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Simulating the onset and spread of anoxic conditions during Cretaceous OAE2

Klaus Wallmann (1), S. Floegel (1), C. Poulsen (2), S. Voigt (3), and W. Kuhnt (4)

(1) IFM-GEOMAR, Kiel, Germany, (2) Michigan University, USA, (3) Frankfurt University, Gemany, (4) Kiel University, Germany

A new model of the global atmosphere-ocean-continent-mantle system was set-up to investigate the triggering of the Oceanic Anoxic Event OAE2 through volcanic degassing processes at large igneous provinces (LIPs). The model simulates the changes in oceanic dissolved oxygen, phosphate, and carbon and the evolution of atmospheric pCO2 values under mid-Cretaceous boundary conditions. It considers the effects of pCO2 on element ratios in marine plankton (C : P) and includes new parameterizations for phosphorus and carbon burial at the seafloor based on modern observations. Independent isotopic and chemical time-series of ocean and atmosphere change over OAE2 are applied to evaluate the model results.

The model results support the hypothesis that OAE2 was triggered by massive CO2 emissions at LIPs. According to the model, the phosphorus weathering flux into the ocean and the C : P ratio in marine plankton were enhanced by the rise in surface temperature and atmosphere pCO2 caused by mantle degassing. Marine export production and oxygen consumption in intermediate and deep water masses increased in response to the expansion of the dissolved phosphate inventory of the ocean and the change in plankton element ratios. The spread of anoxic conditions in bottom waters -induced by enhanced carbon export and respiration- was further amplified by the oxygen-dependent burial of phosphorus in marine sediments in a positive feedback loop. The modeling implies that enhanced CO2 emissions favor the spread of low-oxygen conditions also in modern oceans.