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Authigenic carbonate formation during the PETM: A mechanism for removal of atmospheric CO_2?

Jack Longman (1,2), Thomas M. Gernon (2), and Martin R. Palmer (2)

(1) University of Oxford, Oxford University Centre for the Environment, Oxford, United Kingdom (jack.longman@ouce.ox.ac.uk), (2) School of Ocean and Earth Sciences, University of Southampton, Southampton SO14 3ZH, UK

The Paleocene-Eocene Thermal Maximum (PETM) is one of the best analogues for current anthropogenic climate change. Understanding the underlying processes therefore may yield information about a rapidly warming world. However, the mechanisms by which it ended are uncertain, despite the importance of understanding how the Earth system may recover after extreme hyperthermals. The onset of the PETM has been attributed to magmatism associated with the emplacement of the North Atlantic Igneous Province (NAIP). Here we provide new data from Paleocene-Eocene age volcanic ash layers, which contain abundant calcium carbonate, formed via authigenic precipitation and presumably the anaerobic oxidation of methane. This process is known to consume carbon, and sequesters it into stable carbonate phases, providing a potentially important but hitherto unconsidered sink in the marine carbon cycle. We use Monte Carlo simulations to estimate that the tephra sink is likely to sequester a substantial amount of carbon, with an average modelled value of 735Pg removed during the early diagenesis (the first few thousand years following deposition) of the ash. This value represents roughly a third of the carbon sequestration necessary to return the Earth system to a normal configuration at the end of the PETM. Given the substantial volcanism in the NAIP, authigenic carbonate formation in volcanic ash could be a major mechanism for carbon removal in the terminal phases of the PETM. Our results suggest that this mechanism could occur due to anoxia related to ash deposition in organic-rich sediment. This process may have played a considerable role during other periods of Earth history.