Short communication

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Evolution of vegetation in the eastern part of Khanka Plain (south of the Russian Far East) in the Late Pleistocene cryochron (MIS 2) and the Early Holocene

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ABSTRACT. Reconstructions of changes in vegetation, climate and sedimentation in the eastern part of the Khanka Plain for the last 22 000 cal BP were made from results of palynological analyses. A new evidence of considerable changes in the vegetation structure were provided by the palynological studies supplemented with radiocarbon dates on wood fragments and plant detritus recovered from alluvial, lacustrine and mires sediments. It has been found that at the glacial stage MIS 2, open birch forests with larch and spruce, alternating with Sphagnum mires with shrub birch was dominated the Khanka Plain. Later, at the interstadial, formations typical of southern boreal dark coniferous (needle-leaved) taiga became widely spread. The Early Holocene was marked by wide expansion of broadleaf trees (and first of all, elm and Mongolian oak) in the Khanka Plain ecosystems. Mixed forests with Korean pine became widely spread in the mountains surrounding the lowland. Mires, patches of dark coniferous forests, and open forests of larch persisted on the plains adjoining the lake and on swampy valley floors.

Keywords: Evolution of vegetation, Khanka Plain, Late Pleistocene, Early Holocene

1. Introduction

The Pleistocene glacial epoch MIS 2 and the Holocene was marked by a significant environmental changes that resulted in conspicuous changes of biota in the natural systems. The changes were particularly conspicuous in the middle latitudes. Under conditions of a fast warming of climate, the ecosystems were actively restructuring, their constituents relatively quickly responding to the changing environments. A considerable rise of annual temperature led to essential changes in phytocoenoses, which resulted from the activated migrations of plants. Therefore the structural vegetation units typical of MIS 2 have no analogs in the modern vegetation of the southern Far East. The predicted global warming could activate once more a migration of plants, which would change the landscape appearance and would have various, including negative, consequences for humans. That accounts for a great significance attached to the analysis of the landscapes and climate at the transition from the MIS 2 glacial time to the Holocene; the data obtained are shedding light on the current processes and help in modeling the ecosystem response to the expected climate changes.

2. Materials and methods

Samples were taken from section 6 276 and from boreholes 579 and 508 in the eastern sector of the Khanka Plain. Section 6 276 was laid manually in the eastern sector on the floodplain terrace of the Belaya River. Using a drilling rig based on a GAZ-66 automobile, borehole 579 was drilled from the ice surface of Lake Khanka, where its depth is 1.3 m (1.3 km from its eastern shore). Borehole 508 was drilled in the lower reaches of the Sorochevka River by the same method.

The pollen and spores were identified from 34 samples by N.I. Belyanina and I.G. Gvozdeva using the Micmed-6 and Axio Scope light microscopes at ×400 magnification. The pollen and spores were identified, when possible, to a level of species. In case of microfossils poorly identifiable morphologically, they were determined to a level of genus or family. Proportion of plant groups (trees and shrubs – AP, herbs, grass, and dwarf shrubs – NAP, spores) was calculated in percent of the total amount of microfossils. Individual taxa participation was also expressed as a percentage of total pollen quantity.

Tree and plant remains were dated by radiocarbon in the Institute of Geology (Academy of Sciences of Ukraine, Kiev) by N.N. Kovalyukh. The radiocarbon dates were calibrated using the "CalPal" program (calpal online, quickcal2007, version 1.5, http://www.calpal-online.de).

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3. Results and discussion

Pollen assemblage which were forming under conditions of cold climate in the glacial epoch (MIS 2), were recovered from layer of the dark brown loam at a depth of 1 m in the small flat-bottom valley ("balka") near Novorusanovka settlement (section 6 276). That is suggested by the taxonomic structure of pollen assemblages abounds in shrub birch *(Betul*a sect. *Nana*e) and tree of birch *(Betul*a sp.), as well shrub alder *(Duschekia* sp.). Pollen grains of alder *(Alnus* sp.), birches *(Betul*a sect. *Alba*e and *Betul*a sect. *Costata*e) are also present. Coniferous plants are represented in the pollen spectra by spruce *(Pice*a sp.), larch *(Larix* sp.), as well as by two subgenera of pines *(Pinus* s/g *Haploxylo*n and *Pinus* s/g *Diploxylo*n). The NAP group includes nettles *(Urtic*a sp.) and some members of sedges (Cyperaceae) and Asteraceae families. In the spore group, there were identified Polypodiaceae and Ophioglossaceae families, as well as clubmosses *Lycopodiu*m sp. and *Selaginell*a sp. The pollen assemblage taxonomy reflects the structure of plant formations typical of cold epoch of the Late Pleistocene, as evidenced by the radiocarbon date 22 197 ± 405 cal BP (Ki-2 174).

A slight climate mitigation during an interstadial within MIS 2 is indicated by pollen assemblages recovered from the silt with plant detritus (at a depth of 4.5-6.3 m) of borehole 579. It is dominated by *Picea* pollen, together with an assortment of coniferous and broad-leaved plants: *Pinus* s/g *Haploxylon*, *Betula* sect. *Nanae*, fir (*Abies* sp.) and *Betula* sect. *Albae*, along with a high proportion of marsh herbs and sphagnum moss. As shows the radiocarbon analysis, the age of deposits sampled from the 5.1 m depth is 21 402 ± 453 cal BP (Ki-2 166).

The pollen assemblages in the Sorochevka River floodplain reflected of fast warming of the Early Holocene. These pollen records were obtained from by borehole 508 near Chkalovskoye settlement. The sample of blue-gray sandy loam taken from the depth of 4.5 m was dated at 11 003 ± 186 cal BP (Ki-2 171); the pollen assemblage obtained from the layer is noted for a dominance of tree pollen – *Betula* sect. *Nanae*, *Betula* sp. and *Duschekia*. In the accompanying group there are willow (*Salix* sp.), *Alnus*, *Betula* sect. *Albae* and *Betula* sect. *Costatae*. Coniferous group includes pollen of Korean pine (*Pinus koraiensis*), *Picea*, *Larix* sp. and *Abies*. Among broadleaf species there are Mongolian oak (Quercus mongolica), hazel (*Corylus* sp.) and elm (*Ulmus* sp.). Typical is a high proportion of *Sphagnum* and *Lycopodium* genus.

4. Conclusions

The last cold epoch of the Late Pleistocene in MIS 2 was marked by extensive development of vegetation, typical of the north of the boreal zone. The palynological data substantiated by the radiocarbon dates show convincingly that during the Late Pleistocene cryochron (MIS 2) the plains were dominated by vast mires with shrubs birches and alder, and larch. Open spruce forests with Japanese stone pine, larch, birch and shrub alder grew on the mountain slopes.

Slight warming led to wide spread of south-boreal dark coniferous taiga with participation of *Pinus koraiensis* at around 21 400 cal BP. Spruce, trees and shrub birches, trees and shrub alder dominated in the forests.

In the transition from cryochron MIS 2 to Early Holocene rapid expansion of deciduous forests occurred. That time the elements of the contemporary Manchurian flora such as oak, elm and others appeared on the Khanka Plain ecosystems, which are the main components of natural complexes at present. The range of the Korean pine also expanded northwards and reached the Pre-Khanka Plain in the Early Holocene. The formation of the broad-leaved forests with oak, elm, and Korean pine happened on the slopes of Sinyi Ridge. However, Sphagnum mires with shrub birch still remained on the plains and swampy flood plains of the rivers.