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^{14}C CHRONOLOGY OF LATE PLEISTOCENE–HOLOCENE EVENTS IN THE NIZHNEE PRIAMURIE (SOUTHEAST RUSSIA)

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ABSTRACT. The Russian Far East is characterized by widespread peat bogs with a sufficiently thick peat accumulation. A series of radiocarbon dates from the studied peat bogs (in Lower Amur) were obtained. Analysis of these dates shows that the total peat formation in this territory began in the Late Pleistocene–Holocene (11830 ± 820, TIG-157; 9975 ± 120, SOAN-4025). The rates of peat accumulation and the humidity index were counted. In addition, the botanical composition and degree of peat decomposition were defined. These data allow to study in more detail climate fluctuation and the ^{14}C chronology of Holocene events in the region studied.

INTRODUCTION

Due to continuous accumulation, a peat sequence is a good source for the study of peat bog formation conditions, dynamics of swamping, and the details of climate fluctuation. The continuous accumulation of peat allows us to reconstruct an amplitude of climatic changes and provides a better description of the paleogeographic boundaries in the Late Pleistocene and Holocene.

According to the Peat Fund USSR's division of peat land into districts, the Nizhnee Priamurie territory was distinguished as the largest peat area in the Russian Far East. Peat lands and bogs take up about 58,000 km^2 (Prozorov 1970) and spread to the Amuro-Amgunskaya, Udil-Kizinskaya, Evoron-Chugchagirskaya, and Credneamurskaya lake-alluvial depressions.

Using the data of Neishtadt (1967) and Sokhina et al. (1978), the development of 4 vegetal phases were determined in the Holocene in the territory of the Sredniy and Nizhnee Priamuries. The first phase (Earliest Holocene) consisted of small-leaved forests and shrubs. The second phase (Early Holocene) consisted of coniferous forests, along with small- and broad-leaved trees. The third phase (the *Quercus mongolica* phase—Middle Holocene) was defined by coniferous, broad- and small-leaved forests. The fourth phase (*Pinus koraiensis* phase—Late Holocene) was characterized by coniferous, small-leaved forests and broad-leaved trees. Pollen data from the Gurskiy peat bog are described by Korotky et al. (2000).

The climate of the studied area is temperate with monsoon traits. During the year, the meridional circulation (caused by southern tropical cyclones penetrating far into the north) predominates in this territory and brings a dry, cold air. The average annual temperature in this territory is negative °C. The coldest month is January (–27 to –22 °C) and the warmest month is July (16–18 °C). The precipitation varies drastically during the year. In the warm months, the precipitation in the region is about 80–90% of its total yearly rainfall, while in the winter the rainfall is only about 10–20% of the yearly total. The annual sum of precipitation fluctuates from 500–550 mm in the Sredneamurskaya depression up to 1000–1100 mm on the Tatar Strait coast. The large quantity of precipitation, occurring in a short period, is one of the main reasons for swamping in this territory. The humidity coefficient ranges from 1.4 up to 2.8, characterizing this territory as sufficiently moist and favorable for widespread bogs.

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Up to now, only a few ^{14}C dates were obtained for peat bogs in southeast Russia (Neishtadt 1957; Kulakov et al. 1975; Khotinskiy 1977; Sokhina et al. 1978; Prozorov 1985; Mikishin et al. 1987). Such a small number of dates do not allow the authors to correlate in detail the Holocene paleogeographic events in this territory. Two peat bogs in the Nizhnee Priamurie were studied. The Gurskiy peat bog is situated in the northwestern region of the Sredneamurskaya depression. The absolute altitude of this peat bog is 35 m; the thickness of the deposits is 3.5 m. The Tyapka peat bog is situated in the northern region of the Amuro-Amgunskaya depression, near the Tyapka river. The absolute altitude of this peat bog is 40 m; the thickness of the peat bog is 5.4 m (Figure 1).

