calibration curve (Fig. 3: 3), where the ^{14}C concentration quickly changes. It is important to note that the tree-ring samples cover 1–4 rings and have been dated on a bidecadal scale. Measurement may reflect the fine structure of the curve at this point. One cannot fully exclude poorer precision of measurement, on the one hand, and errors in determining tree-ring ages, on the other. In all cases, uncertainties exist in calibrating ages of tree-ring samples; calendar ranges are sometimes wider than tree-ring dates. However, these uncertainties can be smoothed by dating large quantities of tree rings, as Blocks V and VI (Fig. 2) illustrate. We dated Block V as a whole (AD 873–960); we divided VI into 3 samples: the 1st included 35 inner tree rings; the 2nd, 45 external tree rings; and the 3rd included tree rings from AD 879–958.

Dating archaeological sites of the Novgorod region

Figure 1 shows locations of archaeological sites of the Novgorod region reported here. Of primary importance in studying ancient Novgorod are the complexes of Ryurikovo Gorodishche, the tradecraft and military-administrative center preceding Novgorod. Ryurikovo Gorodishche is the earliest fortified site at the source of the Volkhov River, dating to the 9th century AD (Nosov 1990). The excavation of a moat in 1987–1989 from a depth of 4.5 m from the ancient surface confirmed the presence of the fortification, in contrast to the opinion of some archeologists (Lebedev 1985). Archaeologically, the moat dates to the 9–10th centuries. Table 2 and Figures 4 and 5 show the ^{14}C data sets and corresponding calendar ranges for 1 and 2 σ, respectively. Results obtained on charcoal samples from different levels date the moat to the 7th to the 10th centuries. The moat may have been built between the early 7th and 8th century (LE-3467, 3469). LE-3332 suggests occupation of the site to the Early Iron Age, which also concurs with the presence of pottery typical for this time. The moat was filled in at the time the city was replanned in the 11th century AD (Nosov 1990). A charcoal sample, LE-3333, from a lime-firing kiln, agrees well on stratigraphic, archaeologic and ^{14}C grounds. Erected on the site of the filled-in moat, the kiln is strongly linked to the construction of Blagoveschenje Church in AD 1103 (Nosov 1990). One of the calibrated ranges subsumes this date.

The rich wood buildings with galleries discovered at Ryurikovo Gorodishche are associated with a later period. These buildings must have belonged to royalty (Nosov 1990), as their foundations were dug into the fill of a moat. Artifactual and ceramic assemblages date to the 12th–14th centuries. Three ^{14}C dates (LE-4405, -4411, -3935) from the remains of logs and charcoal at the base of the complex date initial construction to the second half of the 13th century. Six samples (5 charcoal and 1 wood: LE-4406 to -4408a, -4412, -4414) date the destruction of the complexes by fire to the second half of the 15th century.

In the Novgorod area, 34 settlements with cultural layers from the end of the first millennium AD are known from the Ilmen Lake district (Poozerje) and from the upper Volkhov River. Samples from two of these sites, Vasiljevskoe-I and Georgii, on the Veryazha River, yielded two representative ^{14}C data sets. According to the archaeological remains, Vasiljevskoe-I dates fall between the 9th and 10th centuries (Nosov 1990). The calibrated dates (LE-4157, -4388 to -4392 and -3327 to -3329) on charcoal determine the duration of occupation from AD 956–1000(1020) (Table 2, Fig. 5). Beads and Ladoga-type pottery found at the excavation confirm these dates. However, the possibility of earlier habitation cannot be ruled out (Table 2, Fig. 5).

The site of Gorodishche Georgii, situated 0.3 km upstream on the Veryazha River, was dated archaeologically to the 8th–9th centuries (Orlov and Aksenov 1961). Recent excavations (Nosov 1990)

established settlement during the 9th century. Samples LE-3460, and -3937 to -3943, date part of the settlement to *ca.* AD 925–999. Charcoal from Squares 2 and 3 yielded a calibrated range from the end of the 8th to the 9th centuries (LE-3461). Two calibrated dates on charcoal from fortified buildings (LE-3934, -3935) support this interval, but cannot exclude later occupation in the 9th–10th centuries. Archaeological evidence (Nosov 1990) corroborates the synchronic existence of Vasiljevskoe-I and Gorodishche Georgii, at least at one point (LE-3936), during the Early Iron Age.

