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

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РФФИ РОССИЙСКИЙ ФОНД ФУНДАМЕНТАЛЬНЫХ ИССЛЕДОВАНИЙ

## 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/desalinization 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 next 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 ice age, and it was from +90 to +130 km³/year. 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 an ice age, the maximum level of the Black Sea would be approximately +15 m. Conversely, during a period of climatic maximum (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 river 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 enough for long-term conservation of this area of the sea-lake. When the melting of glaciers terminated, the volume of incoming water decreased sharply. For example, the current freshwater balance of 240 km³/year is just 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 could vary from +116 to +15 meters. Thus, the sea-lake was constantly changing its coastline.

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 happened 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.

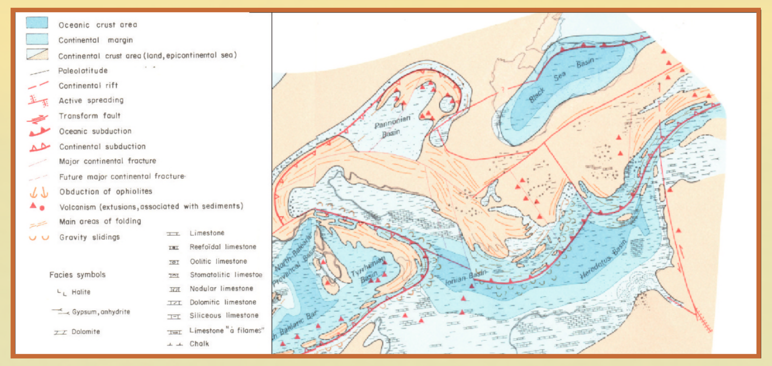

Figure 1. Paleogeographic map of the Black Sea-Mediterranean Sea region in the Tortonian [1]. A mountain massif separates the Black and the Mediterranean seas.

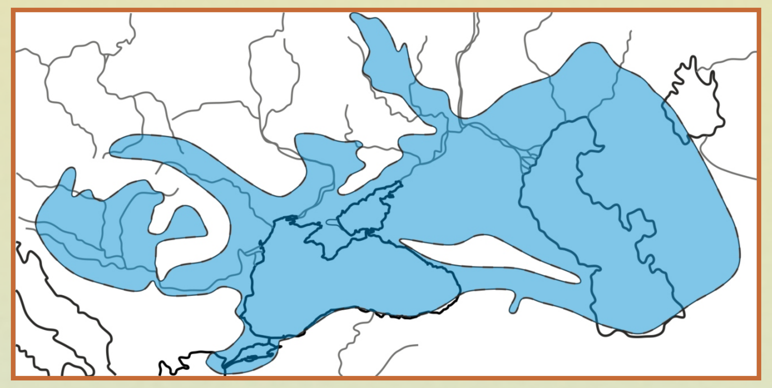

Figure 2. Maximal configuration of the Sarmatian Sea-Lake shorelines according to the results of geologic research [6].

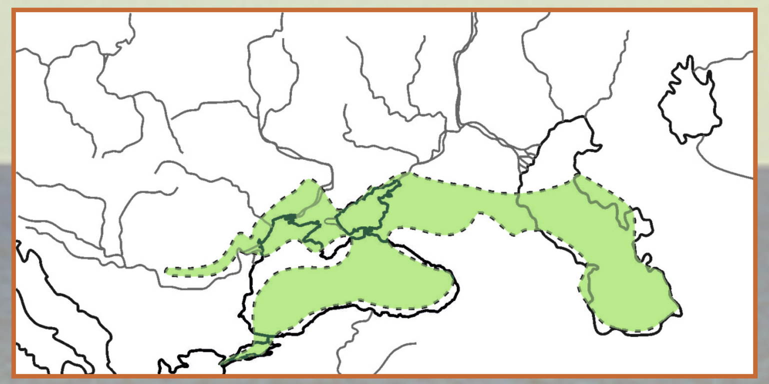

Figure 3. Meotian Sea according to the results of geologic research [6].

