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Late Pleistocene – Holocene sea-level dynamics in the Caspian and Black Seas: Data synthesis and Paradoxical interpretations

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Different multidisciplinary data concerning the paleodynamics of sea-level variations in the Caspian and Black seas are controversial in some aspects. There are at least three paradoxes that are discussed in the paper. The Paradox No. 1 relates to the Early and Late Khvalynian transgressions that occurred in the CS during the second part of MIS 3 (~35–25 ka BP) and the Late Glacial epoch (~17–12 ka BP), respectively. It is unclear what the main source or sources of water were that caused them. Paradox No. 2 emerges from the comparison of climate events and transgressive-regressive cycles in the Caspian Sea and the Black Sea. It implies that large sea-level anomalies occurred in accordance with global climate changes (because they are influenced by climate variations). However, other (not so long-lived) sea-level fluctuations are poorly correlated with climate events. The question is why climatically-induced sea-level changes did not follow climatic variations. Paradox No. 3 concerns the contradiction between the massive water discharge from the Black Sea into the Sea of Marmara via the Bosphorus Strait and the Black Sea level fluctuations in the Latest Pleistocene-Holocene that could not exist simultaneously. It is shown that Paradox No. 2 has been solved, at least on conceptual level. Solutions to Paradoxes No. 1 and No. 3 are still lacking: further geological and geochronological evidence as well as climate simulation are required. Formulation of solutions for these paradoxes should make a major contribution not only to the problems of the Caspian and Black seas' paleogeography, but also provide help in explaining the reasons for inadequate simulation of regional climate changes. This is important in the context of the development of models for future climate prediction.

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1. Introduction

The Caspian Sea (CS) and the Black Sea (BS) (Fig. 1) are relics of the Eastern Paratethys and the largest members of the Ponto-Caspian Corridor (Yanko-Hombach, 2007).

These basins were repeatedly connected (via the Manych outlet) and isolated from each other during the Quaternary. The BS was also periodically connected to the Mediterranean Sea (MS) via the Bosphorus Strait or alternative channel/s (Kerey et al., 2004; Yanko-Hombach, 2007), and then to the World Ocean via the MS and the Strait of Gibraltar. The BS is currently connected to the Sea of Azov via the Kerch Strait. The unique geographical location of these basins predetermined their environmental conditions and hydrologic regimes, and it imposed specific impacts on diverse biological populations (Yanko-Hombach, 2007). Therefore, they act as paleoenvironmental amplifiers and as sensitive recorders of climatic events, in particular for the glacial-interglacial cycles of the East European Plain and mountains that were responsible for main aspects of transgressive-regressive sea-level fluctuations. They also serve as stratotype regions for the development of the Northern Eurasian Quaternary stratigraphy (Yanko-Hombach et al., 2017). For these reasons, the study of their Quaternary geological history has attracted a lot of attention for more than two centuries (see Yanko-Hombach, 2007; Yanko-Hombach et al., 2014, 2017 for the references) and has made available abundant data for synthesis by the IGCP 521, INQUA 501, and IGCP 610 projects (http://www.avalon-

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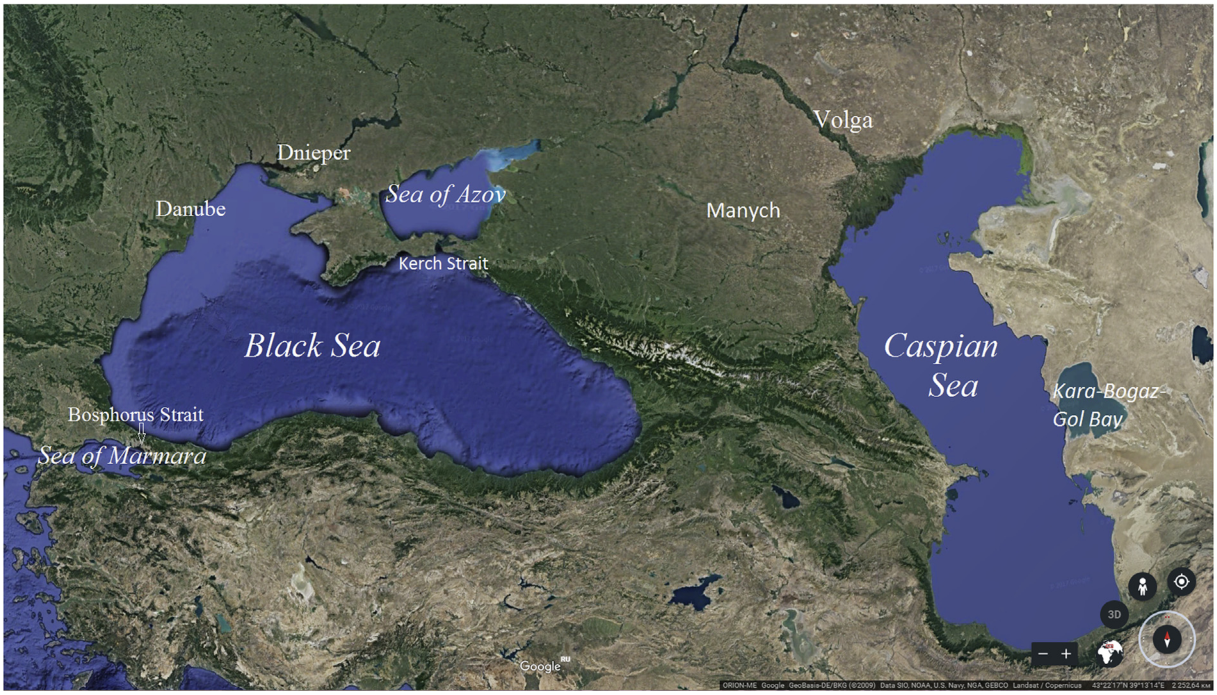

