Geophysical Research Abstracts, Vol. 9, 03451, 2007
SRef-ID: 1607-7962/gra/EGU2007-A-03451

Towards a box model of the circulation of the Mediterranean-Paratethyan system in the Miocene

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Closure of the connection between the Mediterranean Sea and the Indo-Pacific Ocean, during the Middle Miocene, had important effects on the water properties and circulation of the Mediterranean Sea and Paratethys.

We try to gain insight into this and other examples of tectonic control on the past circulation of the Mediterranean/Paratethys by means of modelling. Our first step is to apply so-called box models. Specifically, we use a 3-box model (4-box in the case of considering the Paratethys) to study the behaviour of (1) the exchange flow with the open oceans and (2) water properties, such as salinity, in the Mediterranean Sea and Paratethys. The three boxes represent the Atlantic Ocean, Mediterranean Sea, and Indo-Pacific ocean (in the case of 4 boxes Paratethys is considered also) and they exchange heat and salinity. Neglecting the effect of temperature, there will be a density-driven flow because of salinity differences between the boxes. Using the conservation of salinity and volume for the 3 boxes, leads us to an ordinary differential equation (system of ODE for 4 boxes) for the salinity of Mediterranean (and Paratethys). Since some information, for instance the flow rate between the Indo-Pacific and Mediterranean, salinity of Indo-Pacific and evaporation-precipitation of Mediterranean are not well-known, we treat these as variable parameters of the model. We aim at finding a domain of parameters in which the equation has a valid answer for the steady-state salinity.

For the 3-box model two different cases were considered: surface flow from Indo-Pacific to the Mediterranean Sea which means that Mediterranean is saltier than Indo-Pacific, and vice versa. Our results show that both cases are possible, but each case is valid in a different range of parameters. These ranges represent general possibilities

for the value of the flow rate, salinity, steady-state solution and other parameters which play an important role such as atmospheric forcing.