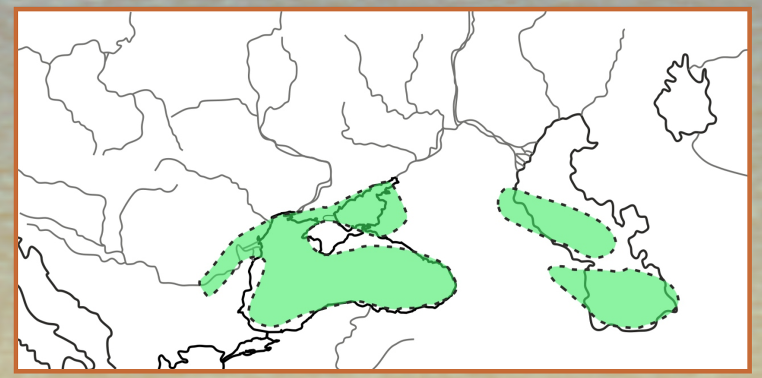

Figure 4. Middle Pliocene, the stage of decay into separate reservoirs [9, 7].

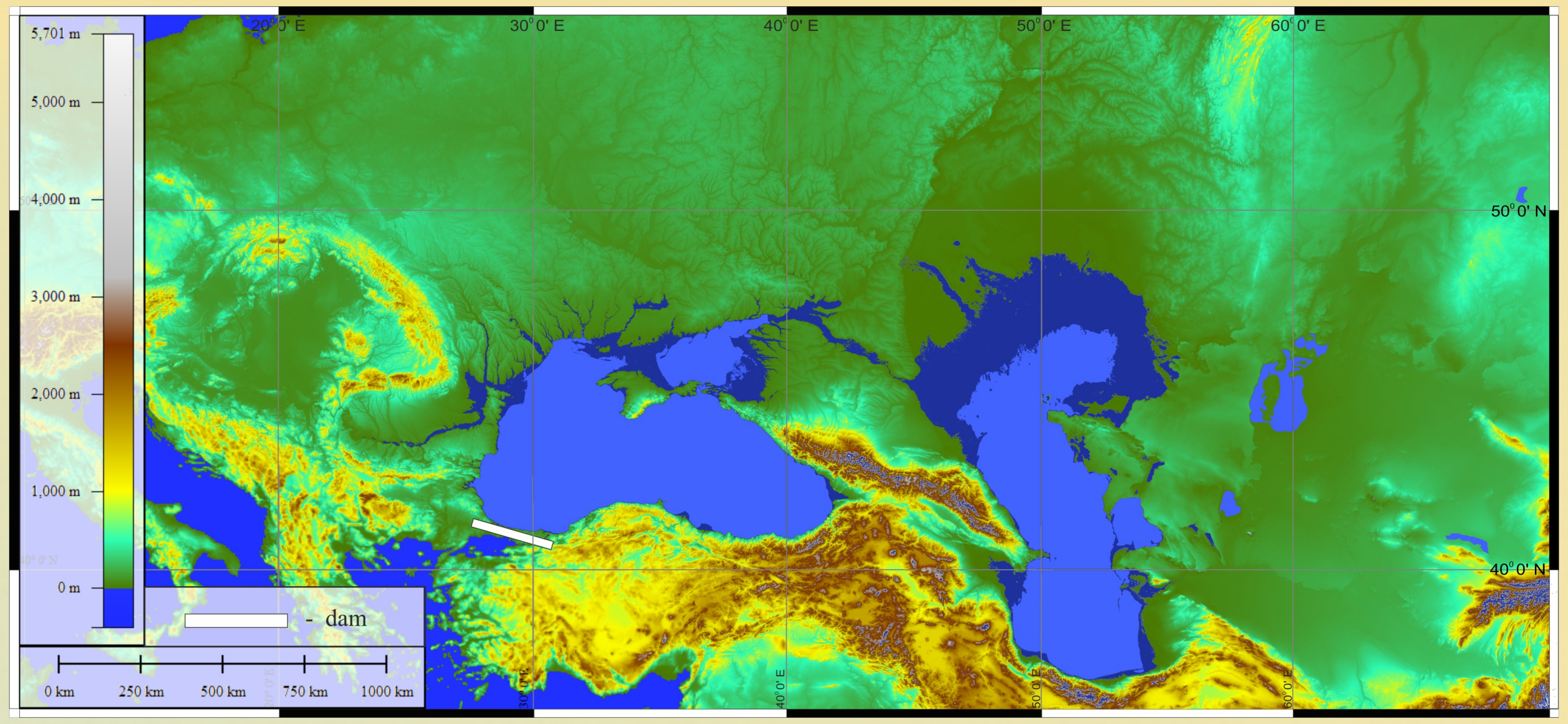


Figure 5. The Black Sea-Caspian Sea region under present climatic conditions in which communication with the Marmara Sea is blocked. Possible hydro-isostasy changes in topography have not been considered.