Historically associated with ancient Novgorod is the famous site of northwest Russia, Staraya Ladoga (Zemlyanoe Gorodishche), which was first excavated in 1909 (Kirpichnikov 1985). Chernykh (1987) combined dendrochronological time scales of Staraya Ladoga with ancient Novgorod. We tree-ring dated two wood samples from Layer E3 (AD 760–830) (Chernykh 1985a). The sample without a tree-ring date was divided into two (1 of sapwood and 1 of heartwood). The calibrated range for samples LE-4158 and -4159 is the same as the dendrochronological period of Layer E3.

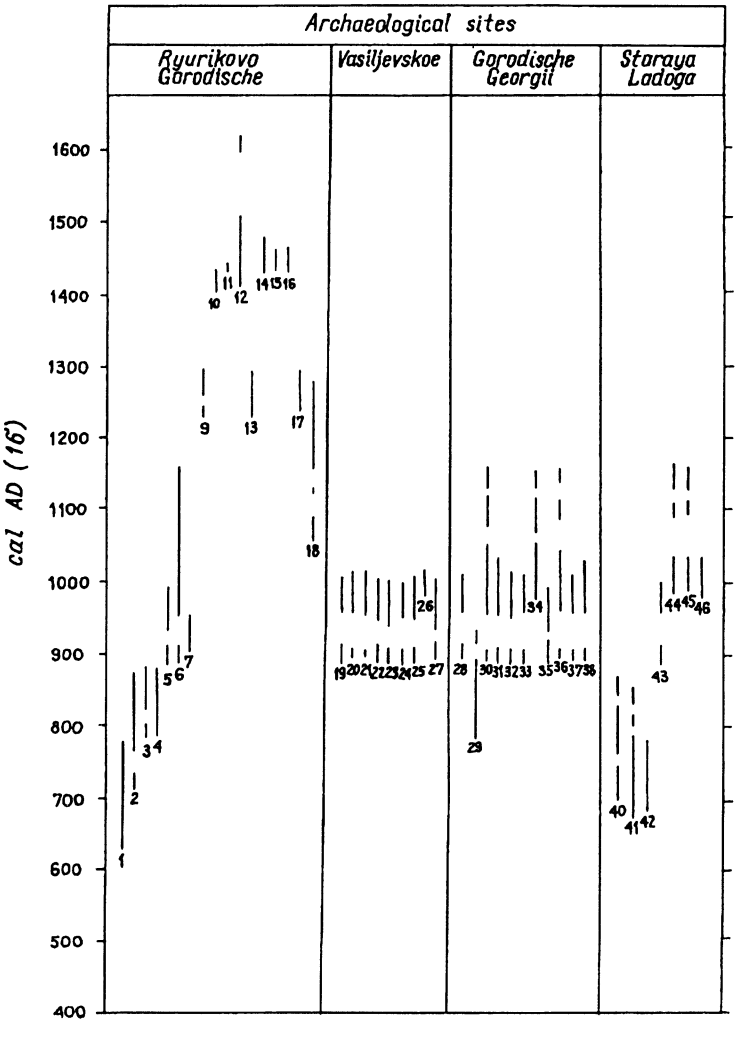

Fig. 4. Calibrated ^{14}C dates (1 σ) on charcoal and wood samples for the Novgorod region. Nos. 1–46 = sample numbers correlated with Table 2.

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An oak sample containing 27 rings from a building erected in AD 776–811 (Chernykh 1989) yielded a calibrated ^{14}C date (LE-4795) of AD 680–786, which lies within the dendrochronological range. ^{14}C ages of planks and logs (LE-4416 to -4419) agree with archaeological ages, and date to the second half of the 10th century.

