Geophysical Research Abstracts
Vol. 15, EGU2013-6165, 2013
EGU General Assembly 2013

Ocean circulation during the Middle Jurassic in the presence/absence of a circumglobal current system

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Pangea breakup started in the Early Jurassic by the formation of the Central Atlantic and its connection with the Neotethys. By the Middle Jurassic, rifting between North and South America may have opened a first marine proto-Caribbean passage. However, the oldest known proto-Caribbean ocean crust is only of early Late Jurassic age.

Based on earlier plate tectonic reconstructions featuring a wide open proto-Caribbean seaway, the existence of a circumglobal equatorial current system has been suggested by many authors as a possible physical mechanism for increasing the poleward ocean heat transport, and hence, producing the reduced meridional temperature gradient documented for the Middle Jurassic. Models with increased atmospheric pCO_2, estimated to be between 1 and 7 times pre-industrial values in the Jurassic, generate elevated temperatures both in the tropics and in polar regions, but do not reduce the meridional gradient. A different mechanism needs to be considered in order to reproduce such reduced meridional temperature gradient. A possibility is enhanced poleward heat transport through the ocean. However, this hypothesis has been questioned by Late Jurassic simulations with a specified, reduced meridional gradient, which showed that the required ocean heat transport is much smaller than in present-day simulations.

We investigate the critical role of a Tethyan–Atlantic–proto-Caribbean passage with respect to the Middle Jurassic ocean circulation by means of coupled ocean/sea-ice numerical models based on detailed plate reconstructions of the oceanic realms. We perform numerical experiments with an open/closed western boundary of the proto-Caribbean basin and we discuss the water properties, the gyre transport and the overturning meridional circulation for these different bathymetric configurations. For an open western boundary, we find a trans-Pangean circumglobal current of the order of 1 Sv, that flows in the upper 300 m along the northern margin of the Central Atlantic and proto-Caribbean basins. We discuss the consequences of such a modest current on the global ocean circulation and on water stratification/low upwelling rates in the Central Atlantic. We compare the predicted effects with a revised analysis of Middle Jurassic oceanic sedimentary records from the proto-Caribbean and the Central Atlantic.