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GEOCHRONOLOGY OF VEGETATION STAGES OF SOUTH-EAST BALTIC COAST (KALININGRAD REGION) DURING THE MIDDLE AND LATE HOLOCENE

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Abstract: The raised bog sediments that have been continuously accumulated over time represent the most suitable natural object which enables us to reconstruct Late Glacial and Holocene vegetation and palaeoclimates. Bog peat consists of organic carbon formed *in situ*. It contains moss, plant fragments and microfossils that are necessary for the study of palaeovegetation and palaeoclimate. However, a successful study of palaeoenvironment can be carried out on the basis of investigation of a great quantity of samples along the whole peatbog thickness. In the present paper, the authors present the results of palynological, botanical investigations and radiocarbon dating of 31 peat samples taken from the raised bog Velikoye, located in the eastern part of Kaliningrad Region. The data obtained have enabled us to reconstruct the palaeovegetation, reveal the evolution of the bog and determine rate of peat formation at different evolutional stages over the last 7500 cal BP.

Keywords: raised bog evolution, palynological analyses, radiocarbon dating, reconstruction of palaeovegetation history.

1. INTRODUCTION

At present the issue concerning the role of human and natural impact on climate change is the subject of considerable discussion in connection with observed increase in annual global temperature in recent decades. Peatbog and lake sediments enriched by plant remains, spores and pollen serve as the most suitable natural archives for reconstruction of climate and environmental changes during Late Pleistocene and Holocene. In the past 15 years we have studied many reference raised bogs sections located in Leningrad and Novgorod regions as well as in the Republic of Karelia. We used the same research method for all sections under study: almost every 10 cm layer along the whole peatbog length was investigated by palynological, botanical and geochronological (^{14}C) methods. On the whole, about 500 radiocarbon dates of peat and gyttja samples have been obtained at the Geochronological laboratory of St.-Petersburg State University (Elina *et al*., 1996; Arslanov *et al*., 1999, 2001; Dolu-

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khanov *et al.*, 2007). V. Klimanov (1976) developed a statistical method to reconstruct quantitative characteristics of the Late Pleistocene and Holocene climates, based on the statistical relationship between recent spore-pollen spectra and recent climatic conditions. The reconstruction was made on the basis of the palynological and geochronological data obtained from the investigated peat-bog and lake deposits (Elina *et al.*, 1996; Arslanov *et al.*, 1999, 2001).

In 2009 complex archaeological and palaeogeographical research aimed at elaborating the history of human early settlement in the Southeast Baltic (the Kaliningrad region, Russian Federation) in Late Pleistocene–Holocene was carried out. Palaeobotanical and geochronological investigations of peatbog sediments from raised bog Velikoye located in the eastern part of Kalinigrad region in the valley of the River Sheshupe (54º57'06" N, 22º20'28" E, 34 m a.s.l.) were carried out in order to reconstruct vegetation and peatbog evolution stages during the Holocene (**Fig. 1**).

2. METHODS

The area of the raised bog Velikoye is about 2000 hectares. Bog samples were taken using a Giller hand drill. Almost every 10 cm section of peat sample along the whole peatbog thickness was investigated palynologically and generally geochronologically (using ^{14}C dating method). The botanical composition of each 10-cm layer of samples was also studied. For ^{14}C dating we used liquid scintillation method described by Arslanov *et al.* (1993). Peat samples for radiocarbon dating were pretreated by heating in 1% HCl for 30 min and then by keeping them in 1% NaOH overnight at room temperature. Lithium carbide was synthesized from coal obtained by pyrolysis from the pretreated peat and humic acid samples. To synthesize benzene from acetylene $V_2O_5 \bullet Al_2O_3 \bullet SiO_2$ catalyst was used, which allowed us to obtain benzene of high purity (with 90-95% yield). Peat samples for palynological analysis were pretreated by boiling in 10% NaOH for 5 min and then washing with distilled water; the residue was then analysed. Heavy liquid (PD-6 or KK-2.6) was used for pollen extraction from mineral samples (Grichuk, Zaklinskaya, 1948). About 400 terrestrial pollen grains per sample were counted and used as pollen sum for pollen percentage calculations. The percentage of spores was based on the sum of pollen and spores. The TILIA and TILIA GRAPH plotting program was used for graphing the pollen data (Grimm, 1991). Pollen zonation was done by visual inspection.

