Boron isotope-based seasonal paleo-pH reconstruction for the Southeast Atlantic – Multispecies approach using habitat preference of planktonic foraminifera

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The boron isotopic composition of planktonic foraminiferal shell calcite (δ¹¹Bₐ) is a reliable tracer for seawater pH. Hence, under the assumption that surface-water pCO₂ is in equilibrium with the atmosphere, δ¹¹Bₐ of fossil surface-dwelling planktonic foraminifera can be used to reconstruct ancient atmospheric pCO₂. However, pH and pCO₂ of surface waters may vary seasonally, largely due to changes in temperature, DIC, and alkalinity. As shell fluxes of planktonic foraminifera show species-specific seasonal patterns, linked to intra-annual changes in temperature, it is obvious that δ¹¹Bₐ of a certain species reflects the pH and thus pCO₂ biased towards a specific time period within a year. This is important to consider for δ¹¹B coretop calibrations and for the interpretation of fossil δ¹¹Bₐ records that mirror seasonal pH signals. Here we present δ¹¹Bₐ coretop data for the planktonic foraminifera Globigerina bulloides, Globigerinoides ruber, Trilobatus sacculifer and Orbulina universa and compare them with δ¹¹Bborate derived from seasonally resolved carbonate system parameters.

To test the applicability of the season-adjusted calibrations, we used a core drilled on the Walvis Ridge in the Southeast Atlantic spanning the last 330,000 years to reconstruct changes in surface-water pCO₂. The reconstruction based on G. bulloides, reflecting the austral spring season, yields values closely following the Vostok ice-core data, indicating that surface-water pCO₂ was close to equilibrium with the atmosphere during the cooler spring season. In contrast, pCO₂ estimated from δ¹¹Bₐ of O. universa, T. sacculifer and G. ruber that predominantly lived during the warmer seasons, exhibits up to ~58 ppmv higher values than the Vostok ice-core data, with larger deviations during interglacials than during glacial.

This is probably due to the higher austral fall temperatures, as shown by Mg/Ca to be on average 4.3 °C higher than during the cooler spring season, accounting for an increase in pCO₂ of 4 % per 1 °C. Our results show that paleo-pH estimates based on δ¹¹Bₐ contain a significant seasonal signal reflecting the habitat preference of the recording foraminifera species.

Keywords: carbon cycle, ocean carbonate chemistry, atmospheric pCO2, boron isotopes, seasonality, foraminifera