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Environmental dynamics of the Baraba forest-steppe (Siberia) over the last 8000 years and their impact on the types of economic life of the population

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ABSTRACT

This article offers a reconstruction of the vegetation and climate of the south-western Siberian Baraba forest-steppe area during the last ca. 8000 years. The analysis of palynological data from the sediment core of Lake Bolshie Toroki using quantitative methods has made it possible to reconstruct changes of the dominant types of vegetation and mean July air temperatures. Coniferous forests grew in the vicinity of the lake, and mean July air temperatures were similar to present-day ones between 7.9 and 7.0 kyr BP. The warmest and driest climate occurred at 7.0–5.0 kyr BP. At that time, the region had open steppe landscapes; birch groves began to spread. A cooling trend is seen after 5.5 kyr BP, when forest-steppe began to emerge. Steppe communities started to dominate again after 1.5 kyr BP. Mean July air temperatures lower than now are reconstructed for the period of 1.9–1 kyr BP, and then the temperatures became similar to present-day ones. Comparing the archaeological data on the types of economy of the population which inhabited the Baraba forest-steppe with the data on changes in the natural environment revealed a connection between the gradual transition from hunting and fishing to livestock breeding and the development of forest-steppe landscapes with a decrease in the area covered by forests. The development of the forest-steppe as an ecotonic landscape starting around 5 kyr BP might have contributed to the coexistence of several archaeological cultures with different types of economy on the same territory.

1. Introduction

The southern part of Western Siberia is a major transit area connecting the Central Asian steppes and the North Asian taiga. Numerous well-studied archaeological sites of the Neolithic, Bronze Age, Iron Age, and the Middle Ages, such as Chicha, Tartas, Vengerovo, Blizhnie Elbany, Irmen, Srostki, Pazyryk, etc., which are known throughout the world, are located in the region (Kiryushin et al., 2010a,b; Molodin, 1977, 1985, 1988, 2012; Molodin et al., 2012; Polosmak, 1994, 2001, etc.). Multilayer archaeological sites from various periods (Chicha-1, Krokhalevka, Tartas-1, Preobrazhenka-6, etc.) have been discovered and studied in detail in the Baraba forest-steppe region of Western Siberia (Materialy "Svoda" …, 1996; Arkheologicheskie pamyatniki …, 2013).

The Holocene is the modern interglacial period nearest to our time and the best-studied not only in the history of the Earth, but also in human history. The Holocene environmental changes are well-reconstructable from high-resolution paleorecords by

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numerous methods available to scholars (Nazarova et al., 2013, 2015; Hoff et al., 2015), while the variety of archaeological sites provides insight into the development of human populations.

Changes in the natural environment in the Holocene could significantly affect the development of human societies in the region. The ideas about the interaction and mutual influence of human societies and the natural environment, and the impact of climate on population dynamics, types of economy, and human migration have been expressed by various authors (Gumilev, 1990; Gupta, 2004; Impact of the Environment …, 2003, etc.). However, attempts to verify these ideas were mostly made on the basis of archaeological excavations, which is insufficient for a thorough understanding of natural changes. A detailed study of the objects which are to a lesser extent affected by human activities is needed for obtaining quantitative climatic characteristics and identifying natural trends in environmental changes.

Small lakes are the perfect objects for detailed reconstructions (Solovieva et al., 2015; Nazarova et al., 2017). They contain continuous paleoecological and paleoclimatic records for the last several thousand years, sometimes covering the entire Holocene. The attractiveness of studying small lakes is further fostered by a high rate of sedimentation and high content of organic matter, which makes it possible to conduct radiocarbon dating and thus to obtain more accurate chronology. Despite the fact that the first contribution to the study of small lakes of Siberia was made by P.B. Vipper and N.V. Korde back in the 1960–1970s, small lakes remain understudied compared to peatlands (Carbon storage …, 2001; Borren et al., 2004, etc.) and such longstanding lakes as Baikal (Williams et al., 1997; Bezrukova et al., 2010; Tarasov et al., 2007, etc.), Khövsgöl (Prokopenko et al., 2007), and El'gygytgyn (Andreev et al., 2014; Brigham-Grette et al., 2013; Tarasov et al., 2013). Several dated Holocene paleoecological and paleoclimatic records of lake sediments are known from the south of Western Siberia (Levina et al., 1987; Klimanov et al., 1987; Khazin and Khazina, 2008; Khazina, 2008; Nenasheva, 2006; Blyakharchuk et al., 2007, 2008; Andreev and Tarasov, 2013; Krivonogov et al., 2012a, 2012b; Rudaya et al., 2009; Rudaya et al., 2012).