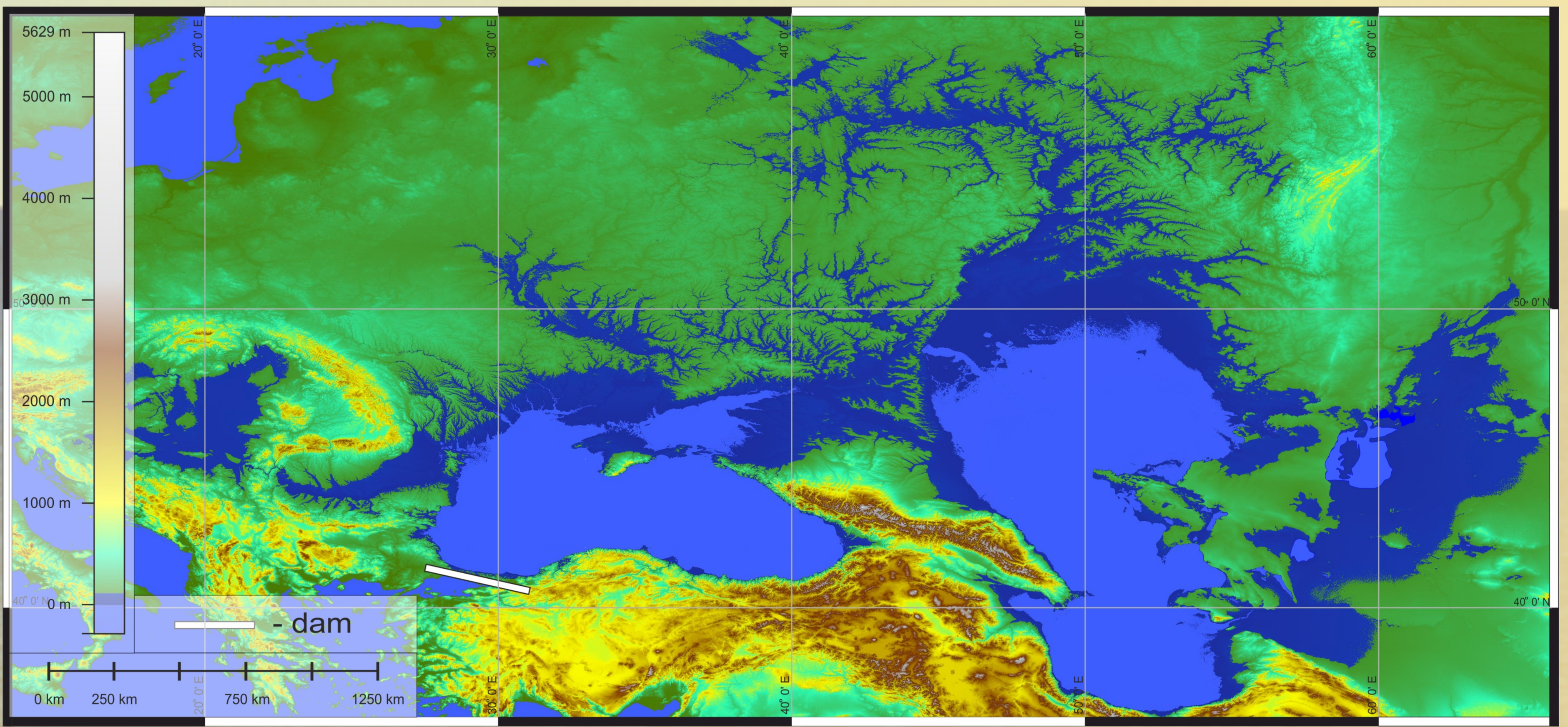


Figure 6. Sea-lake, which would have formed during the period of intensive glacial melting and blockage of the connection with the Sea of Marmara. The sea-lake level would rise 116 m. The shape of the coastline would resemble the coastline of the Sarmatian Sea-Lake (see Figure 2).

