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Model study of the Mediterranean-Atlantic water exchange prior to the Messinian Salinity Crisis: An alternative to the "siphon theory"

Alba de la Vara, Robin Topper, Paul Meijer, and Rinus Wortel
Utrecht University, Faculty of Geosciences, Earth Science Dept, Utrecht, Netherlands (delavarafernandez@uu.nl)

During the Late Miocene the Mediterranean Sea and the Atlantic Ocean were connected by means of two marine passages - the Betic and Rifian corridors. The severe restriction of these corridors due to tectonic processes, in combination with glacio-eustatic sea-level fluctuations, resulted in the so-called Messinian Salinity Crisis. During this event thick sequences of evaporites were deposited in the Mediterranean Sea evidencing dramatic changes in the palaeoenvironmental conditions.

Although the present-day water exchange through the Strait of Gibraltar has been extensively studied, little is certain about the gateway dynamics leading up to the Messinian Salinity Crisis. Knowledge of the behavior of these corridors would be important to be able to link observations (e.g., sedimentary record, faunal or isotope studies) to the corresponding gateway geometries. The objective of this work is to gain physics-based understanding into the role of the interplay of the depth of the two gateways on the Atlantic-Mediterranean water exchange before the Salinity Crisis. To this end we use the regional ocean circulation model SbPOM, which is a parallel version of the Princeton Ocean Model, and Upper Tortonian palaeogeography. The experiments cover systematically various shoaling sequences ranging from relatively deep to closed corridors.

Our results do not support the classic "siphon theory" proposed by Benson et al. (1991) for a double gateway scenario prior to the Messinian Salinity Crisis. These authors suggest unidirectional flow from the Atlantic into the Mediterranean via the Rifian corridor and Mediterranean outflow through the Betic one. In contrast, we find that different flow configurations are possible depending on the depth of one corridor relative to the other. More specifically, when one corridor is shallower than approximately half the depth of the other one, there is one-way flow through the shallow corridor and two-way flow in the deep one. In contrast, when one gateway is deeper than this level, both corridors accommodate two-way flow. The particular strength of our results is that observational evidence for inflow or outflow in one corridor would automatically provide information about the corresponding dimensions of the other one.

Benson, R.H., Bied, K.R.-E., and Bonaduce, G., 1991. An important current reversal (influx) in the Rifian Corridor (Morocco) at the Tortonian-Messinian boundary: The end of Tethys Ocean. Paleoceanography 6, 164-192.