THE PROCESSES OF THE CASPIAN-MEDITERRANEAN CORRIDOR FORMATION AND THE PARATETHYS SEA-LAKE DEGRADATION

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It is known that about 14 million years ago, a division of the Tethys Ocean occurred into the Mediterranean Sea and the Sea-Lake of the Paratethys. During the next 10 million years, its water area decreased in size, the sea-lake became shallow, and eventually subdivided into the Azov, Black, and Caspian seas. The first stage of the Paratethys closure was the Sarmatian Sea-Lake (14.0-10.5 million years ago). The initial water was salty as in the ocean. Then, as a result of the large inflow of freshwater, there was a freshening of the sea water. During Meotian time (10.5-7.0 million years ago), the Mediterranean salt water got into the sea-lake. Then, there was water desalination in the Meotian Sea. During this entire period, the level of the sea-lake changed with a trend towards a decreasing level. Approximately 6-5 million years ago, in the Balakhanian stage (the beginning of the Pliocene), the sea-lake level decreased significantly, and it separated into the Black and Caspian seas.

Usually, researchers explain the evolution of the Paratethys and its subsequent seas by invoking vertical movements of the earth's crust, without presentation of a specific mechanism for the shallowing process. Elaboration of such a mechanism is quite difficult, because the area of a closed lake is determined by the ratio between the amount of water flowing into it and the coefficient of evaporation per unit area, i.e., climatic characteristics. Also, the size depends on vertical elevation (at the periphery of the lake) through which excess water discharge can take place. In the case of outflow configuration, the lake surface area depends on water discharge in the river flowing from the lake. Water discharge over the geologic time scale depends on the intensity of bottom erosion in the flowing river.

Tectonic movements of the earth's crust do not explain where the water disappeared from the Paratethys. Some researchers (e.g., Hain et al., 2009) believe that a part of the Paratethys water could have gone into the deep-sea basin of the Caspian Sea during its emergence. But the fact is that the freshwater always flowed into the Paratethys seas. Therefore, sometime later, the lake surface area should have been restored to its former size, if the climate had not changed.

According to current estimates (Dzhaoshvili, 2003; Esin, 2014), the parameters of the Black Sea freshwater balance at the present time are the following: river flow is 341 km^3/year; precipitation is 214 km^3/year; and evaporation is 330 km^3/year. The freshwater balance is 241 km^3/year. According to other data (Oguz et al., 2006; Zumbühl, 2010), the freshwater balance reaches the value of 300 km^3/year. The area of the Black Sea is 422,000 km^2. According to Biju-Duval et al. (1977), in the Sarmatian stage, the sea was separated from the Mediterranean by a barrier (bridge) in the form of a mountain. Calculations for modern values of the freshwater balance show that if this barrier would exist at the present time, then the level of the closed Black Sea-Lake would be at least 30 meters higher than at present. After rising 27 m, the water would begin to flow through the Manych depression from the Black Sea into the Caspian. Their total area would increase by about 308,000 km^2.

According to the research results of Popov et al. (2009), the glacioeustatic fluctuations in Global Sea level have continued for at least the last 20 million years. Therefore, the evolution of the Paratethys seas took place under conditions that included such fluctuations. According to current data (Chepalyga, 2005), the freshwater balance of the Black Sea increased about 5 times (relatively present) during the melting of the glaciers, and it could have reached values of 1570 km^3/year. The calculations have shown that in the case of such a balance value, the lake area would have been about 2,850,000 km^2. This area is

6 times larger than the area of the present Black Sea, and it is close to the area of the Sarmatian Sea-Lake. If we take the height of the barrier between the Black and Mediterranean seas as the top of a mountain (+150 m), and then raise the level of the Black Sea 150 meters, we get a reservoir very similar to the Sarmatian Sea-Lake based on the shape of its coastline (Figure 1).