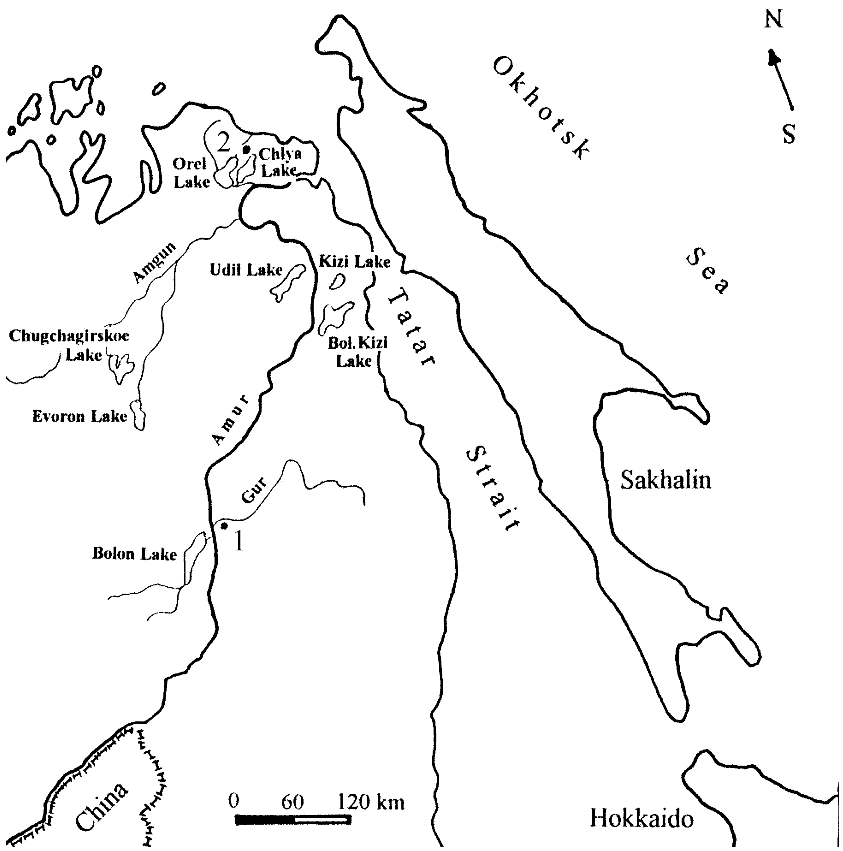

Figure 1 Map showing the location of study sections: 1=Gurskiy; 2=Tyapka

METHODS

Paleoenvironmental reconstructions were based on detailed ^{14}C dating, pollen, and botanical data. Also, we defined the degree of peat decomposition, counted rates of peat accumulation, and determined the index of humidity for the 2 regions. For ^{14}C dating, the peats were first cleaned by acid/alkali/acid. The samples were then decalcified using a hot 3% HCl solution and humics were extracted using a 1 N KOH solution. The extracted matter was acidified to pH 1.0 with dilute HCl to recover the humic fraction. The ^{14}C activity was measured by liquid scintillation counting and the index of humidity was derived by the Elina method for both regions (Elina et al. 1992). Results of all analyses are presented in Tables 1–3.

Table 1 ^{14}C dates for Gurskiy and Tyapka sections

Gurskiy section		Tyapka section	
Depth (m)	^{14}C age	Depth (m)	^{14}C age
0.5	2720 ± 120 (TIG-151)	0.50	1395 ± 60 (SOAN-4017)
1.0	4600 ± 200 (TIG-152)	1.00	2200 ± 70 (SOAN-4018)
1.5	6880 ± 270 (TIG-153)	1.30	2025 ± 100 (SOAN-4162)
2.1	8540 ± 320 (TIG-154)	1.70	2480 ± 70 (SOAN-4163)
2.6	9180 ± 350 (TIG-155)	1.90	2730 ± 65 (SOAN-4019)
3.1	10220 ± 750 (TIG-156)	2.55	3510 ± 60 (SOAN-4044)
3.5	11830 ± 820 (TIG-157)	2.75	4270 ± 125 (SOAN-4021)
		3.05	5325 ± 95 (SOAN-4022)
		3.55	6240 ± 100 (SOAN-4023)
		4.20	7720 ± 100 (SOAN-4024)
		5.20	9975 ± 120 (SOAN-4025)
		5.30	9910 ± 50 (AA-36302)

