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Exploring the feedbacks between Cretaceous ocean circulation, oceanic redox dynamics and sediment diagenesis

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The Mid-Cretaceous oceanic anoxic events (OAEs) are witnesses of major perturbations of the Earth climate, which resulted from important changes in structure of the ocean-atmosphere system and its biogeochemical functioning. They are globally well documented by the ubiquitous presence of organic carbon-rich black shale layers. However, the exact nature and functioning of the palaeo-environment that fostered the massive and almost ubiquitous deposition of organic carbon-rich sediments is still a matter of debate. Numerous outstanding questions remain, not only concerning the dependence of black shale deposition on ocean circulation and redox zonation, but also its influence on the global ocean-atmosphere system.

A new version of the coupled Earth system model GEOCLIM, which combines a climate model (FOAM 3-D GCM) with a vertically resolved diffusion-advection box model of the global ocean, a pelagic biogeochemical model and a fully formulated diagenetic model (BNRS) is used to examine the feedbacks between paleocirculation, ocean redox dynamics, sediment diagenesis and global climate. Different scenarios are designed to assess the influence of the global circulation on the biogeochemical functioning of the ocean during a mid-Cretaceous OAE. Simulation results illustrate the strong feedbacks between Cretaceous ocean circulation, oceanic geochemical dynamics, bioproductivity and sediment diagenesis. A weakening of the deep ocean ventilation increases the importance of diagenetic processes on the geochemical characteristics of the ocean. Ocean anoxia/euxinia can easily develop if the sedimentary nutrient recycling is high enough to sustain enhanced primary production. Thus, the earth system model provides a rational support for a detailed quantitative understanding of the ocean's biogeochemical response to potential circulation changes during a mid-Cretaceous OAE.