3. RESULTS

31 peat samples were taken from the sediment core and studied by palynological, botanical and geochronological (^{14}C) methods. ^{14}C-dating of the samples were

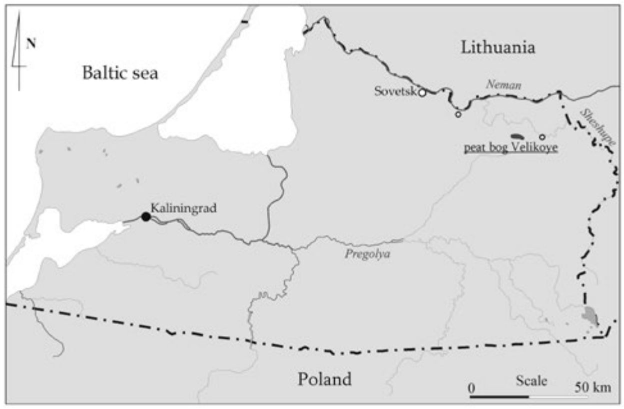

Fig. 1. *Location of the peat bog Velikoye (the Kaliningradregion, RF).*

performed in geochronological laboratory of St. Petersburg University and the results are presented in **Table 1**. Dr. G.F. Kuzmin and Dr. L.A. Sozinova carried out the botanical analysis of each 10-cm layer along the core length. As a result the evolution of the given bog in chronological sequence was revealed. A maximum thickness of peat (660 cm) was revealed in studied peat bog area. The results of the analyses are shown in **Table 2**. Bog formation began with bogging of black alder forest site where low mire wood peat of high degree of decomposition (45%) was deposited. In botanical structure of this peat 30 cm thick (660-630 cm), the bark of black alder, birch, pine and willows was identified. This layer was formed within the range from 5630-5480 cal BC to 4780-4625 cal BC. From depth of 630 cm and less the presence of oligotrophic species of peat *Sphagnum fuscum* and *Sph Magellanicun* (up to 5%) and also – *Eriophorum vaginatum* was identified. From 4780-4625 cal BC to 4530-4370 cal BC in transitional (mesotrophic) stage a thin layer of wood peat 10 cm thick (630-620 cm) was deposited. In this layer the remains of pine, birch and black alder were found. The oligotrophic stage of the bog begins from depth of 620 cm, but small amounts of transitional components and species were found in peat composition up to 500 cm. From the depth of 500 cm (from 510-460 cal BC to the present time) sphagnum moss peat was deposited with absolute prevalence of *Sphagnum fuscum*. The presence of wiggles on the plot ^{14}C-age vs. calibrated age hampers precise estimation of peat accumulation rate. The layer of peat formed between 410-370 cal BC and 1500-1600 cal AD is the most suitable one for determining the average peat accumulation rate. Here an almost linear graphic relationship between radiocarbon age and calendar age is observed (Stuiver *et al*, 1998). For the indicated period, peat accumulated at the rate of about 2 mm/year. The botanical composition of the raised bog Velikoye is typical for the Baltic bog-marsh area (Seaside type of peat accumulation), distinctive feature of which is the formation of a thick layer of homogenous in the botanical composition of *Sphagnum* peat (Kuzmin, 1993).

Table 1. *Radiocarbon and calendar ages of the peat samples from raised bog Velikoye, Kaliningrad region, bore hole 2. Calibration was made using OxCal programme v. 4.1.7 (Bronk Ramsey* et al.*, 2010) and calibration curve IntCal09 (Reimer* et al.*, 2009).*