Conclusion

^{14}C dating of archaeological sites of the Novgorod region is effective for time scales requiring high-precision dating. Shorter calendar intervals can be obtained only by serial dating and comparisons with results obtained using other dating methods. Archaeological sites of the Novgorod region of the end of the first millennium AD allow us to compare the ^{14}C data with dendrochronological, archaeological and historical documentation. ^{14}C dating of dendrochronologically dated tree rings demonstrated that uncertainties can result from converting ^{14}C years to calendar years. We have

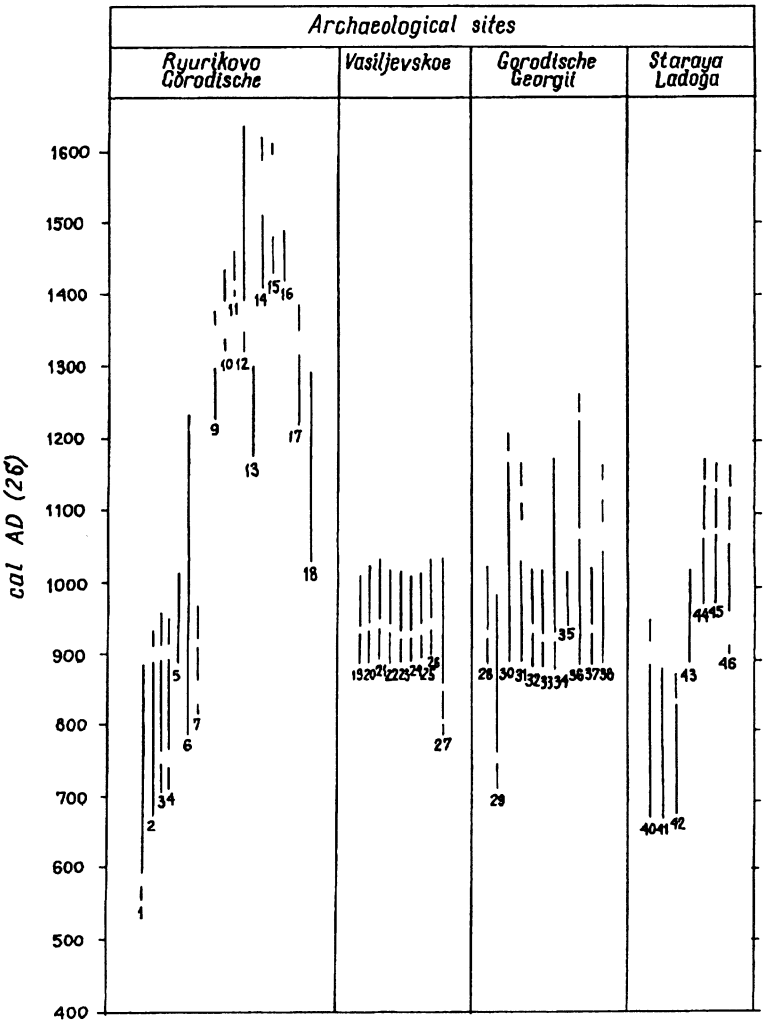

Fig. 5. Calibrated ^{14}C dates (2 σ) for the Novgorod region. For key, see Fig. 4.

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found that at least 10–20 tree rings are needed to obtain reliable dates and to show close agreement between calibrated ^{14}C ranges and tree-ring dates.

The ^{14}C data set for archaeological sites of the Novgorod region and Staraya Ladoga is important for studying Slavic history. Staraya Ladoga was the oldest settlement, dating to the 7th–8th century AD; the lower layers of Ryurikovo Gorodishche are also associated with the same period. The sites of Vasilijevskoe-I and Georgii co-existed during the 9th–10th century AD. Future research for this area should link the history of northwestern Russia to the chronology of ancient Novgorod.

ACKNOWLEDGMENTS

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TABLE 1. Radiocarbon Dates of Tree-Ring-Dated Wood

No.	Lab no.	Tree-ring ages (AD)	Uncalibrated ^{14}C date (BP)	Calibrated range (van der Plicht 1993) (cal AD) 1 σ	2 σ
Latvia – Ushuri, 1964 Excavation (Block 1)					
1	LE-4244	767	1386 ± 90	564–570, 596–726, 732–772	454–480, 540–512, 530–880
2	LE-4243	772	1205 ± 60	724–734, 772–892, 922–941	690–902, 904–968
3	LE-4242	777	1297 ± 50	674–772	658–824, 836–870
4	LE-4241	781	1253 ± 60	694–752, 758–820, 838–866	662–892, 922–942
5	LE-4240	786–787	1217 ± 40	782–876	694–752, 758–892, 920–947
6	LE-3632	796–798	1235 ± 35	774–874	694–752, 758–884
7	LE-4238	798–801	1226 ± 30	780–824, 836–872	714–742, 766–886
8	LE-3633	804–808	1211 ± 40	786–878	706–748, 762–849, 916–957
9	LE-3635	818–828	1216 ± 35	786–828, 832–874	706–748, 762–892, 922–940
10	LE-3636	829–835	1175 ± 40	792–802, 814–846, 853–892, 918–952	780–968

