Upper limits on oceanic anoxia during the PETM: a uranium isotope perspective

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The Paleocene Eocene Thermal Maximum (PETM) is one of the best studied climate perturbation events in Earth history, although the driving mechanisms and recovery processes remain under constrained. The PETM is characterized by the rapid input of isotopically light carbon, probably representing a mixture of carbon from large igneous provinces (LIPs) and oxidized organic C reservoirs [1,2]. This resulted in warming of ~5°C associated with rapid environmental deterioration including ocean acidification [3] and oceanic anoxia [e.g. 4,5]

There is increasing recognition that oceanic anoxia is a defining characteristic of LIP activity throughout Earth history, and important for future warming scenarios. Although local indicators of de-oxygenation are prevalent for the PETM, the total extent is poorly constrained on a global scale, making it difficult to meaningfully compare the PETM to the Mesozoic Oceanic Anoxic Events (OAEs) or larger mass extinctions.

To overcome this limitation, we present new carbonate associated uranium isotope data ($\delta^{238}U$) from three pelagic localities. The new $\delta^{238}U$ data are used together with published $\delta^{13}C$ records [2] as targets for an established C-P-U biogeochemical model [6] which together indicate a maximum 10-fold increase in the area of benthic anoxia during the PETM. We suggest that <2% of global seafloor area was covered by anoxic waters which provides an important empirical constraint for Earth system studies to understand benthic faunal responses and biogeochemical feedback processes.

[1] Zeebe et al., 2015 Nat. Geoscience; [2] Gutjahr et al., 2017 Nature; [3] Zachos et al., 2005 Science; [4] Zhou et al., 2016 Paleoceanography; [5] Dickon et al., 2014 Paleoceanography; [6] Clarkson et al., 2018 PNAS