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Paleoenvironmental changes in the middle Miocene seas of Central Europe explained by gateway dynamics

Wout Krijgsman (1), Dan Palcu (1), Sergey Popov (2), Larisa Golovina (2), Dirk Simon (1), and Paul Meijer (1)

(1) Utrecht University, Earth Sciences, Utrecht, Netherlands (w.krijgsman@uu.nl), (2) Borissiak Paleontological Institute, Russian Academy of Sciences, Moscow, Russia

Changes in gateway configuration played a dominant role in the Middle Miocene paleogeographic evolution of the Paratethys Sea that covered Central Eurasia. Here, we focus on the connection between the Eastern Paratethys (EP), Central Paratethys (CP) and Mediterranean (MED) to understand the paleoenvironmental changes caused by the evolution of these marine gateways. We present an integrated magneto-biostratigraphic framework for the late Langhian-Serravallian (Tarkhanian-Chokrakian-Karaganian-Konkian-Volhynian) sedimentary record of the eastern domain, which allows a direct correlation to the well-dated successions west of the gateway in CP.

We identify and date four major phases on gateway functioning that are reflected in specific environmental changes. First, the base of the Tarkhanian at 14.85 Ma corresponds to an increase in marine connectivity with the Mediterranean during a short episode of rapid sea-level rise that triggered mixing and ended the widespread Maikop anoxia in the EP. The mixing episode was short-lived (∼100 kyr) as the sea-level rise slowed down and connectivity degraded because of tectonic uplift in the gateway area. Second, at the base of the Karaganian at 13.8 Ma, the EP turned into a lake-sea that supplied a unidirectional flow of low-salinity waters to the west, where the CP sea experienced its Badenian Salinity Crisis. This configuration is remarkably similar to the Mediterranean during its Messinian Salinity Crisis. The third phase is marked by a marine transgression from the west at 13.4 Ma, reinstalling open-marine conditions in the CP (upper Badenian) and causing marine incursions in the EP during the Konkian. Finally, the Sarmatian/Volhynian transition at 12.65 Ma is characterized by a new gateway configuration that allows exchange between CP and EP, creating unified conditions all over the Paratethys. We hypothesize that a density driven pumping mechanism in EP is triggered by the increase in connectivity, which simultaneously caused major paleoenvironmental changes at both sides of the gateway and led to the Badenian-Sarmatian extinction event in the CP.

Furthermore, we combine the conservation of water and salt mass with strait-exchange theory to quantitatively link freshwater surface forcing and gateway dimensions to the observed environments. Our model confirms that the proposed global sea-level drop of 50–70 m at 13.8 Ma could have restricted the western gateway to the Mediterranean to such an extent that halite formed in the CP. Subsequently, the progressive opening of the eastern gateway to the Black Sea led to a decrease in lake level, exposure of the shallow margins, and a reduced surface area in the EP. This entailed a reduction in water loss to the atmosphere, which, combined with constant river influx, resulted in a positive freshwater budget for the Paratethys proper, and reduced the salinity in the CP. This provides a novel physics-based explanation for the change from evaporitic to marine to brackish-marine water conditions in a marginal basin.