New observational constraints on seawater carbonate chemistry during the PETM: Implications for Carbon Fluxes

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A wealth of diverse geologic evidence suggests that ~56 million years ago, the geologically rapid release of thousands of PgC into the ocean/atmosphere caused a transient, extreme episode of global warming often referred to as the Paleocene-Eocene Thermal Maximum (PETM). Recently, novel geochemical and lithologic observations have been discovered that shed new light on the response of seawater carbonate chemistry to massive carbon addition on both short and long timescales. Measurements of Boron isotopes and B/Ca of planktonic foraminifera from Pacific and Atlantic deep sea cores reveal abrupt anomalies consistent with a pH reduction of about ~0.3 pH units. This represents the short-term (hundreds to tens of thousands of years) ocean acidification response as CO_2 dissolves into seawater, and the magnitude of this response places constraints on the amount and rate of initial carbon addition. Additionally, recent IODP drilling at abyssal Site U1403 (Expedition 342) recovered a carbonate-rich unit dating from the PETM recovery interval at a depth where previously only clay had been deposited. This onset of carbonate sedimentation represents a long-hypothesized overshoot of the carbonate compensation depth (CCD): a long-term (hundreds of thousands of years) period of carbonate oversaturation (relative to pre-event levels) resulting from the geologically slow negative feedbacks of silicate weathering and possibly organic carbon burial or other carbon removal processes, not unlike the cap carbonates deposited in the aftermath of snowball earth. The relative timing and scale of changes represented by these records provide an important means of testing proposed mechanisms for the PETM and constraining model simulations. Here, we use a global carbon cycle model (LOSCAR) to explore the compatibility of different initial configurations, carbon release scenarios (rate and duration), and recovery mechanisms with these new observations as well as previously documented constraints such as the global CCD shoal and carbon isotope excursion.