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Late Cretaceous oceanic circulation changes revealed by simulations of Cenomanian and Maastrichtian climates

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The warm Late Cretaceous period experienced a long-term cooling, from the climatic optimum of the mid Cretaceous (Late Albian-Turonian) to the cooler latest Cretaceous interval (Campanian-Maastrichtian) (Huber et al., 1995; Clarke and Jenkyns, 1999; Pucéat et al., 2003). Both tectonic changes and climatic deterioration are likely to have resulted in changes of the oceanic circulation during the Late Cretaceous, as it has been suggested both by the distribution of inoceramids in the oceans (ex. MacLeod et al., 2000) and by geochemical data (ε_{Nd}, Pucéat et al., 2005; δ^{18}O and δ^{13}C of benthic foraminifera, Frank and Arthur, 1999). The aim of our study is to explore the changes in oceanic circulation related to tectonic and CO_2 changes during the climatic deterioration of the Late Cretaceous. We simulate the climate of the Cenomanian and of the Maastrichtian using a model of intermediate complexity coupled with a carbon cycle model (GEOCLIM) which allows to compute directly the climate and the pCO_2 consistently for the mid and latest Cretaceous. The atmospheric CO_2 simulated by GEOCLIM is lower by 25% in the Maastrichtian experiment than in the Cenomanian experiment, due to an increase in land area inducing a stronger chemical weathering. The simulations show important changes in oceanic circulation between the Cenomanian and Maastrichtian which result in a marked decrease of deep water temperature in the different oceans, in agreement with δ^{18}O data from benthic foraminifera (Huber et al., 2002). Our results therefore support changes in the predominant mode of ocean circulation as an explanation for the cooling of the Tethyan and South Atlantic deep waters during Late Cretaceous. The simulated oceanic circulation changes are triggered by changes in freshwater fluxes linked to the continental drift occurring during

this period. Interestingly our work shows the development of deep water production in the North Pacific in the Maastrichtian, which does not exist in the Cenomanian simulations, in agreement with ε_{Nd} data (Pucéat et al., 2005). Sensibility experiments on the effect of the presence or absence of a circum-global current at low latitudes (whose existence is discussed for the Cretaceous period; Föllmi and Delamette, 1991; Cousin-Rittemar et al., 2002) have been carried out. These experiments reveal that the presence of such a current results in 1) disappearance of the convection cell in the south Atlantic and Tethys; 2) enhanced convection in the Pacific; 3) increased deep water temperatures.

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