Geophysical Research Abstracts
Vol. 18, EGU2016-5112-1, 2016
EGU General Assembly 2016

Calcium and calcium isotope changes during carbon cycle perturbations at the end-Permian

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Negative carbon and calcium isotope excursions, as well as climate shifts, took place during the most severe mass extinction event in Earth's history, the end-Permian (∼252 Ma). Investigating the connection between carbon and calcium cycles during transient carbon cycle perturbation events, such as the end-Permian, may help resolve the intricacies between the coupled calcium-carbon cycles, as well as provide a tool for constraining the causes of mass extinction. Here, we identify the deficiencies of a simplified calcium model employed in several previous studies and we demonstrate the importance of a fully coupled carbon-cycle model when investigating the dynamics of carbon and calcium cycling. Simulations with a modified version of the LOSCAR model, which includes a fully coupled carbon-calcium cycle, indicate that increased weathering rates and ocean acidification (potentially caused by Siberian Trap volcanism) are not capable of producing trends observed in the record, as previously claimed. Our model results suggest that combined effects of carbon input via Siberian Trap volcanism (12,000 Pg C), the cessation of biological carbon export, and variable calcium isotope fractionation (due to a change in the seawater carbonate ion concentration) represents a more plausible scenario. This scenario successfully reconciles δ^{13}C and δ^{44}Ca trends observed in the sediment record, as well as the proposed warming of $>6^{o}$C.