Table 1. (Continued)

No.	Lab no.	Tree-ring ages (AD)	Uncalibrated ^{14}C date (BP)	Calibrated range (van der Plicht 1993) (cal AD) 1 σ	2 σ
Latvia – Araishiu, 1965–1967 Excavation (Block II)					
11	LE-4225	835–855	1109 ± 55	890–988	792–802, 814–848, 852–1022
12	LE-4224	861–865	1182 ± 40	788–892, 924–934	776–968
13	LE-4223	866–872	1210 ± 60	718–738, 770–892, 926–934	684–900, 906–966
14	LE-4222	872–876	1190 ± 60	780–892, 920–951	696–750, 758–980
Ancient Novgorod, Troitskii-VIII, 1987 Excavation					
	TC-Y111-25-78 (Block III)				
15	LE-4571	878	1143 ± 55	824–836, 872–984	784–1006
16	LE-4572	882–884	1084 ± 30	896–910, 963–1008	892–924, 936–1016
17	LE-4573	888	1011 ± 70	972–1058, 1078–1124, 1134–1160	890–1177, 1192–1206
18	LE-4574	892–895	1022 ± 35	988–1030	900–906, 966–1050, 1088–1118, 1138–1158
19	LE-4576	901–902	899 ± 70	1040–1098, 1112–1146	1020–1269
20	LE-4580	923–924	1104 ± 60	890–996	790–806, 812–1026
21	LE-4581	930–935	1014 ± 50	978–1044, 1092–1116, 1142–1156	894–912, 957–1164
22	LE-4582	936–937	919 ± 80	1032–1177, 1190–1208	1002–1275
23	LE-4583	943–950	907 ± 70	1040–1100, 1110–1146, 1152–1212	1016–1260, 1262–1268
24	LE-4586	958–962	1028 ± 40	978–1032	894–916, 956–1054, 1082–1122, 1136–1158
	TC-Y111-25-63 (Block IV)				
25	LE-4589	913–916	1018 ± 60	970–1052,	

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Table 1. (Continued)

No.	Lab no.	Tree-ring ages (AD)	Uncalibrated ^{14}C date (BP)	Calibrated range (van der Plicht 1993) (cal AD) 1 σ	2 σ
				1086–1118, 1138–1158	892–922, 936–1166
26	LE-4591	921–922	1046 ± 55	894–918, 956–1034	886–1056, 1082–1122, 1136–1160
27	LE-4592	925-927	1089 ± 40	894–918, 954–1008	890–1016
28	LE-4593	930–932	993 ± 60	996–1058, 1080–1122, 1134–1160	898–910, 963–1210
29	LE-4594	935–937	922 ± 30	1042–1096, 1114–1144, 1154–1164	1030–1177, 1192–1208
30	LE-4595	938–940	1045 ± 30	986–1018	900–908, 966–1030
31	LE-4596	942–945	1126 ± 40	892–968	818–840, 858–1012
	TC-Y111-26-88 (Block V)				
32	LE-4791	873–960	1143 ± 30	886–896, 912–963	820–840, 860–986
	TC-Y111-27-130 (Block VI)				
33	LE-4793	879–913	1157 ± 30	878–898, 910–963	792–804, 814–848, 851–974
34	LE-4792	914–958	1116 ± 30	892–922, 941–976	886–991
35	LE-4794	879–958	1136 ± 40	886–902, 904–966	794–802, 814–846, 853–1002
	TC-Y111-28-50 (Block VII)				
36	LE-3627	971–976	1070 ± 30	970–1014	892–920, 946–1022
37	LE-3628	981–983	1092 ± 45	892–920, 950–1008	884–1020
38	LE-3629	988–990	1113 ± 40	892–924, 936–980	876–1016
39	LE-3620	995–999	1045 ± 30	986–1018	900–908, 966–1030