Lab. code	Type of sample	Depth (m)	^{14}C age (BP)	Cal. age ranges 68.2% conf. intervals	Cal. age ranges 68.2% conf. intervals with using the age-depth model (see Fig. 3)
LU-6261	Peat and wood remains	6.6-6.5	6630±100	5629-5486 BC (68.2%)	5630-5484 BC (68.2%)
LU-6262	Peat and wood remains	6.4-6.3	5830±70	4782-4606 BC (68.2%)	4833-4813 BC (6.1%) 4807-4666 BC (62.1%)
LU-6263	Peat	6.2-6.1	5770±80	4716-4532 BC (68.2%)	4552-4454 BC (68.2%)
LU-6265	Twig	6.05-5.9	5180±80	4222-4210 BC (2.4%) 4153-4133 BC (4.2%) 4057-3936 BC (47.5%) 3872-3810 BC (14.1%)	4240-4126 BC (67.6%) 4112-4110 BC (0.6%)
LU-6341	Peat	5.9-5.8	4800±100	3693-3682 BC (2.6%) 3664-3506 BC (54.0%) 3428-3381 BC (11.6%)	3756-3726 BC (8.5%) 3714-3604 BC (59.7%)
LU-6342	Peat	5.7-5.6	4470±120	3351-3016 BC	2992-2893 BC (68.2%)
LU-6267	Peat	5.6-5.5	3820±100	2458-2417 BC (8.3%) 2410-2190 BC (51.5%) 2180-2142 BC (8.4%)	2618-2610 BC (2.4%) 2580-2515 BC (46.7%) 2492-2441 BC (19.1%)
LU-6272	Peat	5.4-5.3	3620±70	2125-2090 BC (10.0%) 2044-1890 BC (58.2%)	1926-1879 BC (24.1%) 1845-1772 BC (44.1%)
LU-6343	Peat	5.3-5.2	3300±70	1665-1500 BC (68.2%)	1510-1493 BC (7.7%) 1486-1414 BC (60.5%)
LU-6273	Peat	5.2-5.1	2680±60	896-801 BC (68.2%)	888-871 BC (12.9%) 865-806 BC (55.3%)
LU-6274	Peat	5.0-4.9	2160±70	357-284 BC (25.6%) 256-247 BC (2.4%) 234-111 BC (40.2%)	507-458 BC (68.2%)
LU-6275	Peat	4.8-4.7	2230±60	381-348 BC (15.6%) 316-208 BC (52.6%)	411-371 BC (68.2%)
LU-6277	Peat	4.6-4.5	2110±80	350-306 BC (10.4%) 209-39 BC (57.3%) 8-5 BC (0.5%)	340-295 BC (68.2%)
LU-6278	Peat	4.4-4.3	2290±70	406-350 BC (28.8%) 310-208 BC (39.4%)	266-215 BC (68.2%)
LU-6279	Peat	4.2-4.1	2270±70	399-350 BC (25.0%) 307-209 BC (43.2%)	190-132 BC (68.2%)
LU-6280	Peat	4.0-3.9	2150±70	355-288 BC (22.2%) 232-92 BC (46.0%)	113-54 BC (68.2%)
LU-6281	Peat	3.8-3.7	1950±70	38 BC-126 AD (68.2%)	38-8 BC (36.2%) 1 BC-30 AD (32.0%)
LU-6282	Peat	3.6-3.5	2030±80	160-132 BC (8.1%) 117BC-54 AD (60.1%)	42-88 AD (51.0%) 100-117 AD (17.2%)
LU-6283	Peat	3.4-3.3	2060±70	172 BC - 4AD (68.2%)	118-132 AD (17.1%) 146-180 AD (37.9%) 190-203 AD (13.2%)
LU-6284	Peat	3.1-3.0	1650±60	264-276 AD (3.8%) 332-438 AD (50.1%) 488-530 AD (14.3%)	258-308 AD (66.0%) 320-322 AD (2.2%)
LU-6285	Peat	2.9-2.8	1770±80	137-200 AD (18.6%) 205-344 AD (49.6%)	350-400 AD (68.2%)
LU-6286	Peat	2.6-2.5	1560±60	428-554 AD (68.2%)	482-530 AD (68.2%)
LU-6287	Peat	2.3-2.2	1380±80	578-708 AD (61.9%) 747-766 AD (6.3%)	615-658 AD (68.2%)
LU-6288	Peat	2.0-1.9	1290±70	655-780 AD (64.0%) 792-805 AD (4.2%)	746-784 AD (68.2%)
LU-6289	Peat	1.7-1.6	1050±70	892-1036 AD (68.2%)	884-916 AD (68.2%)

Table 1. *Continuation.*

Lab. code	Type of sample	Depth (m)	^{14}C age (BP)	Cal. age ranges 68.2% conf. intervals	Cal. age ranges 68.2% conf. intervals with using the age-depth model (see Fig. 3)
LU-6293	Peat	1.1-1.0	1000±50	986-1048 AD (43.6%) 1086-1123 AD (18.8%) 1138-1150 AD (5.8%)	1136-1166 AD (68.2%)
LU-6294	Peat	0.8-0.7	600±60	1301-1367 AD (51.3%) 1382-1404 AD (16.9%)	1274-1305 AD (68.2%)
LU-6295	Peat	0.5-0.4	590±80	1299-1370 AD (47.3%) 1380-1412 AD (20.9%)	1402-1438 AD (68.2%)
LU-6337	Peat	0.30-0.25 (from pit)	290±60	1496-1601 AD (46.6%) 1616-1661 AD (21.6%)	1468-1539 AD (68.2%)
LU-6296	Peat	0.2-0.15	300±70	1490-1603 AD (49.2%) 1610-1654 AD (19.0%)	1501-1598 AD (68.2%)
LU-6338	Peat	0.15-0.10 (from pit)	$\delta^{14}C$= 4.24±0.99%	1956 AD	

Table 2. *Botanical composition of peat samples from raised bog Velikoye, evolution of the bog and rate of peat accumulation.*

