Strangelove Ocean and Deposition of Unusual Shallow-Water Carbonates After the End-Permian Mass Extinction.

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The severe mass extinction of marine and terrestrial organisms at the end of the Permian Period (~251 Ma) was accompanied by a rapid negative excursion of ~3 to 4 per mil in the carbon-isotope ratio of the global surface oceans and atmosphere that persisted for some 500,000 into the Early Triassic. Simulations with an ocean-atmosphere/carbon-cycle model suggest that the isotope excursion can be explained by collapse of ocean primary productivity (a Strangelove Ocean) and changes in the delivery and cycling of carbon in the ocean and on land. Model results also suggest that perturbations of the global carbon cycle resulting from the extinctions led to short-term fluctuations in atmospheric pCO_2 and ocean carbonate deposition, and to a long-term (>1 Ma) decrease in sedimentary burial of organic carbon in the Triassic (Figs. 1 and 2).

Deposition of calcium carbonate is a major sink of river-derived ocean alkalinity and for CO_2 from the ocean/atmosphere system. The end of the Permian was marked by extinction of most calcium carbonate secreting organisms. Therefore, the reduction of carbonate accumulation made the oceans vulnerable to a build-up of alkalinity and related fluctuations in atmospheric CO_2. Our model results suggest that an increase in ocean carbonate-ion concentration should cause increased carbonate accumulation rates in shallow-water settings. After the end-Permian extinctions, early Triassic shallow-water sediments show an abundance of abiogenic and microbial carbonates that removed $CaCO_3$ from the ocean and may have prevented a full "ocean-alkalinity crisis" from developing.

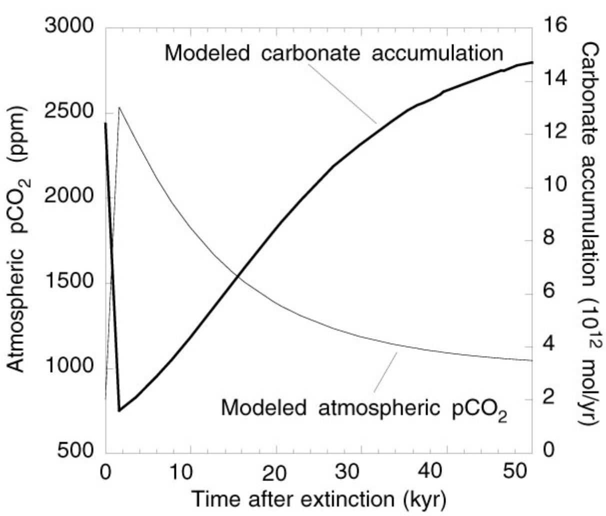

Figure 1: Results of model simulation for shallow-water carbonate accumulation rates (mol/year) and atmospheric pCO_2 (ppm) for the first 50,000 years after a sudden ocean productivity collapse.

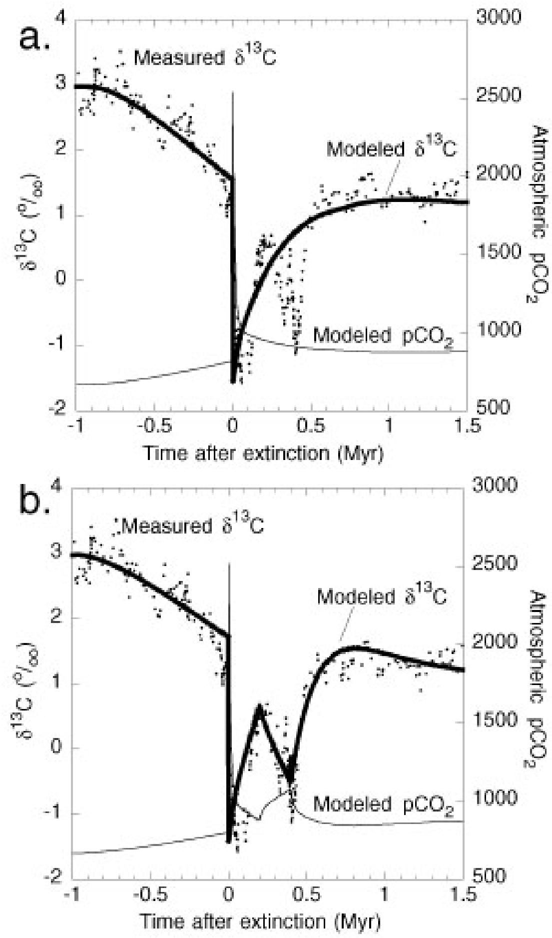

Figure 2. A: Results of model simulation for delta^{13}C of ocean-surface waters compared with data from the GK-1 core from the Carnic Alps, Austria (black dots). In this case, the second delta ^{13}C shift at ~300 ka after the extinction event is interpreted as a local signal. B: Results of model simulation considering that the delta^{13}C shift at of ocean-surface waters ~300 ka after the extinction event represents a global signal. This run includes partial recovery of productivity followed by a second collapse, and a reduction in the rate of burial of organic carbon. The long-term shift in model surface-water delta^{13}C from late Permian to Early Triassic was simulated by a 15% decrease in organic carbon burial. Also plotted is the predicted perturbation of atmospheric pCO_2 calculated by the model.