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The sedimentary carbon sink as a climate regulator: Towards a better description of organic matter degradation dynamics in Cretaceous black shales

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Cretaceous sediments are characterized by sequences of organic carbon-rich black shales, repeatedly deposited on a basin-wide or even global scale. However, the mechanisms that triggered the enhanced organic matter burial in the Cretaceous ocean remain ellussive. In particular, a detailed understanding and quantification of organic matter degradation in Cretaceous black shales and its effect on the ocean-atmosphere system is still missing. Yet, such an understanding is indispensable for a better assessment of Cretaceous climate change.
Here, a reaction-transport model was used to infer the long-term evolution of anaerobic organic matter degradation in Cretaceous black shales from the distribution of authigenic barite in sediments drilled at Demerara Rise (ODPLeg207, Site1258). Fully transient simulations were performed over a period of 100 Myrs. The inversely determined parameters reveal that the reactivity of the organic matter was already low at the time of its deposition in the Cretaceous, implying a high preservation efficiency of organic matter (between 79% and 89%) within the black shale layers. Geochemical characteristics of the drilled sediments, as well as the presence of specific biomarkers, suggest that this low reactivity is most likely the consequence of the euxinic palaeo-conditions favoring the sulfurization of the organic matter. These findings reveal that the extreme environmental conditions that prevailed in the Cretaceous greenhouse increased the importance of factors that favor organic matter preservation. Consequently, the functioning of the Cretaceous sedimentary carbon sink and its effect on the Cretaceous climate system may not be well-described by the existing organic carbon degradation models. Therefore, the results emphasize the need for a generic and mechanstic model that unambiguously relates the fate of organic matter to factors such as the type and composition of the depositional environment, the microbial community structure and the bioenergetic constraints that govern the consumption of organic compounds. In an attempt to address these issues, we are proposing an organic matter degradation model that scales the rates of organic matter degradation to the chemical potentials of organic compounds in situ. Within this formulation, the type of organic matter deposited can be specified along with the environmental conditions (temperature, pressure, types and concentrations of electron acceptors) that this organic matter is exposed to in order to quantify the fate of organic matter deposition in any marine environment.