Fig. 1. Current map of Caspian Sea, Black Sea, connecting straits and main rivers (https://earth.google.com) demonstrating all geographical objects mentioned in this paper (Manych is fragments of spillway, which presumably connected the Caspian Sea and Black Sea).

institute.org/IGCP610/index.php).

This synthesis has enabled us to conclude that some data obtained through earth science investigations contradict other data that were obtained empirically. We call these contradictions paradoxes:

Paradox No. 1 relates to the Early and Late Khvalynian transgressions that occurred in the CS during the second part of MIS 3 (~35–25 ka BP) and the Late Glacial epoch (~17–12 ka BP), respectively (e.g., Yanina, 2012). It is unclear what the main source or sources of water were that caused them. As such, we face a paradox: "The event occurred, but it seems inexplicable because it cannot be described using reasonable arguments about its causation."

Paradox No. 2 emerges from the comparison of climate events and transgressive-regressive cycles in the CS (Yanina, 2012) and BS (Balabanov, 2007; Yanko-Hombach, 2007). It implies that large sea-level anomalies occurred in accordance with global climate changes (because they are influenced by climate variations). However, other (not so large and not such long) sea-level fluctuations are poorly correlated with climate events. The essence of Paradox 2 is why climatically-induced sea-level changes did not follow climatic variations.

Paradox No. 3 concerns the contradiction between the massive water discharge from the BS into the Sea of Marmara via the Bosphorus Strait (e.g., Aksu et al., 2002) and the BS level fluctuations in the Latest Pleistocene-Holocene (Balabanov, 2007; Konikov, 2007; Yanko-Hombach, 2007). Both scenarios could not exist simultaneously.

The main goal of this paper is to provide some ideas on possible reasons for these paradoxes using empirical methods with a hope to solve at least some of them and encourage a new round of research on the interrelation between climate and sea-level change.

2. Results and discussion

Paradox No. 1. The Early and Late Khvalynian transgressions increased water level in the CS to 50 m asl and 0 m asl, respectively (Yanina, 2012; Bezrodnykh et al., 2017). These transgressions were preceded by the Atelian and Enotaevian regressions. At their maximum, the former regression decreased the CS level to −140 m bsl and the latter to −110 m bsl (Maev, 1994). In total, the Early Khvalynian transgression rose from −140 m to +50 m (about 200 m), but Late Lhvalynian transgression rose from −110 m to 0 m (about 110 m). According to Chepalyga (2007), "In the process of flooding, the Khvalynian Sea expanded over an area of about one million km^2, up to 1.1 million km^2 if the Aral-Sarykamysh basin is included. The total area was three times that of the present Caspian Sea, and the accumulated water volume (which reached 48–50 m asl at peak flood stage) was twice that of today's Caspian (130,000 km^3)." These transgressions "… left distinct traces in the morphology of landforms, such as marine terraces, specific coastlines, flattened seafloor surface, as well as sculptured and constructional landforms within the former spillways: the Manych-Kerch Spillway, and the Bosphorus and Dardanelles Straits" Chepalyga (2007).

The question is from where could this water come? Several aspects of the problem were discussed earlier by Chepalyga (2007). Was meltwater from the decaying Scandinavian ice sheet a considerable contributor to the flood (Kvasov, 1979), or was it much higher precipitation in Eastern Europe (up to 600–800 mm per year) and increased river runoff into the CS (Sidorchuk et al., 2009), or decreased evaporation rate over the CS, etc.? Whatever it was, logic dictates that it should have been climatically induced, significantly contributing to river runoff into the CS.

As the first step, let's consider the main components of the water budget in the CS that could provide the long-lived interdecadal water-level trends under climate change. The water budget consists of positive and negative components. The former include

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