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The Ponto-Caspian region: Environmental consequences of climate change during the Late Pleistocene

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ABSTRACT

Evolution of the Caspian and Black Sea (Pont) Basins environments was analyzed in comparison, and both general and specific features of their development under multi-scale and multi-directional changes of climate during the Late Pleistocene were identified. The cold extensive transgressions of the Caspian Sea and the transgressions of the Caspian type of the Pontian Basin, not exceeding the present sea level, developed synchronously in the cold (glacial) climatic epochs. The maximum height of level of the Caspian transgressions was limited by the height of the Manych threshold, and the transgressions of the Caspian type in the Pontian Basin by the height of the Bosporus threshold. The warm small transgressions of the Caspian Sea and the marine (Mediterranean type) transgressions of the Pont with maximum level developed during the warm interglacial epochs. In the Caspian these occurred mainly during the interglacial endothermal (cool and moist) phases, while marine transgressions of the Pont correlated with the interglacial transgressions of the World Ocean. The cold transgressions of the Caspian Sea and the Caspian type transgressions of the Pontian Basin developed asynchronously with the transgressions of the World Ocean.

1. Introduction

The Ponto-Caspian region (Black Sea, Sea of Azov and Caspian Sea) contains a system of basins (Fig. 1), relicts of the East Paratethys that have their own unique environmental features and paleogeographical history. In the evolution the Ponto-Caspian basins global climatic changes are reflected, including glacial – interglacial rhythms of the East European Plain and mountain territories as well as transgressive – regressive events in the World Ocean. The study of the Late Pleistocene development of the Ponto-Caspian basins, initiated at the end of the nineteenth century by the works of Andrusov (1888, etc.), was continued by many researchers (Arkhangelskiy and Strakhov, 1938; Zhukov, 1945; Fedorov, 1957, 1978; Vasiliev, 1961; Moskvitin, 1962; Nevesskaya, 1965; Goretskiy, 1966; Vronskiy, 1974; Kvasov, 1975; Ostrovskiy et al., 1977; Popov, 1983; Balabanov and Izmailov, 1988, 1989; Yanko, 1989; Svitoch, 1991, 2007; Maev, 1994; Chepalyga, 1997; Rychagov, 1997; Bezrodnykh et al., 2004; Yanina, 2005, 2012; Aksu et al., 2006; Badyukova, 2007; Yanko-Hombach et al., 2007; Sorokin, 2011; Tudryn et al., 2013 and many others).

Despite abundant data and insights, major questions about the paleogeographic development of the region are still being debated. Major phases of basin development during the Late Pleistocene in the various basins were identified by the various authors: the Karangat and New Euxinian transgressions and intervening regression in the Black Sea area; the Late Khazar and Khvalynian transgressions, and the intervening Atelian regression in the Caspian area. Disagreements developed over the small-scale events in the history of both seas, their timing, magnitude, hydrological, and ecological characteristics. Today, no broad agreement exists over the interrelation of events in the Ponto-Caspian, their response to global and regional climatic changes, and correlations with paleogeographical events in adjacent territories (Moskvitin, 1962; Markov et al., 1965; Goretskiy, 1966; Fedorov, 1978; Vasiliev, 1982; Zubakov, 1986; Rychagov, 1997; Svitoch et al., 1998; Mangerud et al., 2004; Kislov and Toropov, 2006, 2007; Chepalyga, 2007; Dolukhanov et al., 2009, 2010; Kislov, 2010; Shkatova, 2010; Sorokin, 2011; Yanina, 2012a,b, 2013b).

Global climatic events of the Late Pleistocene (130–11 ka) were presented by the warm interglacial (Eemian, Mikulino) epoch and the successive cold glacial (Weichsel, Valdai) epoch. The Ponto-Caspian environment directly depends on climate change and the sea-level fluctuations caused by them. In the Caspian Basin, the inflow from its basin and the balance between regional

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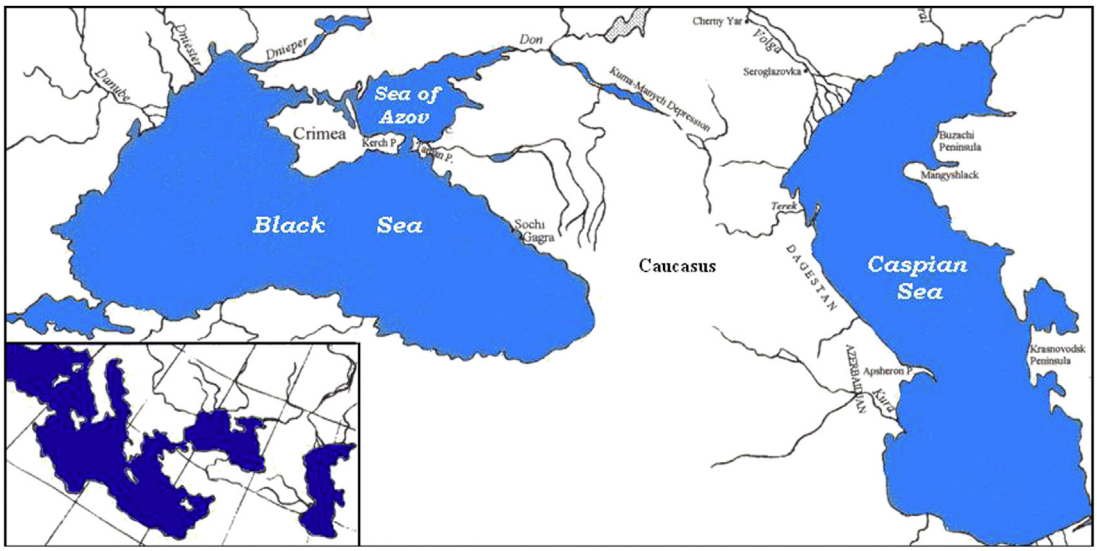

