Investigating long- and short-term trends in seawater boron-based proxies during the Late Paleocene and Early Eocene

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Stable boron isotope ($\delta^{11}B$) and boron concentration (B/Ca) proxies in planktic foraminifera shells are strongly influenced by seawater pH, borate ion concentration, and bicarbonate ion concentration, which are, in turn, related to pCO_2. We can apply these boron-based proxies to fossil shells of planktic foraminifera in order to estimate the pH and carbonate chemistry of the upper oceans in the past. The Paleocene-Eocene Thermal Maximum (PETM; 56Ma), an abrupt global warming event in which ~5,000Pg of carbon was released into the atmosphere causing a drop in ocean surface pH, a large $\delta^{13}C$ excursion and seafloor carbonate dissolution, occurred during a longer-term warming trend beginning in the Late Paleocene and continuing into the Early Eocene (LPEE; 53-59Ma). Using boron-based proxies in planktic foraminifera, a surface ocean pH decrease of ~0.3 units has been estimated for the PETM [1]. In order to place this event in the context of long-term ocean pH change, here we extend the record across the LPEE at Site 1209. 20kyr resolution B/Ca and 200kyr resolution $\delta^{11}B$ measurements are applied to three species of planktic foraminifera across the LPEE, in conjunction with 10-20kyr resolution $\delta^{13}C$ and $\delta^{18}O$ measurements. We observe a ~25% decrease in B/Ca of surface-dwellers across the LPEE, reflecting either a rise in pCO_2 or a decrease in seawater [B]. Boron isotope data are consistent with the higher resolution B/Ca data. Low-amplitude B/Ca eccentricity cycles (400kyr as inferred from $\delta^{13}C$) are also apparent due to the effect of orbital forcing on carbon cycle feedbacks in the Eastern Pacific. B/Ca variations (~10%) on 400kyr timescales correspond to a pH change of <0.1 units. The amplitude of both the long- and short-term B/Ca variability is smaller in the thermocline-dwelling species compared with the surface-dwellers, indicating that the pH gradient of the upper ocean is changing during the LPEE. Replication of the Eastern Pacific record in the South Atlantic shows consistent results. Both records are consistent with expected changes in pCO_2 and pH inferred from $\delta^{13}C$ and CCD shifts.

[1] Penman *et al* 2014. Manuscript in review.