RESULTS AND DISCUSSION

The age of the lowest layer of the Gurskiy peat bog is 11830 ± 820 BP (TIG-157) (Table 1). It is one of the oldest among the peat bogs in southeast Russia. In this region, the peat bog near Chlya Lake has the oldest age (Mikishin et al. 1987). The peat accumulation in this peat bog began in the Late Pleistocene and was continuous during the Holocene. The lowest part of the Gurskiy peat deposits were formed at the base of a hill, where thickness of the peat varies from 3.1 up to 3.7 m, whereas the thickness of peat deposits around this hill base is about 2.7 m. Thus, the local geomorphological features of this place and microclimate were the main causes for the primary peat accumulation in the Late Pleistocene. After that, swamping began in the surrounding territories at the beginning of the Early Holocene. The history of the Gurskiy peat bog development illustrates the role of both climatic zone conditions and local climatic conditions, which sometimes are more considerable.

The ^{14}C date of 10220 ± 750 BP (3.1 m depth) corresponds to the boundary of the Pleistocene–Holocene, and the first appearance of the post-glacial forests in Europe, Japan, and the Pacific coast of Alaska (Khotinskiy 1977). The ^{14}C date of 4600 ± 200 BP (1 m depth) characterizes the boundary of the Atlantic and Subboreal phases of the Holocene and the ^{14}C date of 2720 ± 120 BP (0.5 m depth) is near the boundary of the Subboreal and Subatlantic phases. The peat layer from the 1.5 m depth corresponds to the Atlantic phase and the 2 lower layers situated at depths of 2.1 and 2.6 m, respectively, correspond to the Boreal phase.

The ^{14}C dates from the Tyapka region show that the peat accumulation in this peat bog began in the Early Holocene, which is later than in the Gurskiy peat bog (Table 1). The ^{14}C date of 7720 ± 100 BP (4.2 m depth) is near the boundary of the Boreal and Atlantic phases. The boundary of the Atlantic and Subboreal phases is at 2.75 m depth (4270 ± 125 BP), while the date of 2480 ± 70 BP (1.7 m depth) is the boundary of the Subboreal and Subatlantic periods. The peat layers at the 3.05 and 3.55 m depths correspond to the Atlantic period and the layer at 5.30 m depth corresponds to the Preboreal period of the Holocene (9975 ± 120 BP). The obtained ^{14}C dates allowed dividing the Holocene into the phases.

The sort, accumulation average rate, degree of decomposition, and botanical composition of peat depend on climatic conditions. These data are presented in Tables 2–3. On the basis of these data, we reconstructed the climatic changes in all phases of the Holocene. The description of climatic change is presented in the last columns of Tables 2–3. Figure 2 shows the climatic curves for the study sections and chronological model curve for the northern Eurasia tundra and forest zones (Khotinskiy 1987).