Fig. 1. The Ponto-Caspian region (Black sea, sea of Azov and Caspian sea).

precipitation and evaporation is a main driver, whereas in the Azov/Black Sea the global oceanic sea levels also play an important role. The aim of this paper is to make a comparative analysis of the environmental evolution of the Caspian and Pont Seas during the Late Pleistocene, and to establish general rules and features of the development of these different basins under the conditions of multidirectional climate changes of different scales.

2. Materials and methods

Reliable paleogeographical reconstructions depend on well-constrained age estimates of events and episodes that allow correlation between the different basins. The bases for reconstruction of events in the Ponto-Caspian Seas and their correlation are the biostratigraphical (ecostratigraphical) schemes of the Caspian Sea, the Manych depression and the Black Sea, executed by the author as a result of analyses of all main sections of the Late Pleistocene mollusks in the region (Yanina, 2005, 2012a, 2013a).

In this study, the Late Pleistocene development of the Caspian and Pontian Basins is documented using the malacofaunistic method. The method includes the analyses of taxonomical structure, taphonomy, phylogeny, biostratigraphical distribution, historical development, and biogeography of mollusks. The study focuses on the bivalve genus *Didacna* Eichwald, an index–fossil genus for the modern Caspian Sea and an endemic fossil for the Quaternary Ponto-Caspian basins. The genus is known for its high evolutionary rates at the species and subspecies levels. The use of *Didacna* species for the stratigraphical subdivision of the Pleistocene, not only of the Caspian Sea but also of the Black Sea, plays an important role at the correlation of deposits and events of the region. For paleogeographical reconstructions, the interface method was used, complementing and supervising results of geomorphological, lithological, facial, palynological, diatom, isotope, geochronological and other analyses of the recent deposits. Materials about global and regional climatic events of the Late Pleistocene are taken from references.

3. Results and discussion

3.1. Caspian Sea

During the Late Pleistocene, several transgressive and regressive episodes developed, including the Late Khazar (Late Khazar and Girkan transgressive stages) and the Khvalynian (Early Khvalynian and Late Khvalynian transgressive stages) transgressive epochs, separated by the Atel regression (Fig. 2).

The Late Khazar transgression developed in two successive stages that are separated by a regression. Lake levels in the earlier Late Khazar basin, according to spatial distribution of the deposits, did not exceed −10 m, and its surface area was not much bigger than the modern Caspian Sea. The mollusc fauna contained crassoidal-type *Didacna* and was characterized by the occurrence of *Didacna nalivkini* and *Didacna surachanica* (Fedorov, 1978; Yanina, 2005). The fauna is characterized by the large size and massive nature of shells, especially in the southern parts of the Caspian Basin. Abundant trigonoidal and catilloidal *Didacna*-dominated faunas occurred in the freshened areas of the northern Caspian, influenced by the Volga River during Late Khazar times. Common gigantism of shells, high carbonate content in the sediment, and the presence of oolites represent warm climate conditions during Late Khazar times. Salinities reached from 10 to 12‰ in the northern up to 14–15‰ in the southern part of the Caspian Basin, higher than today's salinities. Data on foraminifera (Yanko, 1989) support this conclusion. The warm climatic phase is also shown in palynological analyses (Abramova, 1974; Yakhimovich et al., 1986). During early Late Khazar times, the Caspian Basin was occupied by an isolated lake-sea that lacked any connection with the Black Sea Basin.

After the Early Late Khazar stage, a regression followed that is seen in hiatuses in the depositional sequences of Dagestan and erosion and soil formation in the Volga River valley (Yanina and Svitoch, 1990; Svitoch et al., 1993, 1997; Yanina, 2005). Stratigraphic hiatuses from this regressive stage were recorded by Fedorov (1957), Rychagov (1997), and Popov (1983). At present, there is no direct evidence to estimate the extent of the Late Khazar regressive phase. As the composition of the mollusc fauna was not much altered, this probably was a minor regression.

Traces of the second transgressive Late Khazar stage are not preserved along the Caspian coasts. Based on borehole material from the northwestern part of the Caspian region, Goretskiy (1957) and Popov (1955, 1967) indicated the presence of a brackish water basin which existed after the Late Khazar transgression and before the Khvalynian transgression, the Girkan transgression. The Girkan basin was inhabited by "Khvalynian-like" fauna, traces of which have not been recorded elsewhere. A number of researchers strongly objected to the Girkan transgression concept (Shkatova,