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Circulation and water properties of the Miocene Mediterranean Sea and Paratethys before and after closure of the Tethys Seaway: a regional ocean model study

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The Mediterranean Sea and Paratethys, forming the southern and northern domain of the central Tethys Ocean respectively, had gateways to both the Indian Ocean and the Atlantic Ocean during the Early Miocene (19 - 23 Ma). The eastern gateway to the Indian Ocean (known as "Tethys Seaway") underwent profound changes until its final closure in the Middle Miocene. This closure affected the temperature, salinity and sedimentary environment of the Mediterranean Sea and Paratethys. We present the first quantitative analysis of the general circulation and distribution of water properties in the Mediterranean and Paratethys prior to the closure and their changes upon closure. In a more general sense, our study addresses fundamental issues concerning the role of gateways, basin planform and bathymetry in the circulation of a semi-enclosed sea.

A 3-D ocean general circulation model, the Mediterranean version of the Modular Ocean Model Array (MOMA; Webb, Comput. Geosc. 22, 1996), has been applied to the Miocene paleogeography of the Mediterranean and Paratethys. The incorporated boundary conditions have been derived from a global coupled climate model experiment (von der Heydt and Dijkstra, Paleoceanography 21, 2006). While assessing the effect of the gateway to the Indian Ocean is the main aim of our analysis, we have also investigated the role of bathymetries in the Mediterranean and Paratethys. Moreover, we compiled geological data on the Paratethyan temperature during the Miocene. The temperatures computed by the model for either open or closed gateways to the Indian Ocean are compared with those estimated from the data to assess the role of gateways.

Our findings confirm that gateways play an important role in controlling the circulation and water properties of the basins. We have been able to identify the regions where the closure is likely to have had the most significant effects. The main conclusions of our model calculations are: (1) with open and deep gateways to the Indian Ocean, Paratethys and the Mediterranean Sea had westward surface flow and eastward deep flow, (2) the Indian Ocean controlled the water properties in the Mediterranean Sea and especially in Paratethys prior to closure, (3) restriction of the gateways to the Indian Ocean reversed the overturning circulation in Paratethys and the Mediterranean Sea, (4) closure resulted in cooling of the Paratethys (mainly the Eastern Paratethys) and (5) the change in salinity and temperature of the Mediterranean Sea and Paratethys in response to closure was not uniform throughout the basins.