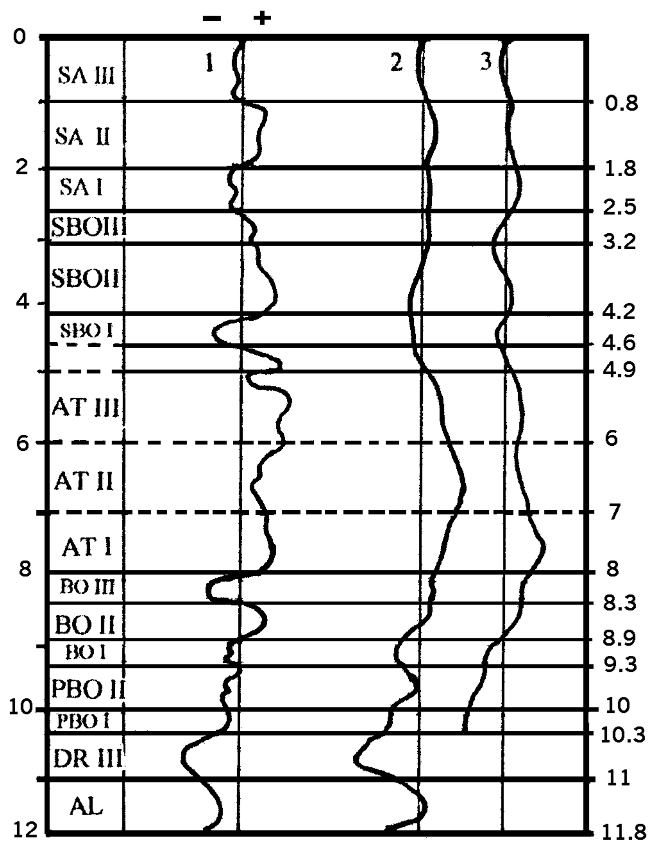

Figure 2 Climatic curves: 1=chronological model curve for northern Eurasia tundra and forest zones (Khotinskiy 1987); 2=for Gurskiy section; 3=for Tyapka section

The general features of these curves are the same. Climate in the Nizhnee Priamurie region changed less abruptly than in the northern part of Eurasia. In Khotinsky's opinion (1977), the Holocene optimum in the far eastern part of Russia becomes apparent in the Boreal phase. Our data do not confirm this opinion. The climate became warm in the Boreal phase and was warmer than at the present time.

Table 2 Environmental characteristics of the Gurskiy section

Holocene phases	Average rate of peat accumulation	Peat sort	Average degree of peat decomposition, %	Index of humidity	Vegetation	Climate
SAT III	—	green moss	20	2.5	*Pinus, Betula, Quercus*	temperate, damp and warm
SAT II	0.20	arboreal-grassy	up to 60	3.5	*Pinus, Betula, Alnus, Quercus*	dampest, temperate warm
SAT I	—	arboreal-grassy	55	2.5	*Betula, Alnus, Quercus*	temperate damp, warm
SBO III	—	arboreal-grassy	60	2	*Betula, Alnus, Quercus*	dry, warm
SBO II	0.26	arboreal-grassy	55	2.5	*Betula, Alnus*	temperate damp, cooler then in SBO I
SBO I	—	arboreal-grassy-mossy	70	2.5	*Betula, Quercus, Alnus*	temperate damp, cooler then in AT III
AT III	—	arboreal-grassy-mossy	75	2.5	*Betula, Quercus, Ulmus*	temperate damp, less warm, then in AT II
AT II	0.29	arboreal-grassy	up to 85	2.5	*Quercus, Ulmus, Betula*	temperate damp, warmest
AT I	—	arboreal-grassy	75	2	—	dry, warm
BO III	0.78	arboreal-grassy	80	2	*Betula, Quercus, Ulmus*	dry, warm
BO II	—	grassy-arboreal-sphagnous	60	3	*Betula, Alnus, Ulmus*	damp, warmer then in BO I
BO I	—	grassy-arboreal-sphagnous	55	3.5	*Betula, Alnus*	dampest, cool
PBO II	0.48	grassy-arboreal-sphagnous	60	3	*Betula, Alnus*	damp, cool
PBO I	—	grassy-green moss-sphagnous	70	3.5	*Alnaster*, decrease of *Betula nanae*	dampest, less cold then in DR-3
DR-3	0.25	green moss-grassy-sphagnous	up to 80	3	*Betula nanae, Alnaster*	damp, very cold
AL	—	green moss-sphagnous grassy	60	3	*Betula, Alnaster*, a few quantities of *Quercus* and *Ulmus*	damp, warm

