Refining the alkenone-*p*CO_2 method: Nutrient constraints and the effect of growth rate

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The alkenone-*p*CO_2 method is one of the most widely used approaches to reconstruct the atmospheric CO_2 level in the Cenozoic. Based on the fractionation of stable carbon isotopes between dissolved CO_2 and biomass of haptophyte algae, this relationship (known as ε_p) scales inversely with growth rate and positively with CO_2 [1]. Recently published records of alkenone-derived CO_2 from late Pleistocene samples, however, are poorly correlated with ice core CO_2 records, indicating that improvements to the current methodology are needed. Models and experiments indicate that algal growth rate as represented by the physiological parameter '*b*' – which must be specified in order to reconstruct CO_2 levels – are sensitive to nutrient concentrations (*e.g.*, phosphorous, [2]) as well as other environmental conditions [3]. Here we revise the relationship between seawater reactive phosphate concentration and *b* using published core-top ε_p data. The sediment-based data show a shallower slope of the phosphate-*b* regression than the widely used relationship derived from suspended organic matter. Further, we show that the archaeal lipids often co-occuring with alkenones in the sediments may be used to estimate past changes of seawater nutrient levels and therefore to calibrate '*b*'. Applications of this refined alkenone-*p*CO_2 method to two published datasets yield similar trends and magnitude of *p*CO_2 changes over the last glacial-interglacial cycle, matching the ice-core records.

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