The mechanism of the Caspian-Mediterranean corridor formation. The Paratethys Sea evolution

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Introduction

The transformation of the Paratethys Sea into the Sarmatian Sea-Lake, its subsequent shallowing, and its subdivision into two main water bodies—the Black and Caspian seas—describe one of the mysterious of geologic phenomena. This transformation started about 14 million years ago together with the equally intriguing periodic salinization/desalination cycles and sea-level changes within these basins. All events require some explanation.

It is commonly accepted that the Paratethys Sea and the Mediterranean Sea were connected to each other and formed from the ancient Tethys Ocean. Approximately 14 million years ago, the Paratethys was separated from all external basins and transformed into an isolated Sarmatian Sea-Lake. During the last stage of Paratethys evolution, it became the Meotian Sea, with a smaller water area. Later, other seas followed with the same trend of decreasing water area (Figs. 2-4). In the literature, the shallowing of the Paratethys seas is usually attributed to tectonic processes [5, 7]. In our opinion, the main factor affecting Paratethys degradation was the formation of the Great South drainage channel. During periods of Sarmatian Sea-Lake overflow, the water discharge occurred through this channel. Over time, and as a result of erosion, the channel deepened and the level of the Paratethys seas decreased. We assume that in the beginning, there was one barrier between the two seas (Fig. 1), which was later divided into two when the Straits of the Bosporus and the Dardanelles were formed.

The mechanism of the Caspian-Mediterranean corridor formation

In the papers by Esin et al. (2010) and Esin (2014), we estimated the possible discharge of the river flowing out of the Black Sea during the last ca. 7000 years, the average freshwater balance of the Black Sea was 240–300 km³/year [4]. At the end of the late Pleistocene – early Holocene, during the period of most intensive melting of glaciers, the freshwater balance of the Black Sea increased to 1580 km³/year [2]. Currently, the average amount of water evaporation from the Black Sea surface is 330 km³/year. If we hypothesize a closure of the Bosporus, creating a dam height of 115 meters, the following would occur. The water would accumulate in the Black Sea-Caspian depression, and the level and area of the sea-lake would increase. Calculations have shown that during a period of climatic maximum, the maximum level of the Black Sea would be approximately +15 m. Conversely, during a period of climatic minimum (for example, at present), the level of the Black Sea would rise by 30 meters, and water would start to flow into the Caspian Sea through the Manych depression. In this case, the total area of the Black and Caspian seas would have increased by 308,000 km² (Fig. 5). During the period of intensive melting of glaciers the level of Black and Caspian seas would have risen by 116 m, and the water would have begun to flow through the dam into the Marmara Sea. A huge sea-lake would have formed with a size and shape close to that of the shores of the Sarmatian Sea-Lake (Fig. 6). On top of the mountain, the sea-lake would have formed, flowing into the Mediterranean Sea (Fig. 7). The vertical height of the riverbed would then have been lowered as a result of erosion, the height of the bridge between the seas would have been reduced and the sea level will be lowered.

Thus, the calculations showed that, during the Pleistocene, enough water flowed into the Black Sea-Caspian depression to form a sea-lake with an area of 2,848 million km² like the water area of the Sarmatian Sea-Lake, but not for long-term conservation of this area of the sea-lake. When the melting of glaciers terminated, the volume of incoming freshwater decreased sharply. For example, the current freshwater balance of the Black Sea is 640 km³/year, which is enough to keep the sea-lake at an area of 730,000 km². It follows that, as a result of climate change, the Paratethys Sea-Lake level would be lowered. When the melting of glaciers terminated, the sea-lake level would be lowered. During the tectonic movements of the rock massif located between the Black and Mediterranean seas caused by Messinian Salinity Crisis of the Mediterranean Sea, there was the possibility of the penetration of Mediterranean salt water into the Paratethys Sea-Lake. At the final stage of Paratethys degradation, and as a result of reduced pressure on the bottom of the sea-lake (because the depth of the water layer was declining to less than 100 meters), the bottom was uplifted a few tens of meters. Thus, a barrier between the Black and Caspian seas was formed.

Conclusion

The paper by Yelin and Dimityrev (1987) shows that the Gibraltar Strait was formed due to the bottom erosion of the river flowing from the Atlantic Ocean to the Mediterranean Sea. Now, it is possible to conclude that the Bosporus and Dardanelles straits were created mainly by erosion as well.

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References