Geophysical Research Abstracts
Vol. 12, EGU2010-5476, 2010
EGU General Assembly 2010

A regional ocean circulation model for the mid-Cretaceous proto-North Atlantic Basin: implications for black shale formation

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In the Mesozoic, high amounts of organic matter accumulated in marine sediments during Oceanic Anoxic Events (OAEs). OAEs are stratigraphic intervals defined by δ^{13}C excursions, which are thought to be the result of perturbations in the global carbon cycle. Whether the local lithological expression of an OAE is organic-rich or not, depends on palaeogeography and local climate.

Model studies of these events invariably make use of global ocean circulation models. In this study, however, a regional model for the proto-North Atlantic Basin at the Cenomanian-Turonian boundary is developed and tested. Advantages of a regional model over a global model are a higher resolution (0.5° x 0.5 °) and shorter model run times allowing for more sensitivity experiments. A version of MOMA was adapted for application to the mid-Cretaceous proto-North Atlantic Basin. Surface boundary conditions (virtual salt flux and heat flux) are extracted from the results of a recent global Cenomanian CCSM3 run. The bathymetry represents the proto-North Atlantic Basin at ca. 90 Ma and is constructed from the oceanic lithosphere reconstruction from *Müller et al.* (Science, 319, 1357-1362, 2008) and the bathymetry from *Sewall et al.* (Clim. Past, 3, 647-657, 2007). A first-order check of the results is performed by comparison with the results from the global Cenomanian CCSM3 run. The regional model proves to be able to maintain tracer patterns and produce velocity patterns similar to the global model.

In order to test the hypothesis that ocean circulation may be behind the deposition of black shales during OAEs, the regional model was used to examine changes in the proto-North Atlantic circulation for three different sets of boundary conditions, which are interpreted as representing scenarios for pre-OAE, OAE and post-OAE time envelopes. The pre-OAE scenario has a 150 metre lower sea level with respect to the OAE scenario which results in a decrease in continental shelf area, influencing both deep water formation and upwelling along the coasts. In the post-OAE scenario a deep water connection with the South Atlantic Ocean is implemented and it results in a change in the source for proto-North Atlantic intermediate water and hence in the source for water which replenishes upwelling along the South American and African coast. We will discuss (changes in) the circulation and upwelling patterns and (anticipated) nutrient supply for all three scenarios to predict whether and where the conditions in the proto-North Atlantic were favourable for black shale formation during each of these time envelopes.