Type of peat bog	Depth (cm)	***Species of bog plants*** **(%)**	Cal age (BC/AD) with using the age-depth model	Rate of accumulation, (mm/year)
Oligotrophic moss peat	5-30	*Sphagnum fuscum* – 65-85 *Sphagnum angustifolium* – 5-20 *Sphagnum magellanicum* – 5-10 *Eriophorum vag.* – 5 *Ericaceae* – 5-10	Recent – 1470-1540 AD	2.03
	30-50	*Sphagnum fuscum* – 35-65 *Sphagnum angustifolium* – 20-25 *Sphagnum magellanicum* – 10-15 *Eriophorum vag.* – 20 *Ericaceae* – 5	1470-1540 AD - 1400-1440 AD	
	50-80	*Sphagnum fuscum* – 50-90 *Sphagnum angustifolium* – 5-20 *Eriophorum vag.* – 25 *Ericaceae* – 5	1400-1440 AD - 1270-1310 AD	
	80-90	*Sphagnum fuscum* – 35 *Sphagnum angustifolium* – 10 *Sphagnum magellanicum* – 10 *Eriophorum vag.* – 40 *Ericaceae* – 5		
	90-100	*Sphagnum fuscum* – 90 *Ericaceae* – 10		
	100-110	*Sphagnum fuscum* – 35 *Sphagnum angustifolium* – 10 *Sphagnum magellanicum* – 5 *Eriophorum vag.* – 45 *Ericaceae* – 5	1140-1170 AD	
	110-130	*Sphagnum fuscum* – 85-90 *Sphagnum angustifolium* – 5 *Eriophorum vag.* – 5 *Ericaceae* – 5		
	130-340	*Sphagnum fuscum* – 85-95 *Sphagnum angustifolium* – 5 *Ericaceae* – 5	880-920 AD - 120-200 AD	

Table 2. *Continuation.*

Type of peat bog	Depth (cm)	*Species of bog plants* (%)	Cal age (BC/AD) with using the age-depth model	Rate of accumulation, (mm/year)
Oligotrophic moss peat	340-350	*Sphagnum fuscum* – 10 *Sphagnum angustifolium* – 30 *Sphagnum majus* – 30 *Sphagnum cuspidatum* – 20 *Sheuchzeria pal.* – 5 *Sphagnum magellanicum* – 5 *Ericaceae* – 5	120-200 AD	2.03
	350-380	*Sphagnum fuscum* – 70-80 *Sphagnum angustifolium* – 15-20 *Sphagnum magellanicum* – 5-10 *Ericaceae* – 5	40 BC-30 AD	
	380-390	*Sphagnum fuscum* – 10 *Sphagnum angustifolium* – 45 *Sphagnum majus* – 20 *Sphagnum cuspidatum* – 5 *Sheuchzeria pal.* – 15 *Ericaceae* – 5		
	390-400	*Sphagnum fuscum* – 25 *Sphagnum angustifolium* – 25 *Eriophorum vag.* – 40 *Sheuchzeria pal.* – 5 *Ericaceae* – 5	110-50 BC	
	400-490	*Sphagnum fuscum* – 80-95 *Sphagnum angustifolium* – 5 *Sphagnum magellanicum* – 5 *Eriophorum vag.* – 5 *Ericaceae* – 5-10	110-50 BC - 410-370 BC	
	490-500	*Sphagnum fuscum* – 45 *Sphagnum magellanicum* – 30 *Sphagnum angustifolium* – 5 *Sheuchzeria pal.* – 5 *Eriophorum vag.* – 5 *Ericaceae* – 10	510-460 BC	
	500-540	*Sphagnum fuscum* – 20-40 *Sphagnum magellanicum* – 15-30 *Sphagnum angustifolium* – 5-10 *Sheuchzeria pal.* – 5-10 *Eriophorum vag.* – 25-35 *Ericaceae* – 5	510-460 BC - 1930-1770 BC	0.27
	540-560	*Sphagnum fuscum* – 10-15 *Sphagnum magellanicum* – 20-25 *Sphagnum angustifolium* – 5 *Sheuchzeria pal.* – 5 *Eriophorum vag.* – 45-55 *Ericaceae* – 5	1930-1770 BC - 2620-2440 BC	
	560-600	*Sphagnum fuscum* – 5-10 *Sphagnum magellanicum* – 5-10 *Sphagnum angustifolium* – 5 *Sheuchzeria pal.* – 5 *Eriophorum vag.* – 65-75 *Ericaceae* – 5 *Pinus* – 5-10	2620-2440 BC - 4240-4110 BC	
	600-620	*Sphagnum fuscum* – 5 *Sphagnum magellanicum* – 5 *Sphagnum angustifolium* – 5 *Sheuchzeria pal.* – 5 *Eriophorum vag.* – 50-80 *Ericaceae* – 5 *Pinus, Betula* – 10-30	4240-4110 BC - 4550-4450 BC	

