Goldschmidt 2026 Abstract
https://doi.org/10.46427/gold2026.38201

Spatial controls on marine sedimentary carbonate preservation across the PETM

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Export and burial of carbonate in marine sediments regulates the Earth system response to massive CO_2 injection. A well known example of this feedback is the Paleocene-Eocene Thermal Maximum (PETM, ~56 Ma), which records major dissolution of carbonate in marine sediments, consistent with the rapid release of carbon to the atmosphere and ocean. During the PETM recovery, deep-sea sites also record an increase in carbonate preservation, consistent with an alkalinity overshoot driven ostensibly by silicate weathering. Theoretically, both the extent of dissolution and the magnitude of the overshoot should scale with the magnitude of atmospheric carbon release. However, a combination of local environmental factors influence carbonate preservation, including both (1) changes in photic zone export and depositional rain of carbonate and organic matter from the overlying water column, and (2) controls on deep ocean water and pore fluid chemistries. Local factors generate spatial variations that can impede the use of changes in sedimentary carbonate as a constraint on the global forcing.

Here we assess spatial controls on carbonate preservation across the PETM using a combination of modeling and geochemical approaches. We employ geochemical analyses of selective chemical extractions of bulk marine sediments along with Earth system modeling (cGENIE) and reactive transport modeling to interpret the factors that govern the spatial variability in carbonate preservation across the PETM and subsequent ocean alkalinity overshoot. We compare carbonate geochemistry, carbon isotopic composition, and calcium isotopic composition in marine records from globally distributed locations to modeled environmental parameters (e.g., carbonate saturation state, dissolved oxygen). In doing so, we demonstrate that changes in modeled ocean circulation are an important control on the spatial heterogeneity experienced by deep ocean saturation state and carbonate accumulation across the PETM. Our findings contribute to an understanding of how changes in marine carbonate preservation relate to carbon cycle forcing and recovery mechanisms, during the PETM and similar events.