Excitations of Earth's Carbon Cycle

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The great environmental disruptions of the geologic past remain enigmatic. Each results in a temporary change in the oceans' store of carbon that is expressed as changes in the carbon isotopic composition of sediments. Although the causes remain controversial, these changes are typically interpreted as a proportionate response to an external input of carbon. This talk suggests instead that the magnitude of many disruptions is determined not by the strength of external stressors but rather the carbon cycle's intrinsic dynamics. Theory and observations indicate that disruptions with a characteristic magnitude and timescale are excited by carbon fluxes into the oceans that exceed a threshold. Mass extinction events are associated with influxes well above threshold. The threshold depends on the duration of the influx. If the duration exceeds the timescale at which the oceans homeostatically adjust their pH (about 10,000 yr in the modern carbon cycle), the threshold flux is constant; for shorter durations τ the threshold scales like $1/\tau$. Consequently the unusually strong but geologically brief duration of modern anthropogenic oceanic CO2 uptake is roughly equivalent, in terms of its potential to excite a major disruption, to relatively weak but longer-lived perturbations associated with massive volcanism in the geologic past.