Table 2. *Continuation.*

Type of peat bog	Depth (cm)	*Species of bog plants* (%)	Cal age (BC/AD) with using the age-depth model	Rate of accumulation, (mm/year)
Mesotrophic wood peat	620-630	*Sphagnum fuscum* – 5 *Sphagnum magellanicum* – 5 *Sphagnum angustifolium* – 5 *Eriophorum vag.* – 20 *Ericaceae* – 5 *Pinus, Betula, Alnus gl.* – 65	4550-4670 BC	0.37
Low mire wood peat	630-640	*Betula humilis, Alnus glutinosa, Betula pubescens* - 95 *Sheuchzeria pal.* – 5	4830-4630 BC	
	640-650	*Betula, Alnus* – 100		
	650-660	*Alnus Betula, Salix* – 100	5630-5480 BC	

The bog sediments of 657 cm in thickness were studied with the method of the spore-pollen analysis. All samples contained amounts of microfossils sufficient for statistical analysis. In each preparation about 400 grains were counted with the exception of samples of flooded peat. Analysing the characteristic changes in the composition of flora and quantitative ratios of pollen of various plants, in the spore-pollen diagram five pollen zones can be distinguished, the formation of which occurred during the Boreal–Subatlantic time under the Blytt-Sernander scheme (**Fig. 2**).

LPAZ-1: *Pinus-Cyperaceae-Polypodiaceae*, 660-650 cm. Zone 1 is characterized by domination of *Pinus* (40%) and *Betula* pollen (25%). The *Alnus* pollen content reach 10% and *Corylus* – 5%. Percentages of herb pollen including *Cyperaceae* (15%), *Artemisia* (7%), *Rosaceae* (3%) and *Poaceae* (2%) are relatively high (27%). The *Polypodiaceae* dominate (25%) among spores. The green algae of *Pediastrum* are notable only in this zone (37%).

LPAZ-2: *Alnus*, 650-600 cm. The composition of spore-pollen spectra changes very sharply. The main dominant becomes *Alnus* pollen (50-60%), the pollen of *Quercus*, *Ulmus*, *Tilia*, *Fraxinus* also appear. The pollen of herb and spore plants is represented by some grains only.

LPAZ-3: *Alnus-Quercus-Corylus-Sphagnum*, 600-515 cm. Zone 3 is distinguished from zone 2 by the highest percentage of *Quercus* pollen (18%), *Tilia* (6%), *Ulmus* (4%); also appear *Ericaceae* pollen at the beginning of this zone and *Picea* pollen - at the end of the zone. Sphagnum also attains maximum percentages (62%).

LPAZ-4: *Alnus-Picea-Carpinus,* 515-60 cm. The main particularity of fourth zone is the appearance of *Carpinus* pollen (13%) and a significant increase of both *Picea* and *Betula* pollen up to 15% and 35% correspondingly and a decrease of *Pinus* (10%), *Alnus* (15%), *Quercus* (3%).

LPAZ-5: *Pinus-Poaceae-Calluna,* 60-0 cm. *Pinus* pollen dominates in spore-pollen spectra of this zone (30%), *Betula* (25%) and *Alnus* (10%) pollen follow. Pollen of herbs content is increased up to 33% including *Poaceae* (8%) and *Calluna* (14%).

Results of the spore-pollen analysis allow us to conclude that during the formation of pollen zones 2 and 3 in the second half of Atlantic period and practically all Subboreal period the spectra contain maximum quantity of alder (40-60%) and broadleaf species of trees such as elm, linden, oak (in total up to 20%) and hazel grove (up to 20%).

Data of spore-pollen analysis of a bog Velikoye sediments allow to reveal the dynamics of tree species.

Throughout the whole section absolute domination of pollen of tree species and bushes (80-95%) was observed. Only at the end of the Subatlantic period a reduction of pollen of wood species to 65% and an increase in grassy plants was registered.

Spruce *(Picea)*. Occurrence of the pollen of a fir-tree was registered around 4470 ^{14}C BP. Further upwards on a section there is a gradual increase in the curve of the spruce pollen content and about 2150 ^{14}C BP it forms a maximum of 15%. The following considerable peak (approx. 16%) is registered at the approx. time 600 BP.

Pine *(Pinus)*. The content of pine varies in the section from 5% to 40%. Its maximum quantity registered at the time of 6630 ^{14}C BP and last 300 years and less.

