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GENERAL BIOLOGY

The First Reconstruction of the Late Glacial Plant Communities on the Yamal Peninsula Based on Plant Macrofossils

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Strong climatic fluctuations during the Late Glacial stages of the Late Pleistocene, which resulted in transformation of vegetation in northern Eurasia, have been characterized in detail on the basis of numerous paleobotanic data [1–3]. At this time, there were two interstadial periods of warming—Bölling (12 400–12 000 radiocarbon years ago) and Allerød (11 800–10 900 radiocarbon years ago)—when the most pronounced climatic changes occurred, accompanied by expansion of woody vegetation to the subarctic areas of Eurasia [4–6]. The time interval from 12 400 to 10 900 years ago was often regarded as an interstadial Bölling–Allerød complex interrupted by a minor short-term cooling of the Older Dryas (12 000–11 800 radiocarbon years ago), which preceded a significant and strong cooling of the Younger Dryas (10 900–10 200 radiocarbon years ago) [2, 7, 8].

Despite the extensive paleobotanic material that characterizes the Late Glacial stages of the vegetation growth in the subarctic areas of Russian Arctic [4, 5, 9], only separate reports [10, 11] concerning the reconstructions of the Late Glacial paleovegetation in the areas north of Western Siberia are available. In this paper, we describe the first dated complexes of plant macrofossils from the alluvial deposits of the Yuribey River valley. They served as the basis for reconstruction of the plant community of the Yamal Peninsula during interstadial Bölling–Allerød warming.

The Ngoyun cross-section lies on the west bank of an unnamed lake 0.5 km northeast of Lake Ngoyun, on the left bank of the Yuribey River, upstream the meridional flow on the Yamal Peninsula (68°32′ N, 72°06′ E) [12]. According to geobotanical zoning, the Yuribey River valley lies currently in a subzone of southern shrub tundra [13]. This territory is mostly represented by ledum–small shrub–lichen–moss (moss–lichen) grumous, spotted grumous, and sometimes polygonal tundras. On the convex relief, there is the shrub-spotted grumous and polygonal tundras. The following plants form the basis of the herb–shrub layer of tundra: *Betula nana* L., *Ledum decumbens* (Ait.) Lodd. ex Steud., *Empetrum hermaphroditum* (Lange) Hagerup., *Salix nummularia* Anderss., *Vaccinium vitis-idaea* L., *Arctous alpina* (L.) Niedenzu, *Carex arctisibirica* (Jurtz.) Czer., *Calamagrostis neglecta* (Ehrh.) Gaertn., Mey et Scherb., *Festuca ovina* L., *Eriophorum vaginatum* L., *Oxytropis sordida* (Willd.) Pers.; *Hedysarum arcticum* B. Fedtsch., *Equisetum arvense* L., etc. The moss–lichen layer of typical tundra species is everywhere.

In the Ngoyun cross-section, alternating benches of sand and silt–loam strata with a total thickness of 6 m are found (figure). Twelve samples were obtained from these deposits. Paleokarpologic material was obtained from six samples. Plant macrofossils of two of them (samples 11 and 6) were used to perform two AMS datings in the Beta Analytic radiocarbon laboratory (Miami, United States) (Table 1). The radiocarbon dates suggest that the stratum formation of the deposit analyzed occurred during the Late Glacial stages of Late Pleistocene and the formation of some portions falls into the interstadial Bölling–Allerød period.

In the paleocarpologic samples of the Ngoyun cross-section deposit, 1082 macrofossils of 46 plant taxa have been identified, 27 of which were identified to the species level; 15, to the genus level; 3, top the family level; and 1, to the class level (Table 2). In the samples studied, the number of plant macrofossils varied greatly (from 13 to 492), but the wetland and riparian plants, mostly various sedge species (*Carex* spp.), dominated (at least 50%). In total, six macrofossil complexes were described, which characterize the dynamics of plant communities in the Yuribey River valley.

The first complex of plant macrofossils (sample 11) contains winged seeds of the woody birch (*Betula* sect.

