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Detailed reconstructions of Holocene climate and environmental changes in the Taman Peninsula (Kuban River delta region) and their correlation with rapid sea-level fluctuations of the Black Sea

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ABSTRACT

The paper presents results of a detailed subdivision of Holocene sediments in the region of the Kuban River delta into climate-stratigraphic units and reconstructions of the vegetation, climate and depositional environment changes on the Taman Peninsula (NE Black Sea region) during the last 7400 years. The reconstructions are based on data from geological-geomorphological and lithological-facies analysis, palynological studies and radiocarbon dating of six sections penetrated by boreholes in various parts of the Kuban River delta. The studied lithological sequences present an assortment of *liman*, fluvial, lacustrine and marsh sediments, as well as subaerial deposits that accumulated in the course of the delta development.

The factual materials thus obtained provided the basis for reconstructing changes in zonal vegetation types and transformations of zonal and intra-zonal formations in the Holocene landscapes of the Taman Peninsula, induced by changes in edaphic conditions and regional climate. Seventeen phases (stages) have been recognized in the evolution of vegetation and climate through the Middle and Late Holocene, and a detailed description is given to every phase. A detailed pollen-climate-chronostratigraphic scheme of the Black Sea level fluctuations over the last 7400 years is proposed.

Steppe and forest-steppe landscapes were dominant on the Taman Peninsula over the greater part of the studied period of the Holocene. The warmest and most arid conditions were typical of the phases dominated by steppes with grass, herb and grass, and pigweed-wormwood (Chenopodiaceae-*Artemisia*) plant communities. Such phases were dated to intervals ~4660–4400, 3780–3430, 2910–2280, 1540–1230 and 900–830/730 cal yr BP. The most humid intervals within the studied period are dated at ~5160–4900, 4400–3780, 2280–1540 cal yr BP. They were distinct because of the dominance of broadleaf (mostly beech-oak-hornbeam) forests. Those humid intervals most likely correspond to the maxima of the Kalamitian, Dzemetinian, and Nimphaean Black Sea transgressions.

The climatic indexes and zonal attribution of the dominant plant communities can be matched with six transgressive and seven regressive sea level fluctuations of various ranks over the last 7400 years. Of the six transgressive stages, one stage was marked by a relatively cool and humid climate, whereas five others occurred under warm and wet conditions. The regressive stages include four phases of relatively warm and dry climate and three periods of dry and relatively cold (or cool) climate.

1. Introduction

The history of the seas bordering the East European Plain to the south has been the subject of thorough investigations for many decades, the specialists' attention having been concentrated both

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on the sea coasts and on the water bodies themselves. In the process, abundant information has been collected, including geological, geomorphological, paleontological (mostly on malacofauna), geo-archeological and historical data, complemented with archival materials and radiocarbon dating. The information obtained formed the basis of numerous regional and inter-regional paleogeographic schemes (e.g. Fedorov and Skiba, 1960; Nevessky, 1970; Varuschenko et al., 1980, 1987; Balabanov and Izmailov, 1988). The authors of various schemes often disagree on a number of points, such as the hypsometric position of ancient coastlines, as well as chronological boundaries, amplitude and hierarchical order of the sea level fluctuations (transgressive and regressive) at the transition from the late glacial to post-glacial and through to the modern interglacial epoch. A constructive analysis of various recently developed schemes, together with new or revised curves of sea level fluctuations in the Azov-Black Sea and the Caspian Sea basins during the Holocene, is presented in a number of recently published papers (e.g. Chepalyga, 2002; Balabanov, 2007, 2009; Konikov et al., 2007; Kroonenberg and Hoogendoorn, 2008; Martin and Yanko-Hombach, 2011; Svitoch, 2011, 2012).

Palynological studies of Holocene sequences within the limits of the marine paleo-basins contribute significantly to the understanding of vegetation, climate and sea level history. Until recently (the last 15–20 years), there were only a small number of known Holocene sections in the south of the East European Plain that were studied palynologically and dated by radiocarbon. Quite a few of them were situated close to the coasts of the Caspian Sea, Black Sea and the Sea of Azov, and these provided information needed for a detailed climatic-stratigraphic subdivision of the sequences, permitting reconstructions of detailed vegetation and environmental changes, and potential relationships with climate-controlled sea level fluctuations (Bolikhovskaya, 1990; Bolikhovskaya et al., 1989, 2001; Lavrushin et al., 1991; Spiridonova, 1991; Gerasimenko, 1995, 1997; Kremenetski, 1991; Kremenetski et al., 1999).

