SFB 754 | Ocean Deoxygenation: Drivers and Consequences · Past · Present · Future ·

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About the beginning and end of OAEs: A story of biogeochemical feedbacks and organic matter burial

Despite more than 40 years of research on oceanic anoxic events (OAEs), the specific mechanisms that initiated, maintained and terminated widespread ocean anoxia (and euxinia) are still disputed. One way to explain these extreme conditions is via increased oxygen demand in the water column resulting from enhanced productivity, itself fueled by increased nutrient availability for instance from the sediments as the burial efficiency of phosphorus declines when bottom waters become anoxic. Also for the recovery from OAEs the sediments may play a dominant role, here via globally increased organic matter (OM) burial, as it removes CO2 from the ocean/atmosphere system and drives oxygen accumulation in surface waters, eventually leading to the reoxygenation of the deeper ocean and a shut-down of the positive feedback of anoxia, P-regeneration and productivity. Although diagenetic processes and OM burial are considered of pivotal significance for OAEs the role they play has yet to be quantified using an explicit OM diagenesis model. The major hurdle is the high computational cost of simulating the essential redox reactions in marine sediments, which are critical to quantify the burial of OM and benthic recycling fluxes. In order to close this knowledge gap, we developed a mechanistic analytical early diagenetic model resolving OM cycling (OMEN- SED) and coupled it to a 3D Earth system model (cGENIE). Using this new model we investigate feedbacks between water column anoxia/euxinia and enhanced OM preservation using OAE2 as a case study.

Our results imply that feedbacks between carbon, oxygen, phosphorus and sulfur cycles in the ocean-sediment system lead to significantly enhanced OM preservation during OAE2 compared to background Cretaceous values. In addition, we show that the coupled model can reproduce geographical patterns of OM-rich black shales as observed in the geological record. Model simulations further illustrate that anoxia/euxinia develops from oxygen minimum zones in the photic zone and at the seafloor. Simulated sediment-water interface fluxes show enhanced P- regeneration from the sediments in response to seafloor anoxia which could further intensify marine productivity.

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