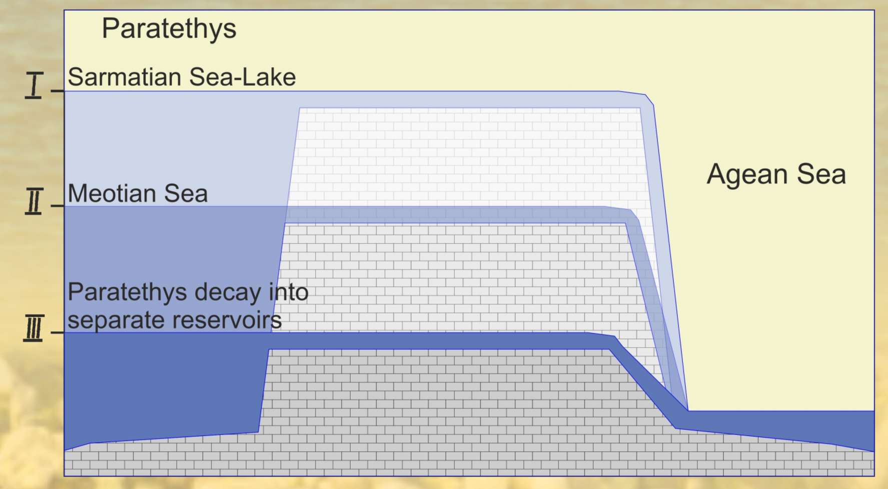


Figure 7. Scheme of the Paratethys Sea-Lake deepening under conditions of bridge erosion. In this scheme, three positions of the canyon bottom are shown crossing the mountain range between the Black and the Aegean seas. The erosion base level is a regressive level of the Aegean Sea.

## Conclusion

The paper by Yesin and Dimitriyev (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

1. Biju-Duval, B., Dercourt, J., and Le Pichon, X., 1977. From the Tethys Ocean to the Mediterranean seas: a plate tectonique model of the evolution of the Western Alpine system. In Biju-Duval, B. and Montadelt, L. (eds.), International Symposium on the Structural History of the Mediterranean Basins, Split, Yugoslavia, October 15-29, 1976. Editions Technip, Paris, pp. 143–164.
2. Chepalyga, A.L., 2005. Prototip vsemirnogo potopa [The prototype of the Flood]. Znanie-Sila [Knowledge is Power], 12: 85–91. (In Russian)
3. Esin, N.I., 2014. Dinamika urovnia Chornogo moria v poslednie 20 tysiach let [The dynamic of the Black Sea level during the last 20,000 years]. PhD thesis, P.P. Shirshov Institute of Oceanology, Russian Academy of Sciences, Moscow. http://www.ocean.ru/disser/index.php/dissertatsii/category/23-esin.html. (In Russian)
4. Esin, N.V., Yanko-Hombach, V., and Kukleva, O.N., 2010. Mathematical model of the Late Pleistocene and Holocene transgressions of the Black Sea. Quaternary International, 225(2): 180–190.
5. Khain, V.E., Popkov, V.I., and Yudin, V.V., 2009. Paleogeodinamika Chernomorsko-Kaspijskogo regiona [Paleogeodynamics of the Black Sea-Caspian region]. Geologicheskii vestnik Kubanskogo GU [Geological Vestnik of Kuban SU], 1: 4–13. (In Russian)
6. Nevesskaia, L.A., Paramonova, N.P., Ananova, E.N., Andreeva-Grigorovich, A.S., et al., 1986. Stratigrafija i korreljacija sarmatskikh i mjeoticheskikh otlozhenij juga SSSR [Stratigraphy and correlation of the Sarmatian and Meotian deposits in the southern USSR]. In Nevesskaja, L.A. (ed.). Saratov, Publishing House of Sarat. (In Russian)
7. Sysoev, D., 2014. Kratkaia istoriia Kaspiiskogo basseina [A Brief History of the Caspian Sea]. Internet resource: http://stepnoy-sledopyt.narod.ru/kaspian/istoria.htm 2014. (In Russian)
8. Yesin (Esin), N.V., and Dmitriyev, V.A., 1987. On the possible mechanism of formation of the Messinian evaporites in the Mediterranean Sea. International Geology Review, 29(3): 258–263.
9. Zubakov, V.A., 1990. Global'nye klimaticheskie sobytija neogena [Global Climate Events of the Neogene]. Gidrometeoizdat, Leningrad. (In Russian)

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