The lack or insufficient amount of radiocarbon dates hampered a proper interpretation of many of the palynological records available for some terrestrial Holocene sequences, including those obtained by sea bottom drilling in the Black, Caspian and Azov seas. For example, the results of pollen analysis of the bottom sediments sampled in the Black and Azov seas (Vronsky, 1976, 1984; Isagulova, 1978) as well as of those from the eastern Azov Sea off the Kuban River delta and from the shallow lakes (*liman*) of the coastal plain (Chebanov et al., 1992; Mishchenko, 2002) were interpreted rather schematically. The authors gave only general characteristics of the four main stages in the evolution of the vegetation and climate of the coastal lands, namely the ancient, Early, Middle and Late Holocene. Similarly, the lack or insufficient coverage of absolute dating has hindered development of comprehensive climatic and environmental reconstructions based on palynological studies of the Holocene Caspian sediments. Even so, pollen analysis of bottom sediments from the Caspian Sea, together with data obtained from lacustrine, fluvial and subaerial deposits in the Caspian lowland, provided sufficient information for reconstructing plant communities and climatic parameters of the coastal regions. These include records for the Mangyshlak (Early Holocene) regression, the New Caspian (Novocaspian) maximum transgression (the late Atlantic period of the Middle Holocene) and several phases during the Late Holocene (Abramova, 1971, 1974, 1980, 1985; Vronsky, 1980, 1987). Mathematical methods applied to palynological data allowed quantitative estimates of paleoclimatic parameters to be obtained, including mean annual rainfall, annual temperatures and those of July and January (Abramova and Turmanina, 1988; Bukreeva and Vronsky, 1995).

The recent decade is notable for a sizeable volume of new data on the paleovegetation (based on pollen assemblages) and absolute geochronology of the Holocene obtained from semiarid (i.e. steppe) regions of the northeast coastal regions of the Black and Azov Seas (Bolikhovskaya et al., 2004, 2014a, b; Cordova and Lehman, 2005; Sapelko and Subetto, 2007; Cordova et al., 2011a, b; Krasnorutskaya and Novenko, 2011; Matishov et al., 2011, 2012, 2013; Shumilovskikh et al., 2012; Dyuzhova, 2013). Comparable data are now available from the arid (i.e. desert and semi-desert) regions to the northwest and northeast of the Caspian Sea (Bolikhovskaya, 2011a, 2011b; Bolikhovskaya and Kasimov, 2008, 2010a, b; Richards and Bolikhovskaya, 2010; Richards et al., 2014, 2017) and from offshore (e.g. Leroy et al., 2007, 2013; Leroy, 2010).

This paper presents the main results of a detailed vegetation and climatic-stratigraphic subdivision of Holocene deposits studied at the Kuban River delta (Taman Peninsula, NE Black Sea region). The sequences were minutely subdivided based on data from lithology and facies studies, palynological analysis and radiocarbon dating, performed on the sections considered to be most informative paleogeographically. The work permitted reconstructions of zonal and intra-zonal plant formations in the Holocene landscapes on the Taman Peninsula and vegetation changes that are attributable to variations in edaphic conditions and climate. Data obtained gave us an insight into regional climate patterns in the recent interglacial epoch and elucidated their impact on environmental and topographic conditions on the Black Sea coasts. These data provided the basis for a palyno-climatic-chronostratigraphic scheme and to assess the relationship with climate-controlled fluctuations of Black Sea level over the last ca. 7400 years. The studied cores are of Middle to Late Holocene age and therefore post-date the reconnection of the Black Sea with the Mediterranean Sea around 7500 years ago (Aksu et al., 2002; Marret et al., 2009; Yanko, 1990; Yanko-Hombach, 2007; Filipova-Marinova, 2007; Filipova-Marinova et al., 2013).

The results of our previous studies in the region (Bolikhovskaya et al., 2002, 2004) focused on changes in vegetation, climate and sea level fluctuations within the period of ca. 7000–1000 years BP. Unfortunately, we could not develop a comprehensive scheme of paleoclimatic changes for the last 2500 years because of insufficient geochronological data and an incompleteness of the Late Holocene sections under study. Recently obtained pollen records and absolute dates have now made it possible to consider the evolution of climate and environments throughout the Holocene in more detail, and to define more precisely chronological boundaries of identified stages. The new reconstructions will be instrumental in permitting easier and more accurate correlations between vegetation, landscape and paleoclimatic events recorded in the NE Black Sea region and those in the lower Volga and Akhtuba region of the NW Caspian Lowland (Bolikhovskaya, 2011a, 2011b; Bolikhovskaya and Kasimov, 2010a,b; Richards et al., 2014) (Fig. 1). The new data also offer a clearer view on the significance of climate-controlled fluctuations of the adjacent sea level. The integrated analysis of paleoclimatic events in the maritime regions of the semiarid (e.g. lower Kuban River region) and arid (e.g. lower Volga River region) zones is of great significance in the development and validation of paleogeographic forecasts of future environmental changes in the coastal regions in the south of the East European Plain induced by climate change.

2. The study area, material and methods

2.1. The Kuban River delta and Taman Peninsula modern environments

2.1.1. Geomorphology

The Kuban River has its source close to Mount Elbrus in the

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