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Redox-controlled carbon and phosphorus burial: A mechanism for enhanced organic carbon sequestration during the PETM

NEMANJA KOMAR*[1] AND RICHARD ZEEBE[1]

[1] Department of Oceanography, University of Hawaii, Honolulu, Hawaii, USA;
(*komar@hawaii.edu, zeebe@hawaii.edu)

Geological records reveal a major perturbation in carbon cycling during the Paleocene-Eocene Thermal Maximum (PETM, ~56 Ma), marked by global warming of more than 5°C and a prominent negative carbon isotope excursion of at least 2.5‰ within the marine realm. The entire event lasted about 200,000 years and was associated with a massive release of light carbon into the ocean-atmosphere system over several thousands of years. In this presentation I will focus on the terminal stage of the PETM, during which the ocean-atmosphere system rapidly recovered from the carbon cycle perturbation. We employ a carbon-cycle box model to examine the feedbacks between surface ocean biological production, carbon, oxygen, phosphorus, and carbonate chemistry during massive CO_2 release events, such as the PETM. The model results indicate that the redox-controlled carbon-phosphorus feedback is capable of producing enhanced organic carbon sequestration during large carbon emission events. The locale of carbon oxidation (ocean vs. atmosphere) does not affect the amount of carbon sequestered. However, even though the model produces trends consistent with oxygen, excess accumulation rates of organic carbon (~1700 Pg C during the recovery stage), export production and $\delta^{13}C$ data, it fails to reproduce the magnitude of change of sediment carbonate content and the CCD deepening during the recovery stage. The CCD and sediment carbonate content overshoot during the recovery stage is muted by a predicted increase in $CaCO_3$ rain. Nonetheless, there are indications that the $CaCO_3$ export remained relatively constant during the PETM. If this was indeed true, then an initial pulse of 3,000 Pg C followed by an additional, slow leak of 2,500 Pg C could have triggered an accelerated nutrient supply to the surface ocean instigating enhanced organic carbon export, consequently increasing organic carbon sequestration, resulting in an accelerated restoration of ocean-atmosphere biogeochemistry during the termination phase of the PETM.