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Calcium Isotope Constraints on Global Carbon Cycle Dynamics during the End-Permian Mass Extinction

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Numerous lines of evidence indicate substantial perturbations to the global biogeochemical cycling of several important elements (C, S, N) during and after the end-Permian mass extinction, ca. 252 Ma. One of the best-documented changes is a large negative shift in the $\delta^{13}C$ of carbonate rocks and organic matter. The negative shift in $\delta^{13}C$ is commonly interpreted to reflect the rapid addition of ^{13}C-depleted carbon into the oceans and atmosphere, but the isotope composition and quantity of carbon released cannot be uniquely constrained by the carbon isotope data alone. Because the geological cycles of carbon and calcium are strongly coupled by shared sources and sinks (carbonate rocks), isotopic constraints on the geological cycling of calcium can further constrain interpretations of global carbon cycle dynamics beyond what can be gleaned from the carbon isotope record alone. Here we use $\delta^{44/40}Ca$ data from carbonate rocks from south China and Turkey, as well as $\delta^{44/40}Ca$ data from conodont microfossils from the global stratotype section and point (GSSP) for the Permian-Triassic boundary at Meishan, China to constrain the amount and isotopic composition of carbon released at the time of the end-Permian mass extinction. $\delta^{44/40}Ca$ constraints on carbon cycle dynamics suggest as much as 50,000 GT of carbon were released over an interval radiometrically constrained to span less than 200 ky. They further imply that the average isotope composition of this carbon was heavier than -25‰, suggesting biogenic methane could not have been the sole source of this carbon. Regardless of the precise source, the implied rate and magnitude of carbon release would have caused an episode of ocean acidification. These findings, coupled with petrographic and paleobiological data, suggest an important role for acidification as an end-Permian kill mechanism.

Key words: Permian, Triassic, mass extinction, carbon cycle, calcium, volcanism, acidification

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