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TABLE 2. Radiocarbon Dates of the Novgorod Region and Staraya Ladoga

No.	Lab no.	Provenience	Material	Uncalibrated date (BP)	Calibrated date (van der Plicht 1993) 1 σ, cal AD/BC	2 σ, cal AD/BC
Rurikovo Gorodishche 1987–1989 Excavation						
	Moat					
1	LE-3467	Sq. 237, depth 3.75 m	Charcoal	1340 ± 80	634–782	558–576, 594–884
2	LE-3469	Sq. 238, depth 5.35 m	Charcoal	1240 ± 50	718–740, 768–876	672–892, 924–934
3	LE-3468	Sq. 237, depth 4.2–4.6 m	Charcoal	1210 ± 40	786–878	708–748, 762–894, 914–957
4	LE-3477	Sq. 195, pit, depth 3.7–3.8 m	Charcoal	1210 ± 40	786–878	708–748, 762–894, 914–957
5	LE-3476	Sq. 241, depth 3.56 m	Charcoal	1100 ± 40	892–920, 946–998	886–1014
6	LE-3475	Sq. 233, pit, depth 2.18 m	Charcoal	1020 ± 100	890–920, 952–1160	790–1230
7	LE-4404	Sq. 184, layers on moat walls	Charcoal	1160 ± 20	882–893, 919–951	821–839, 865–902, 904–967
	Cultural layer					
8	LE-3332	Sq. 201, high layer	Charcoal	2870 ± 40	1114–1094 BC, 1072–986 BC, 960–938 BC	1158–1148 BC, 1126–916 BC
	"Northern" complex					
9	LE-4405	Sq. 165, base of fill: log on step	Wood	740 ± 40	1257–1296	1225–1304, 1362–1378
10	LE-4406	Sq. 165, crude boards	Charcoal	530 ± 30	1406–1430	1322–1334, 1396–1440
11	LE-4407	Sq. 164–171, base	Wood	465 ± 20	1443–1446	1422–1459
12	LE-4408(a)	Posthole in NW	Charcoal	460 ± 75	1406–1508, 1600–1618	1318–1342, 1394–1638
	"Southern" complex					
13	LE-4411	Sq. 179, base	Wood	770 ± 50	1236–1287	1170–1300
14	LE-4412	Sq. 185, base	Charcoal	440 ± 40	1434–1476	1414–1516, 1588–1624
15	LE-4413	Sq. 175, black basal layer	Charcoal	430 ± 25	1442–1466	1434–1486, 1606–1610
16	LE-4414	Sq. 175, 182, base	Charcoal	450 ± 30	1434–1463	1420–1482
17	LE-3935	Sq. 169–176, gray humic layer	Charcoal	740 ± 50	1242–1298	1216–1312, 1350–1390
	Lime-firing kiln					
18	LE-3333	Fill of kiln; depth 2.14 m	Charcoal	850 ± 80	1056–1080, 1122–1134, 1160–1277	1032–1287
	Valilyevskoe-I, 1986–1989 Excavation					
19	LE-4157	Hearth frame (excav. 1986)	Charcoal	1090 ± 30	896–914, 959–1004	892–926, 932–926

TABLE 2. (Continued)