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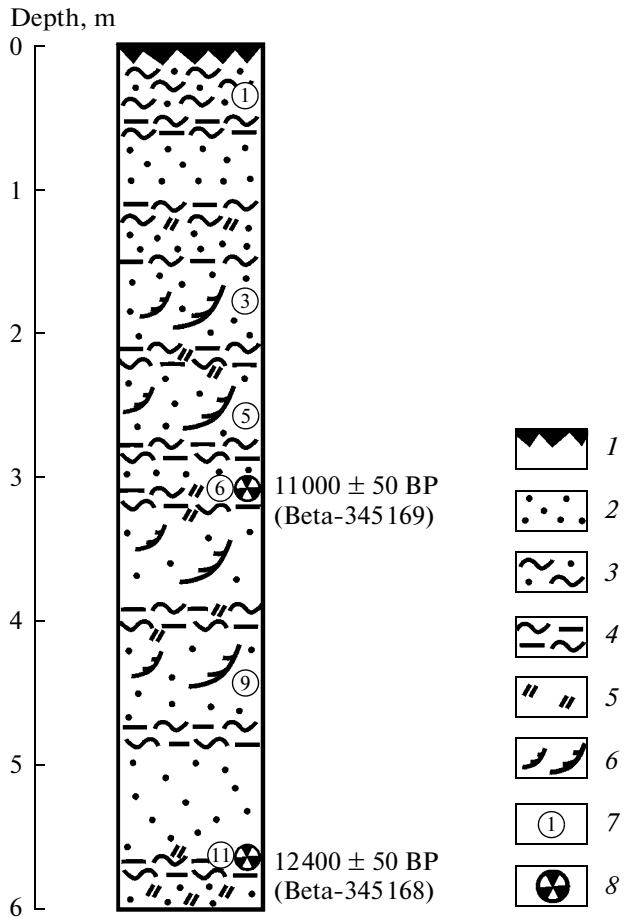

Geological structure of the Ngoyun cross-section deposits. Designations: *1*, turf; *2*, sand; *3*, sand silt; *4*, loam silt; *5*, peat; *6*, pinnate rock alternation; *7*, paleocarpologic samples; *8*, samples for AMS dating.

Albae), various fossils of the dwarf birch (*Betula nana*), fruits and seeds of aquatic, riparian, and meadow herbs. This complex has the floristic composition of the open birch woodland including dwarf birch. At present, these plant communities are not found on the Yamal Peninsula [14].

The second complex (sample 9) is represented by a small number of macrofossils. It is, therefore, impossible to characterize paleocommunities.

The third complex (sample 6) contains the maximum amount of plant macrofossils, which are represented by spruce needles (*Picea* sp.), winged seeds of the wood birch, fruits and scale of the dwarf birch, and by various fossils of aquatic and riparian herbs. The complex is characteristic of the birch open woodlands that include spruce, dwarf birch, and bog–meadow vegetation.

The fourth complex of plant macrofossils (sample 5) contains also spruce needles (*Picea* sp.), while the shrub and herb fossils are similar to those of samples 11 and 6. This complex has the characteristics of the forest–tundra communities that include spruce, dwarf birch, and bog–meadow vegetation.

The fifth complex (sample 3) differs from those described above in that it does not contain woody plants. The overall composition of plant macrofossils is characteristic of the paleocommunities similar to the modern tundra vegetation in the waterlogged flood areas [14].

The six complex of plant macrofossils (sample 1) contains winged seeds and scale of the dwarf birch; fruits, seeds, and leaves of hypoarctic small shrubs (*Arctous alpina, Empetrum nigrum, Vaccinium vitis-idaea*), and corn seeds. The floristic composition of this complex is similar to that of modern vegetation of the Yuribey River valley and is characteristic of dwarf birch–willow–small shrub–forb–grass tundras [13].