Table 3 Environmental characteristics of the Tyapka region

Holocene phases	Average rate of peat accumulation	Peat sort	Average degree of peat decomposition, %	Index of humidity	Vegetation	Climate
SAT III	0.36	green moss-sphagnous-grassy-arboreal	20	3	*Picea* (up to 30%), decreasing *Betula nanae*, appearance of broad-leaved	dry, cool
SAT II	0.62	sphagnous-grassy	up to10	5	decreasing coniferous, increasing *Betula nanae* and *Alnaster*	temperate damp, very cool
SAT I	0.88	sphagnous-grassy	20	4	increasing coniferous, decreasing *Betula nanae* and *Alnaster*	temperate damp, cool
SBO III	0.80	sphagnous-grassy	5	7	decreasing coniferous, increasing *Betula nanae* and *Alnaster*	dampest, very cool
SBO II	0.77	sphagnous-grassy-arboreal	25	5	increasing coniferous, decreasing *Betula* and *Alnaster*	damp, cool
SBO I	0.39	arboreal-grassy-sphagnous	up to 30	3.5	*Picea* (up to 40%), apperance of *Betula nanae*, decreasing *Alnaster*, disappearance of broad-leaved	temperate dry, cold
AT III	0.20	arboreal-grassy-sphagnous	up to 50	3	*Betula*, increasing broad-leaved	dry, warm
AT II	0.66	sphagnous-grassy-arboreal	up to 40	6.5	coniferous (up to 19%), *Alnaster* (up to 18%), *Betula*, decreasing broad-leaved	damper and less warm than in AT I
AT I	0.41	arboreal-grassy-sphagnous	60	5	*Picea* (up to 37%), maximum quantity of broad-leaved	damp, warmest
BO II	0.31	arboreal-grassy-sphagnous	up to 60	4	*Betula*, the first appearance of broad-leaved	temperate damp, cool
BO I	0.31	arboreal-grassy-sphagnous	up to 60	3	small increase of coniferous, *Betula*; sharp decrease of *Betula nanae*, *Alnaster*	dry, very cool
PBO	—	sphagnous-grassy	up to 40	6	*Betula nanae*, *Alnaster*, *Selaginella*	damper, cold

However, the temperature was increasing and had reached the maximum in the Atlantic phase. In the Tyapka section, the climatic optimum of the Holocene is recorded in the first part of the Atlantic phase. In the Gurskiy section, the climatic optimum is recorded in the second part of the Atlantic phase. Thus, the optimum of the Holocene on the coastal region began earlier than in the continental region of the Nizhnee Priamurie.

Most investigators observed that there was only 1 cooling in the Holocene in the Nizhnee Priamurie. According to Karaulova (1974), there were 3 coolings in the Holocene in the Russian Far East. Our data indicate 2 coolings on a climatic curve for the Gurskiy section (Figure 2). One of them is in the PBO-BO I phase and the next is in the SAT I phase. There are 3 coolings on the curve for the Tyapka region. The first of them is in the PBO-BO phase and the next 2 coolings are at the beginning of the phase and divide these Subatlantic coolings (the last parts of the Subatlantic phase). There was weak warming in the SBO II phase in the Gurskiy region. However, later in the phase, the glacial cooling (Dryas III) was severe. In addition, the Alleroed warming was warmer in the Gurskiy region than in the continental part of Eurasia (Khotinskiy 1987).

CONCLUSION

The detailed ^{14}C dating of peat bogs allowed division of the Holocene into phases for the Nizhnee Priamurie region. The use of particular methods for peat analysis allowed the authors to reconstruct climatic changes in more detail. Local geomorphological features and microclimate were the main causes for the primary peat accumulation about 12000–13000 yr ago. This leads to the conclusion that the Alleroed warming was warmer than on the continental part of Eurasia and the Dryas III cooling was very cold. The active, widespread peat formation in the Nizhnee-Amur region began in the Early Holocene (9000–10000 BP). Climatic and vegetation changes were more slight than on the continent. Holocene climatic changes had a metachronical character in this region. The Boreal phase was warmer than the present climate. On the marine coast, the Holocene optimum is recorded at the beginning of the Atlantic phase, while in the continental part of this region the optimum is recorded in the middle of the Atlantic phase. There were 2 coolings in the continental region and 3 coolings in the coastal region during the Holocene in the Nizhnee Priamurie.

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