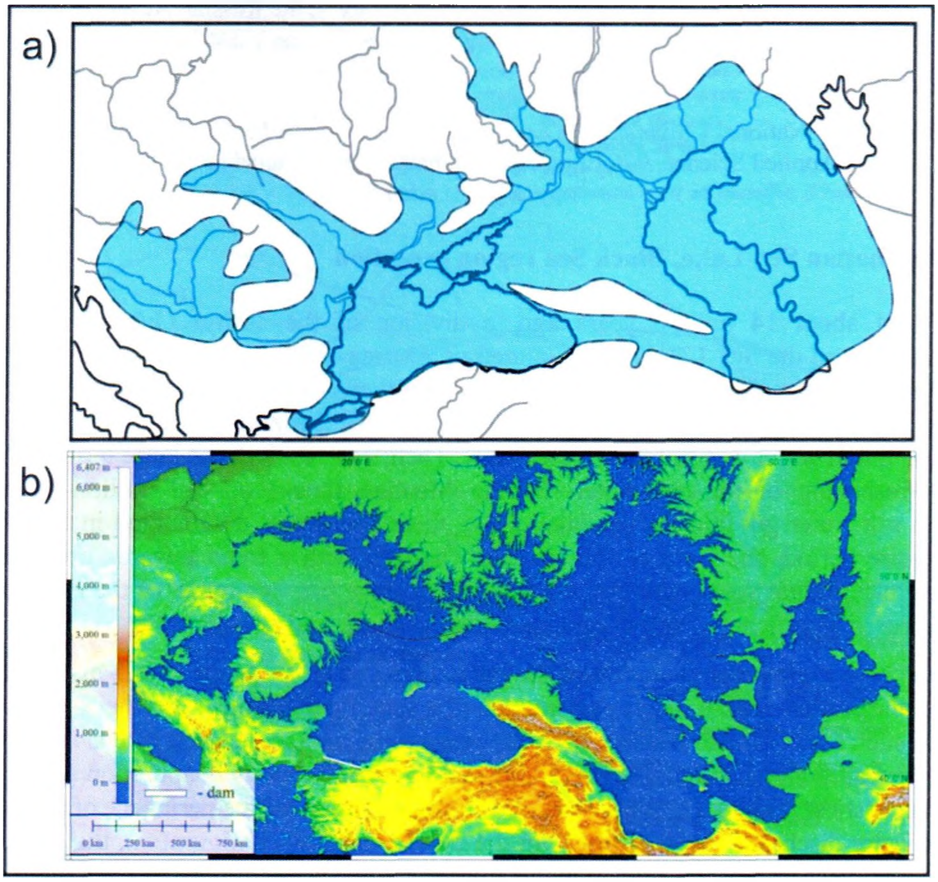

Figure 1. (a) – maximal configuration of the Sarmatian Sea-Lake shore according to results of geologic research (Nevesskaia et al., 1986); (b) – the configuration of the basin shoreline using the current topography if the water level were +150 m.

On the basis of these calculations, it can be determined which processes governed the evolution of the Paratethys seas. In the Sarmatian stage, freshwater came into the depression between the Black and Caspian seas and the basin level probably increased more than a hundred meters above the modern Black Sea level, reaching a saddle in the mountains that played the role of barrier. The rivers (or a river) were formed at this height and discharged excess water from the Sarmatian Sea-Lake into the Mediterranean Sea. This river eroded its bed and lowered the barrier between the seas. Therefore, during each subsequent melting of glaciers, the sea-lake level was lower than during the previous cycle of glacial melting.

The freshening of the sea-lake water continued until the period of the Messinian Salt Crisis of the Mediterranean Sea. We previously showed (Yesin (Esin) et al., 1986; 1987) in a model revealing the mechanism of the beginning of the Messinian Crisis and its completion that the periphery of the Mediterranean Sea could have dropped to 100 meters during the desiccation. When the Mediterranean Sea was being filled by ocean water, the connection between the Paratethys and Mediterranean Sea opened, and salty water with high salt concentration flowed into the sea-lake.

In the so-called Balakhanian stage, the barrier between the Black and Mediterranean seas was cut to the elevation of the level of the transgressive World Ocean. This allowed the excess water to drain from the shallow lake. The uplifting of the bottom between the Black and Caspian seas (due to a less pressure on the bottom by the Paratethys water) also contributed to this. So there was a division of the final

Paratethys into two seas.

After the Balakhanian stage, the connection between the Black and Mediterranean seas resumed. At first, the connection was one-sided: excess water flowed from the Black Sea into the Mediterranean Sea. River channels deepened, and in cases of high ocean level, straits formed that contained an upper flow into the Mediterranean Sea and a bottom counter-flow toward in the Black Sea. With the deepening of riverbeds, more Mediterranean water entered in the Black Sea. Therefore, salinity in the Black Sea increased after each ocean transgression. This pattern is evident throughout the Pleistocene.

In conclusion, we note that the project IGCP 610 is actually studying the final phase of the process of Paratethys Sea-Lake drainage channel system formation. Although the sea-lake is gone, there is still an excess of freshwater in the Black Sea, and because of this, there is probably still a process of ongoing erosion along the Bosphorus Strait bottom during periods of glacial maxima. It is interesting, also, to mention the following. Earlier—Yesin (Esin) et al. (1986; 1987)—we showed that the Gibraltar Strait occurred during the Messinian Crisis as a result of riverbed erosion (a river flowing into the Mediterranean Sea from the Atlantic Ocean). Taking into account the content of this report, it may be concluded that all three of the Mediterranean Straits (the Bosphorus, Dardanelles, and Gibraltar) are erosional in origin.

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