The radiocarbon dates (Table 1) indicate that the macrofossils from samples 11, 6, and 5 are characteristic of the plant communities of the Bölling–Allerød interstadial period (12 400–10 900 years ago). The presence of spruce and woody birch macrofossils suggests that, during this time interval, the environment of the Yuribey River valley was favorable for the woody vegetation growth. The floristic composition of the complexes is characteristic of forest–tundra open woodland; it is different from the modern plant vegetation of the Yamal Peninsula but similar to the modern birch–spruce open woodland of the continental forest tundra [15]. The macrofossil complex of sample 3 seems to be similar in floristic composition to that of plant communities of the dwarf birch–herb–alder tundra which proved to spread throughout the valley of the Yuribey River after the Bölling–Allerød period. The complex from the top sample 1 is the closest to the modern tundra communities.

Table 1. Radiocarbon dating of the Ngoyun cross-section deposits on the Yamal Peninsula by means of accelerator mass-spectrometry (AMS-dates)

Laboratory no.	Depth, cm	Material for dating	Radiocarbon age, years ago, BP	Calibrated age, years ago, BP (2σ, 95% probability)
Beta-345169	310–315	Seeds	11 000 ± 50	12 720–13 070
Beta-345168	575	Seeds	12 400 ± 50	14 150–14 810

BP (before present), the scale for dating from 1950 backward.

Table 2. Species composition and the number of plant macrofossils found in the deposits of Ngoyun cross-section

Taxon	Sample no.					
	1	3	5	6	9	11
Bryophyta	2*	1*				
Equisetum arvense L.	1*v	2*v				
Picea sp.			1*v	1v		
Potamogeton cf. *alpinus* Balb.			2	2		
Potamogeton cf. *lucens* L.		1				
Potamogeton sp. sp.		1		1	1*	
Alisma plantago-aquatica L.				1		
Calamagrostis cf. *lapponica* (Wahlb.) Hartm.	3				1	
Festuca sp.	1					
Hierochloe alpina (Sw.) Roem. & Schult.	7					
Poaceae gen. indet.		3	1	23		2
Carex aquatilis Wahlenb.	1					
Carex sp. sp.	2	63	70	306	3	156
Eleocharis palustris (L.) Roem. & Schult.			1	2		1
Salix nummularia Andersson	8v					
Salix sp. sp.	14* + 1v				1v	1*
Betula sect. Albae				34		18
Betula nana L.	5 + 1v	5	10 + 2s	82 + 8s	2 + 2s	1v + 88 + 25s
Duschekia fruticosa (Rupr.) Pouzar		1				
Rumex acetosella L.				1		1
Rumex sp.		1*				
Gastrolychnis sp.					1	
Minuartia sp.		1	1			
Stellaria sp.		1				
Batrachium sp.		2		1		2
Ranunculus monophyllus Ovcz.				4*		
Ranunculus pygmaeus Wahlenb.				4*		
Ranunculus reptans L.			1	2		5
Ranunculus sceleratus L.			2			
Ranunculus sp.		1*	5*	5*		2*
Thalictrum cf. *simplex* L.			1			
Papaver sp.		1				1
Brassicaceae gen. indet.				1	1	
Comarum palustre L.		1		3		
Potentilla cf. *kuznetzowii* (Govor.) Juz.		2	2	10*		4 + 7*
Potentilla sp.						1
Rubus cf. *idaeus* L.		1				
Empetrum nigrum L.	4 + 1v	1				
Hippuris vulgaris L.			2	1		
Andromeda polifolia L.			1			
Arctous alpina (L.) Nied.	2*					
Ledum sp.	1*v					
Vaccinium vitis-idaea L.	1 + 10v					
Androsace sp.			2			
Menyanthes trifoliata L.		3	1			
Artemisia tilesii Ledeb.					1	
Plant macrofossils in total	65	92	105	492	13	315

v, plant organ fossils and their number; * fruit and seed fragments and their number; s, birch scales.

Thus, analysis of the first dated complexes of plant macrofossils from the deposits of the Ngoyun cross-section suggests that, during the Late Pleistocene interstadial Bölling–Allerød period, the birch–spruce open woodlands of the forest–tundra type with dwarf birch and bog–meadow vegetation occurred throughout the valley of the Yuribey River on the Yamal Peninsula.

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