No.	Lab no.	Provenience	Material	Uncalibrated date (BP)	Calibrated date (van der Plicht 1993) 1 σ, cal AD/BC	2 σ, cal AD/BC
20	LE-4388	Sq. 31, 46	Charcoal	1060 ± 40	900–906, 966–1020	892–926, 932–1028
21	LE-4389	Sq. 41, 42, 51, 52	Charcoal	1060 ± 40	900–906, 966–1020	892–926, 932–1028
22	LE-4390	Sq. 51, 54, top	Charcoal	1090 ± 40	892–918, 954–1008	932–1028, 888–1014
23	LE-4391	Sq. 51, 54, bottom	Charcoal	1090 ± 35	894–916, 956–1006	890–928, 930–1012
24	LE-4392	Sq. 55	Charcoal	1090 ± 25	896–912, 963–1000	892–922, 936–1012
25	LE-3327	Sq. 55	Charcoal	1080 ± 40	894–914, 959–1012	890–926, 930–1018
26	LE-3328	Sq. 63	Charcoal	1050 ± 30	984–1018	898–910, 963–1028
27	LE-3329	Sq. 56–61	Charcoal	1090 ± 55	892–922, 944–1010	794–800, 816–844, 854–1032
	Gorodische Georgii, 1988 Excavation					
28	LE-3460	Sq. 6, 7	Charcoal	1070 ± 40	898–910, 963–1016	892–926, 932–1024
29	LE-3461	Sq. 2, 3	Charcoal	1190 ± 50	780–892, 922–938	712–744, 764–976
30	LE-3934	Trench, Sec. ZH, depth 2.5–3.0 m	Charcoal	1020 ± 70	898–908, 965–1054, 1082–1122, 1136–1158	886–1174, 1194–1206
31	LE-3935	Trench, Sec. A–B, dark-gray charcoal layer	Charcoal	1050 ± 50	896–912, 961–1028	886–1046, 1092–1116, 1142–1156
32	LE-3937	Construction in sq. 34, 37, basal charcoal layer	Charcoal	1075 ± 40	896–912, 961–1014	890–926, 930–1020
33	LE-3938	Clay-charcoal layer, sq. 31, 34	Charcoal	1080 ± 30	898–908, 965–1010	892–922, 938–1018
34	LE-3939	Pit, sq. 13, 14, 18, 19, top of fill	Charcoal	1010 ± 60	976–1052, 1084–1120, 1138–1158	892–922, 940–1170
35	LE-3940	Pit, sq. 13, 14, 18, 19, bottom of fill	Charcoal	1100 ± 40	892–920, 946–998	886–1014
36	LE-3941	Pit, sq. 39, 40	Charcoal	1030 ± 50	900–906, 966–1040, 1098–1110, 1146–1152	892–924, 936–1060, 1067–1124, 1130–1160
37	LE-3942	Construction in sq. 24, 25	Charcoal	1080 ± 40	894–914, 959–1012	890–926, 930–1018
38	LE-3943	Cultural layer in sq. 16	Charcoal	1050 ± 50	896–912, 961–1028	886–1046, 1092–1116, 1142–1156

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TABLE 2. (Continued)

No.	Lab no.	Provenience	Material	Uncalibrated date (BP)	Calibrated date (van der Plicht 1993) 1 σ, cal AD/BC	2 σ, cal AD/BC
39	LE-3936	Trench, Sec. D, depth 0.1–0.3 m	Charcoal	2350 ± 70	752–730 BC, 714–716 BC, 530–360 BC, 286–254 BC	762–672 BC, 666–628 BC, 596–576 BC, 558–342 BC, 324–200 BC
Staraya Lagoda (Zemlyanoe Gorodishche) Horizon E3						
40	LE-4158	Pillar, external tree rings	Wood	1250 ± 60	704–748, 760–826, 834–872	664–892, 920–945
41	LE-4159	Pillar, inner tree rings	Wood	1275 ± 55	672–792, 804–814, 848–850	666–880
42	LE-4795	Pillar of construction N3 (1982) (sample N105), brown humin (felling date: AD 776–811)	Wood (oak)	1270 ± 40	680–786	672–826, 834–872
43	LE-4416	Remains of 3rd layer, sq. D 30	Wood	1085 ± 40	894–916, 956–1010	890–1016
44	LE-4417	2nd pavement, sq. D28–E28	Wood	1010 ± 40	988–1049, 1093–1112, 1144–1152	970–1064, 1074–1126 1132–1162
45	LE-4418	Top of pavement, sq. D28–E28	Wood	1010 ± 40	988–1049, 1093–1112, 1144–1152	970–1064, 1074–1126 1132–1162
46	LE-4419	Felling frame, sq. Z30	Wood	1020 ± 35	988–1032	902–904, 966–1052, 1086–1120, 1138–1158

REFERENCES

Arslanov, Ch. A. 1987 *Radiocarbon: Geochemistry and Geochronology.* Leningrad, Leningrad University: 300 p. (in Russian).

Bassalygo, L. A., Sorokin, A. N., Khoroshev, A. S. 1988 The streets of the Troitsky excavation site (topography, stratigraphy, chronology). In *Novgorod and the Novgorod Region: History and Archeology.* Abstracts. Novgorod: 63–66 (in Russian).