Palynological records are some of the most reliable and authoritative archives for the study of nature in the past. Currently, there are a number of new methods and approaches to interpreting palynological data obtained from lake cores, which makes possible a quantitative reconstruction of natural changes: biomisation method, method of indirect ordination, transfer functions, etc. in addition to taxonomic analysis (Klemm et al., 2013; Nazarova et al., 2011, 2015; Rudaya et al., 2016).

This study presents the results of a detailed study of the sediment core from Lake Bolshie Toroki (situated in the Baraba forest-steppe) and covering the last 8000 years, using the palynological method supplemented by radiocarbon dating, quantitative reconstructions of climate and vegetation, as well as archaeological evidence. The goal of this study is to establish the relationship between the changes in climate and vegetation on the one hand, and the types of economical activities in the region over the last 8000 years, on the other hand.

2. Description of the site and regional setting

The Baraba forest-steppe is located in the central part of the Ob-Irtysh interfluve and is distinguished as flat, poorly dissected and gently sloped terrain. Its surface is slightly inclined from the northeast to the southwest. The climate of Baraba is continental; the annual temperature amplitudes are around 38 °C. Mean January temperatures range from −19 to −21 °C with minimum temperatures from −52 to −56 °C. Mean July temperatures are 17.5–19° Cwith maximum temperatures from 36 to 40 °C. The region is waterlogged and heavily swamped, especially in the northern part due to the spread of loess-like loams acting as natural aquifuge and impeding drainage (Orlova, 2004). Ground waters occur close to the surface (0.5–4 m) and feed numerous rivers, lakes, and swamps.

The vegetation of Baraba is of the forest-steppe, a temperate-climate ecotone and habitat type, where birch groves are interspersed with swamps and meadow steppes. In the north, the forest-steppe borders the southern taiga. A narrow transition belt (50–200 km) is composed of small-leaved aspen and birch forests. In the south, the forest-steppe transforms into the Kulunda Depression overgrown with mixed grass and feather grass steppe communities (Gvozdetsky and Mikhailov, 1978).

Lake Bolshie Toroki is located in the Kargat District of Novosibirsk Region (55.39350°N, 80.61860°E; Fig. 1). It is an undrained lake with an area of 9.57 km^2 and a depth of about 1 m, with weakly alkaline and weakly mineralized (845 mg/l) water (Maltsev et al., 2014). Aquatic vegetation is predominantly represented by pondgrass (*Potamogeton*) and watermilfoil (*Myriophyllum*). The surrounding onland vegetation consists of agricultural lands with birch groves and marshy lowlands.

3. Materials and methods

3.1. Coring and chronology

Two boreholes were drilled in the summer of 2012 in the middle of Lake Bolshie Toroki using a Livingstone piston corer; continuous 1.8 and 1.9 m long cores were retrieved. The first core (Toroki01) was analyzed by sedimentological and geochemical methods (Maltsev et al., 2014). The second core (Toroki02) was used for pollen analysis and was dated by the radiocarbon method. Both cores had the same structure and an insignificant mismatch between the boundaries of the layers.

The core Toroki02 (Fig. 2) showed the following layers: macrophytogenic sapropel of light olive color (0–75 cm), macrophytogenic sapropel of dark olive-green color (75–125 cm), peaty sapropel of brown-grey color (125–160 cm), a transitional organic-mineral layer (160–170 cm), and underlying loams (170–190 cm).

The deposits are characterized by four radiocarbon dates (the Toroki02 core) from the following depths: 31 cm–1880 ± 60 years BP (SOAN-8913), 71 cm–3080 ± 45 years BP (SOAN-8914), 123.5 cm–5330 ± 80 years BP (SOAN-8915), and 141 cm–5740 ± 95 years BP (SOAN-8916). An age model (Fig. 3) was constructed using the Bacon 2.2 package (Blaauw and Christen, 2011) with the R software (R: A language …, 2013). The calibration of radiocarbon dates was carried out using the IntCal13 calibration curve (further in the article, all ages are calibrated). Mean values were taken for calculating the ages of boundaries in pollen zones and ages of events.

3.2. Pollen analysis

Eighty four samples were taken for palynological analysis 2.5 ml each at every 2 cm of the core (the lowest sample was taken at a depth of 168 cm). The samples were chemically treated according to the technique for lake sediments (Textbook of …, 1989), including treatment with a 10% solution of hydrochloric acid for dissolving carbonates, 10% solution of potassium hydroxide for removing humic acids, and high-concentration hydrofluoric acid for removing silicates. Acetolysis was not performed. A *Lycopodium* spore tablet was added to each sample for calculating the total pollen and spore concentration. The prepared sample was studied under a microscope with 400× magnification; we calculated at least 300 pollen grains per sample. For determining pollen species