Eocene seawater pH - atmospheric CO_2 reconstructions using boron isotopes in planktonic foraminifera

ANAGNOSTOU, E.[1]*, ELEANOR, H. J.[2], EDGAR, K. M.[3], PEARSON, P. N.[2], RIDGWELL, A.[4], INGLIS, G.[5], PANCOST, R. D.[5], LUNT, D. J.[4] AND FOSTER, G. L.[1]

[1]University of Southampton, Southampton SO143ZH, UK; *correspondence: e.anagnostou@noc.soton.ac.uk
[2]Cardiff University, Cardiff CF103AT, UK
[3]Bristol University, Bristol BS8 1RJ, UK
[4]Bristol University, Bristol BS8 1SS, UK
[5]School of Chemistry-Cabot Institute, Bristol University, BS8 1TS and BS8 1UJ, UK

The Eocene (56 -33.9 Ma) is characterized by a transition from a greenhouse climate state of the Early Eocene Climatic Optimum (EECO, ~51 Ma), to the icehouse of the Oligocene (~ 34Ma). However, the role of atmospheric carbon dioxide (CO_2) in driving Eocene warmth and the subsequent long-term cooling is uncertain (current CO_2 reconstructions: 500-3000 ppm). Here we utilise recent analytical and methodological developments to generate a record of surface seawater pH (pHsw) and CO_2 using the boron isotope composition of planktonic foraminifera from the Tanzania Drilling Project, ODP 865, and ODP 1258/1260, and revisiting previous estimates. We show that pHsw during the EECO was 7.65 ± 0.06 and CO_2 was 1400 ± 420 ppm, in agreement with the presence of nahcolite in Early Eocene [1]. Subsequently, pH levels increased and CO_2 declined through the Eocene and into the early Oligocene (pHsw = 7.87 ± 0.05, CO_2 = 560 ± 140 ppm). Given a knowledge of the latitude dependency of sea-surface temperature change for a given climate forcing [2] we suggest that this CO_2 decline was the likely driver of the recently documented high and low latitude cooling that occurred through the Eocene. Additionally, the EECO and late Eocene exhibit an Equilibrium Climate Sensitivity on average 2.4 - 4.3 ºC per CO_2 doubling, well within the canonical range of the IPCC (1.5 - 4.5 ºC), indicating that a large fraction of the warmth of the Early Eocene greenhouse was caused by CO_2 concentrations.

[1] Lowenstein & Demicco (2006), *Science* **313**, 1928. [2] Rohling *et al*. (2012), *J. Clim* **25**, 1635-1656.