Birch arboreal *(Betula sect. Albae)*. The lowest percentage of birch pollen (10-25%) is registered at the lower part of the section within the time range from 6630 to 2680 BP, which is comparable with the Atlantic and Subboreal periods of Holocene. The maximum of 35% is comparable with the Subatlantic period and corresponds to ca. 1700 BP.

Hazel *(Corylus)*. There is a higher content of this pollen (10-20%) within the time range from 5770 ^{14}C BP to 3300 ^{14}C BP, with a maximum of 20% approx. 4500 ^{14}C BP. Further up the section its content does not exceed 5%.

Alder *(Alnus)*. The maximum concentration of alder pollen (30-58%), as well as hazel, is observed in the lower part of the section within the time range from 6630 ^{14}C to 3300 ^{14}C BP with a peak at 5830 ^{14}C BP. Further there

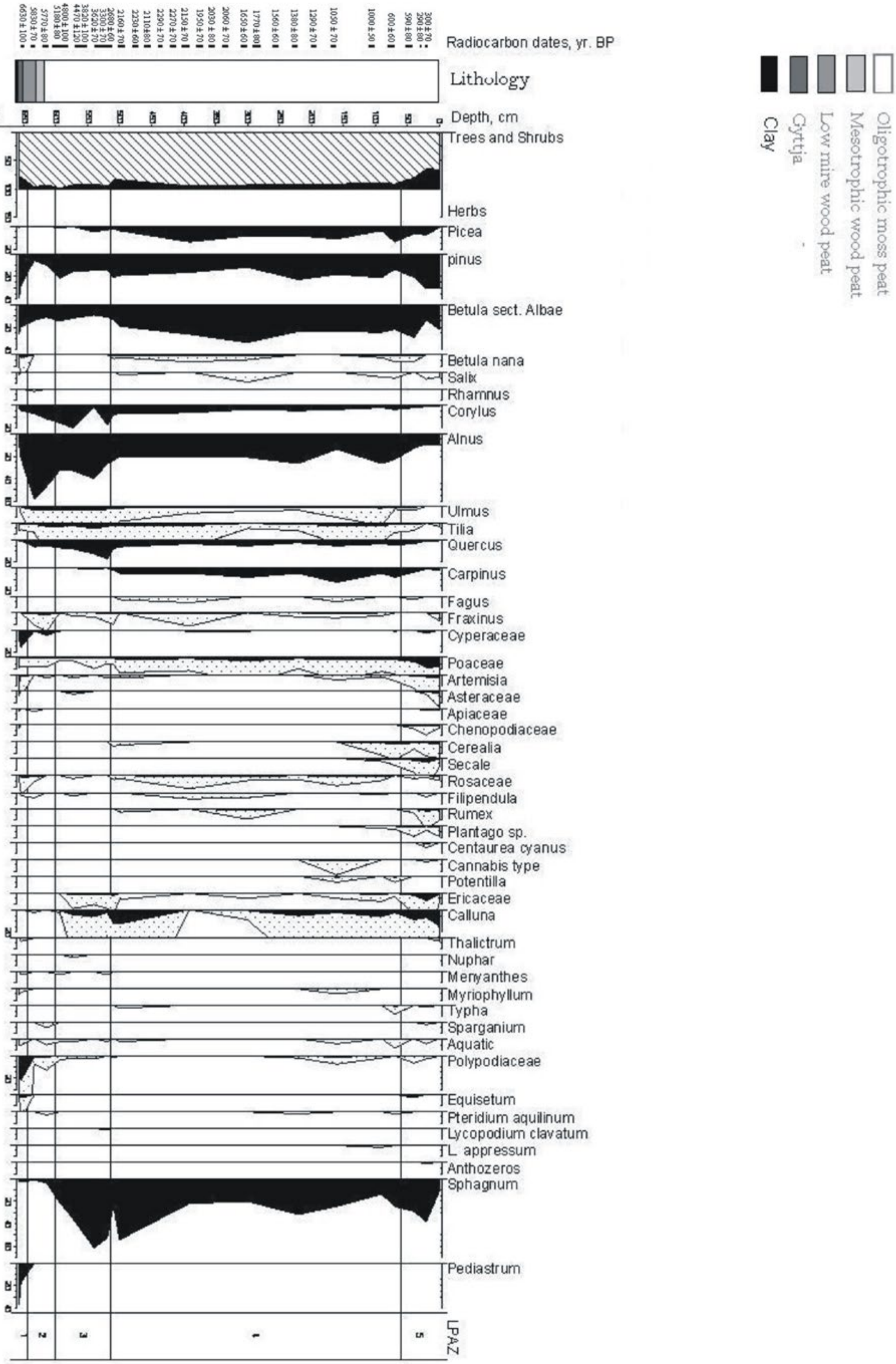

Fig. 2. *Chorono-palynologicaldiagram of Velikoye peat bog sediments (Kaliningrad area, Russia).*