Chernyk, N. B. 1985a Dendrochronology of Ladoga (excavation in the vicinity of Varyagskaya Street). *In* V. V. Sedov, ed., *Ladoga in the Middle Ages: New Archaeological Discoveries and Investigations.* Leningrad, Nauka: 117–122 (in Russian).

____1985b Dendrochronology of the earliest horizons of Ladoga (based on excavation results at the Zemlyanoe Gorodishche site). *In* V. V. Sedov, ed., *Ladoga in the Middle Ages: New Archaeological Discoveries and Investigations.* Leningrad, Nauka: 76–80 (in Russian).

____1987 Dendrochronological scales of the second half of the first millennium AD through the second millennium AD. *In* T. Bitvinskas, ed., *Temporal and Spatial Variations of Climate and Annual Tree-Rings.* Kaunas: 90–99 (in Russian).

____1989 Chronology and stratigraphy of the lower layers of Zemlyanoe Gorodishche Staraya Lagoda according to dendrochronological dates. *In* Chernykh, E. N., *Scientific Methods in Archaeology.* Moscow, Nauka: 201–214 (in Russian).

Kirpichnikov, A. N. 1985 Ladoga in the Middle Ages (Archaeological research). *In* V. V. Sedov, ed., *Ladoga in the Middle Ages: New Archaeological Discoveries and Investigations.* Leningrad, Nauka: 3–26 (in Russian).

Lebedev, G. S. 1985 *The Viking Epoch in Northern Europe.* Leningrad, Leningrad University Press: 283 p. (in Russian).

Lesman, Yu. M. 1984 Burial monuments of Novgorod and the Novgorod region (the problem of synchronization). In Gaidukov, P. G. and Janin, V. L., eds., *Archaeological Research in the Novgorod Region.* Leningrad, Leningrad University Press: 118–153 (in Russian).

____1990 Chronology of Novgorod jewelry. In *Materials on Novgorod Archaeology, 1988.* Moscow: 29–98 (in Russian).

Nosov, E. N. 1990 *Ryurik Gorodischche Near Novgorod.* Leningrad, Nauka: 214 p. (in Russian).

Orlov, S. N. and Aksenov, M. M. 1961 Early Slavic settlements in the Novgorod region. *Novgorodsky Istoricheskiy Sbornik* 10: 161–168 (in Russian).

Popov, S. G., Svezhentsev, Yu. S. and Zaitseva, F. I. 1991a Radiocarbon and dendrochronology as systems for absolute dating of Novgorod and the archaeological monuments of the Novgorod region. *In* Janin, V. L, Nosov, E. N. and Gaidukov, P. G., eds., *Materials on the Archaeology of the Novgorod Region, 1990.* Moscow: 169–182 (in Russian).

____1991b Radiocarbon and the absolute chronology of archaeological monuments of the early Middle Ages in northwest Russia. *In* Gaigalas, A. I., ed., *Geochronological and Isotope-Geochemical Investigations in Quaternary Geology and Archaeology.* Vilnius, Vilnius University: 131–143 (in Russian).

____1993 Radiocarbon chronology of early medieval archaeological sites in northwestern Russia. *In* Punning, J.-M., Long, A. and Kra, R. S., eds., Applications of Radiocarbon Dating in Eastern Europe and Siberia. *Radiocarbon* 35(3): 487–493.

Stuiver, M. 1993 A note on single-year calibration of the radiocarbon time scale, AD 1510–1954. *In* Stuiver, M., Long, A. and Kra, R. S., eds., Calibration 1993. *Radiocarbon* 35(1): 67–72.

Stuiver, M. and Pearson, G. M. 1993 High-precision bidecadal calibration of the radiocarbon time scale, AD 1950–500 BC and 2500–6000 BC. *In* Stuiver, M., Long, A. and Kra, R. S., eds., Calibration 1993. *Radiocarbon* 35(1): 1–23.

Urieva, A. F. 1989 Dendrochronology of planking from the Troitsky excavation in Novgorod. *In* Chernykh, E. N., *Scientific Methods in Archaeology.* Moscow, Nauka: 214–228 (in Russian).

van der Plicht, J. 1993 The Groningen Radiocarbon Calibration Program. *In* Stuiver, M., Long, A. and Kra, R. S., eds., Calibration 1993. *Radiocarbon* 35(1): 231–237.