Short communication

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Approaching a new theory on Caspian Sea response to global climate changes during MIS2 - MIS1: generalization and reassessment of $\delta^{18}O$ data

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ABSTRACT. The study represents correlation $\delta^{18}O$ records from the Caspian basin together with available stable oxygen data on the continual sequence of deep-sea cores and on Kara-Bogaz-Gol Gulf, nearby lakes, and caves to complete palaeogeographical reconstruction of the Caspian Sea region. Typical Quaternary caspian ostracods shells and valves were measured for the $\delta^{18}O$ analysis. Oxygen isotope data allowed to correlate region transgressive-regressive events with glacial-interglacial rhythm and global climate changes. It was distinguished three main evolution stages of the Caspian Sea region, including the Last Ice Sheet degradation with a series of step-like environmental shifts matching the sequence of abrupt cooling/warming events; abrupt warming at the beginning of the Holocene; and climatic fluctuations of a smaller scale and different sets during the second part of the Holocene. It was established that Caspian Sea level oscillations occur as a response to climatic changes among numerous probable causes. Transgressions were usually accompanied by the freshening of water and cold climate while regressions were primarily correspond to increased salinities and warm climate. The reconstruction of the Caspian Sea hydro-climatic changes was confirmed by observed similar trends in the oxygen isotope record of nearby regions.

Keywords: stable oxygen isotopes, Pleistocene-Holocene transition, sea level changes, correlation

1. Introduction

The Caspian Sea (CS) is highly variable on spatial and temporal scales, fluctuating substantially in the geological and historical past. After more than a century of research, there is not yet a full understanding of the amount and causes of the sea-level fluctuations and the dynamics of the Sea. Instrumental observations for the CS level (CSL) and hydrometeorological parameters cover only the last 150 years. The rare studies available so far on the CSL during the Late Pleistocene and Holocene have been made inferred from coastal sections or in the shallow northern basin and suffer from deposition hiatuses during low-stand periods and sedimentation starvation. Closed basins or lake systems in general and the Caspian Sea, in particular, are important paleoclimate archives that preserve paleogeographic and hydrologic responses to critical periods in Quaternary history, such as glacial-interglacial cycles.

Measurements of $\delta^{18}O$ biogenic carbonate are indicators of paleogeographic variability in such systems throughout the geologic record. The correlation of paleogeographic events within the region is as important as a comprehensive consideration of the history of the development of the CS against the background of global climate changes.

Here we use our $\delta^{18}O$ records from the Caspian basin together with available stable oxygen data on the continual sequence of deep-sea cores and on Kara-Bogaz-Gol Gulf, The Black Sea, nearby lakes, and caves to complete palaeogeographical reconstruction of the CS.

2. Materials and methods

The use of the stable oxygen isotopes in combination with the micropaleontological studies appears to be a most productive way to study the regional natural processes which are developed during considerable time intervals. We study three marine cores from the Central and 4 cores from the Southern parts of the CS. The applicability of ostracods, which are more common in the cores compare to foraminifera, for stable oxygen isotope analysis was proved during the last century. We measured $\delta^{18}O$ in typical Quaternary Caspian ostracods shells and valves.

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Samples were sieved through a 63 μm mesh using distilled water. The dry fractions 0.1–2 mm and 0.063–0.1 mm were analyzed using a binocular microscope. After full ostracod record and taxonomic revision for integration with ecological data ostracod samples were picked for stable oxygen measurements. The analyzes were performed at the Center for Collective Use, Primorsky Center for Local Elemental and Isotopic Analysis of the Far Eastern Geological Institute, Far Eastern Branch of the Russian Academy of Sciences, Vladivostok using The Finnigan MAT 253 stable isotope ratio mass spectrometer system.

3. Results and discussion

We correlate the results with our previous data on stable oxygen composition of the North Caspian cores (Berdnikova et al., 2018), four deep-sea cores from the joint Russian-French expedition, organized in 1984 (Ferronsky and Polyakov, 2012), core from the north-west part of the Kara-Bogaz-Gol Gulf (Ferronsky and Polyakov, 2012), Eski Acigol former crater lake in the Central Anatolian volcanic province (Roberts et al., 2001), Van Lake (Wick et al., 2003; McCormack et al., 2019), Zeribar Lake (Stevens et al., 2001), Mirabad Lake (Stevens et al., 2006), Karakul Lake (Aichner et al., 2019) and Issyk-Kul Lake (Ricketts et al., 2001), Sofular cave (Fleitmann et al., 2009), Poleva Cave (Constantin et al., 2007) and Katalekhor cave (Andrews et al., 2020).

Oxygen isotope data allow us to correlate the transgressive-regressive events in the region with glacial-interglacial rhythm and global climate changes.

We distinguish several evolution stages for the region:

1. The Last Ice Sheet degradation. A series of step-like environmental shifts may match the sequence of abrupt cooling/warming events recorded in different paleo-archives (like the Greenland ice cores).
   - 1.1 Values of $\delta^{18}O$ were higher for 19-16 ka. A similar trend was observed in data from the nearby lakes. For such periods with the light in isotopic compositions wer characterized by an high sedimentation rates.
   - 1.2 Complex internal dynamics: two distinct peaks in the higher isotope composition during Bølling–Allerød warming and the lower $\delta^{18}O$ values during the stadials (change to glacial conditions at the onset of the Younger Dryas). CSL change was presumably a result of shifts in temperature and precipitation. The isotopic characteristics were changed in a different manner along for the southern and middle sections of CS.
2. Abrupt warming at the beginning of the Holocene. An abrupt increase of isotope ratio likely illuminated significant shifts in lake-water balance.
3. The climatic changes of the second part of the Holocene reflected differently in various cores: staggered weighting/stabilization and increase of isotope values.

4. Conclusions

According to our results, CSL oscillations occur as a response to climatic changes among numerous probable causes. Transgressions are usually accompanied by the freshening of water and cold climate while regressions primarily correspond to increased salinities and warm climate. Within the considered paleo-geographical period the upcoming transition was accompanied by a plentiful glacier and permafrost melting, and by increased river runoff, CSL changes as a result of shifts in both temperature and precipitation, and finally abrupt warming. The reconstruction of the CS hydro-climatic changes was confirmed by similar trends observed in the oxygen isotope record of nearby regions.

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Conflict of interest

The authors declare no conflict of interest.

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