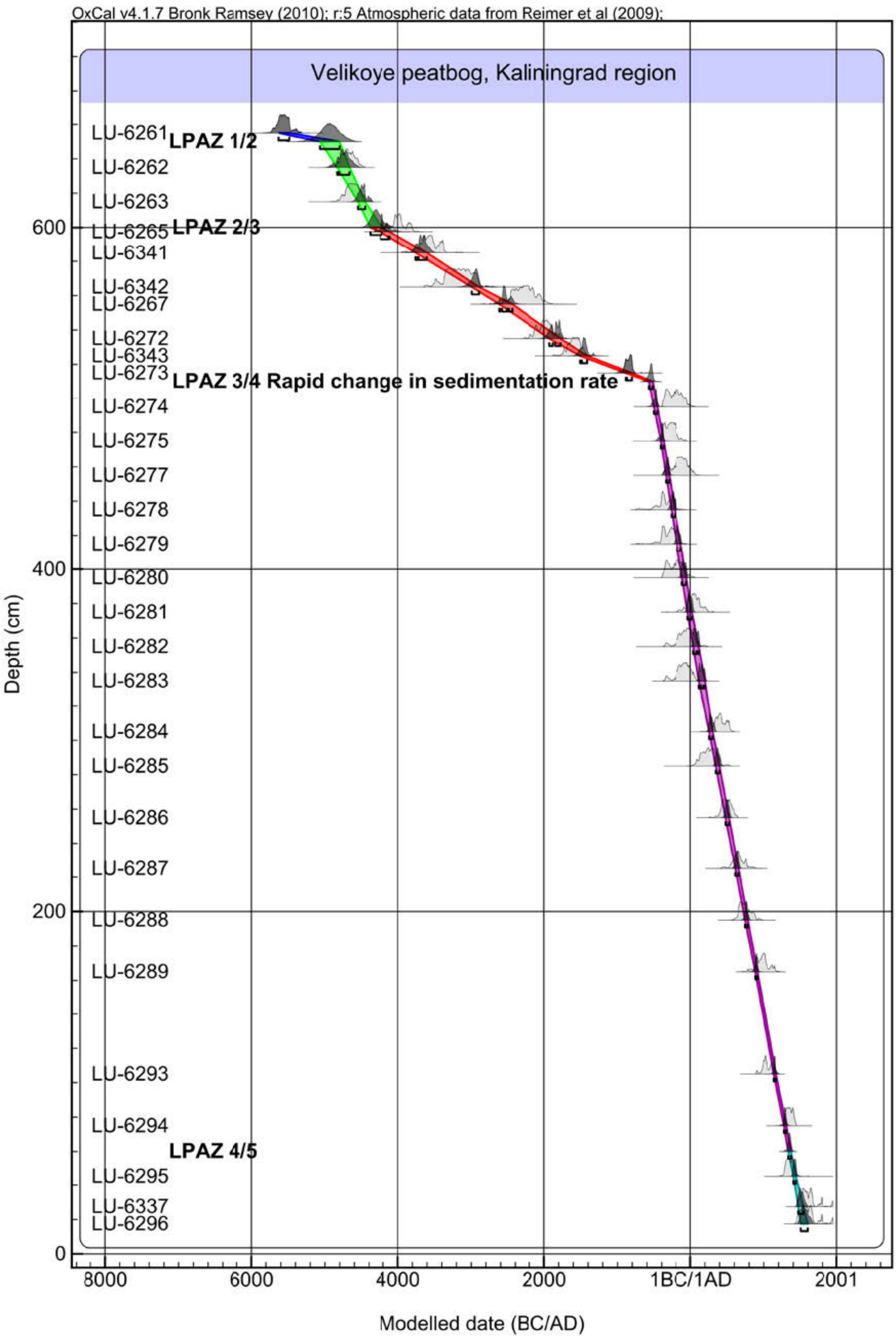

Fig. 3. *Age-depth model for peat samples from peat bog Velikoye, Kaliningrad region (Bronk Ramsey et al., 2010). The boundaries between local palynozones (LPAZ, **Fig. 2**) are also marked.*

is a drop in the pollen curve to 10% at the end of the Subatlantic period.

