Between a rock and a hard place: The history of Palaeocene ocean pH

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Lying between the charismatic carbonate system perturbations at the Palaeocene-Eocene Thermal Maximum and the K-Pg boundary, the carbon-climate system of the Palaeocene epoch remains relatively understudied. Yet Palaeocene marine sediments record a number of short- and long-term carbonate system changes that, through their study, may allow us to better understand the evolution of the Earth's carbonate system. Evidence to date suggests the climate cooled and CO_2 levels dropped in the early Palaeocene [1] before a progressive warming towards the greenhouse climates observed prior to the PETM [2]. The most extreme estimates of CO_2 during this interval from leaf stomatal indices would imply suprisingly low atmospheric pCO_2 comparable to those observed after Antarctic glaciation [3], despite boron isotope measurements suggesting very low ocean pH at this time [4]. Besides this, the Palaeocene spanned one of the most dramatic shifts in deep ocean $\delta^{13}C$ of the Caenozoic [2], several transient carbonate system re-organisations [5] and marine lysocline fluctuations [6] that remain poorly understood.

Here we present a new record of surface ocean pH across this crucial interval in Earth history, as recorded in planktic foraminiferal $\delta^{11}B$. These MC-ICPMS-derived boron isotope measurements extend high-resolution records of ocean pH back a further 10 million years in geological time, and provide the basis for new estimates of atmospheric pCO_2 during the Palaeocene. In doing so, they provide new insights into the long-term effects of bolide impacts, the evolution of greenhouse climate states, and the baseline for later hyperthermal events in the Palaeogene.

[1] Hollander *et al*. (1993) *Palaeo.*[3] **104**, 229-237. [2] Zachos *et al*. (2001) *Science* **292**, 686-693. [3] Beerling & Royer (2011) *Nature Geosci*. **4**, 418-420. [4] Pearson and Palmer (2000) *Nature* **406**, 695-699. [5] Coccioni *et al*. (2012) *Terra Nova* **24**,380-386. [6] Hancock and Dickens (2006) *Proc. ODP, Sci. Results* **198**, 1-24.