Elm *(Ulmus)* and Linden *(Tilia)*. There is a low concentration of pollen of elm and linden trees, which does not exceed 4-5% throughout the section. Relatively high pollen content of these broad-leaved trees is associated with 5830-3300 ^{14}C BP, then it is reduced to 1% and ca. 600 ^{14}C BP this pollen disappears from the spore-pollen spectra.

Oak *(Quercus)*. The curve of the content of oak pollen develops similarly to the curves of the pollen content of linden and elm described above, but its presence is slightly higher and amounts to 7-15% with a maximum of approx. 2680 BP. The oak pollen from the spore-pollen spectra became extinct around ca. 300 BP.

Hornbeam *(Carpinus)*. The diagram clearly shows the appearance of hornbeam pollen ca. 2160 BP. Then the curve shows an increase in its percentage until 1050 BP where the maximum of 10% is registered, later there is a lowering of the curve, and in the last 300 years the number of hornbeam pollen has not exceeded 1%.

4. DISCUSSION

As seen from **Fig. 2** and **Tables 1-2**, the accumulation of low mire wood peat in the given point began in the second half of the Atlantic period (AT-2) 6630±100 BP (5630-5480 cal BC). According to M. Kabaylene (1977), in the adjacent south-western part of Lithuania in the first half of the Atlantic period (AT-1) in the interval from 7750±260 BP to 6750±140 BP alder forests with a small admixture of broad-leaved trees (elm, linden, oak) dominated, whereas in the second half of the Atlantic, during the period from 6750±140 BP to 5350±140 BP, in south-western Lithuania alder forests with a substantial admixture of broad-leaved trees (optimal phase for broad-leaved trees) dominated.

In Poland, linden and oak forests became an essential component of wood only 8000-7000 BP, while hazel was widespread around 9500 BP (Ralska-Jasiewiczowa and Starkel, 1994). P.M. Dolukhanov (1977) notes that the maximum amount of the pollen of thermophilic plants (alder, elm, linden, oak) in lake and bog sediments of the eastern Baltic region also occurred in the second half of the Atlantic period, the upper limit of which, according to his data, corresponds to 4500 BP. The palynological and geochronological data on the composition of forests during the AT-2 are quite consistent with the data of the above authors. However, there are some differences: in the raised bog Velikoye the maximum content of oak pollen is observed in the Subboreal period, just like in Lithuania, but in its later phase - 3300±70 BP (1510-1410 cal BC), whereas in the south-west Lithuania, the maximum content of oak pollen was found in its first half (Kabaylene, 1977). According to the author, culmination distribution of oak in different parts of Lithuania took place at different times. It is worth noting that the fact that Late-Subboreal maximum amount of pollen spruce (5%), registered at 3620±70 BP (1930-1770 BC), is small. This difference may be explained by local conditions and more sections of lake-marsh sediments in this region should be studied.

A distinctive feature of the spore-pollen diagram (**Fig. 2)** is the fact that the empirical boundary of hornbeam pollen begins only at the end of the Subboreal time 2680±60 BP (890-810 cal BC). Three subsequent peaks of pollen hornbeam (about 7%, 5% and 7%) correspond to ^{14}C ages 1770±80 BP (350-400 cal AD), 1000±50 BP (1140-1170 AD) and 600±60 BP (1270-1300 AD), respectively. Kabaylene (1977) also notes that in the south-western and south-eastern Lithuania the content of hornbeam in the Atlantic and Subboreal periods was negligible (less than 1%), which conforms well with the spore-pollen data of sediments from the bog Velikoye.

CONCLUSIONS

1) Raised bog Velikoye in the valley of the River Scheschupe was formed during Atlantic-Subatlantic periods from 6630±100 BP (5630-5480 BC) to present time.
2) The evolution of the peat bog included low mire wood peat (30 cm), mesotrophic wood peat (10 cm) and oligotrophic moss peat (620 cm); maximal rate of peat accumulation (2.03 mm/year at depth 0-500 cm) occurred over the entire Subatlantic period.
3) Botanical composition of raised bog Velikoye is typical of the Baltic bog-march area (Seaside type of peat accumulation, Kuzmin, 1993) distinctive feature of which is the formation of a thick layer of homogeneous in the botanical composition of *Sphagnum* peat.
4) According to geochronological (^{14}C) and palynological studies, the formation of the peat bog from 5630-5480 cal BC to 1510-1410 cal BC occurred in the optimum climatic conditions: palynozones included maximum quantity of alder pollen (60%) and broad-lived trees pollen (oak, elm, linden and hazel, in total up to 20%).
5) The subsequent time interval from 1510-1410 cal BC 1400-1440 cal AD alder and birch forests dominated in the area under investigation with a considerable admixture of spruce and hornbeam.

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