The Atlantic Ocean deep sea was very warm during the late Cenozoic. What does this mean for $\delta^{18}$O$_{sw}$ and ECS?

Warm late Cenozoic bottom water temperatures until 2.2 Ma, revealed from clumped isotopes of ODP Site 1264

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1 Intro

Oxygen isotopes of foraminiferal shell remains have unlocked much of Earth’s climatic history. However, the $\delta^{18}$O signal is not only temperature-dependent: it also depends on the composition of the fluid source from which the carbonate precipitated, which in turn is influenced by ice-sheet volume, Ocean currents, and evaporation/precipitation. Clumped isotope ($\Delta_c$) palaeothermometry can disentangle the two; it is based on thermodynamic principles, is independent of composition of the sea water, shows no species-specific fractionation, and it measures regular stable isotopes simultaneously from the same samples.

2 Material and Methods

- Create ≥25 aliquots of 10–15 (80 to 100µg) washed foraminiferal shells.
- Dissolve in phosphoric acid at 70°C in a Kiel IV carbonate device and purify released CO$_2$ with cold traps and a porapak trap at –40°C to get rid of organic compounds.
- Measure isotopes on a Thermo Fischer Scientific 253 Plus.

- Pressure sensitive Base Line correction [1].
- Empirical Transfer Function (ETF) using 3 carbonate standards, ETH-1–3.
- Temperature calibration [2, 3].
- Calculate $\delta^{18}$O$_{sw}$ from $\delta^{18}$O$_{cc}$ and T [4, 5].
- Get higher $\Delta_c$, $\delta^{18}$O, and a low-res $\Delta_c$, T, $\delta^{18}$O record.
- 253 Plus.

3 Results

- Our South East Atlantic clumped isotope ($\Delta_c$) record from benthic foraminifera corroborates global warm bottom water temperatures during the Miocene and Pliocene.
- We reconstruct high $\delta^{18}$O$_{sw}$ values, which would indicate the presence of a larger-than modern Antarctic ice sheet.
- This is highly unlikely, there are probably other influences on $\delta^{18}$O$_{sw}$
- Bottom water temperatures ultimately cooled to modern temperatures at around -2.5, when CO$_2$ values dropped.

4 Conclusions

- We reconstruct high $\delta^{18}$O$_{sw}$ values, which would indicate the presence of a larger-than modern Antarctic ice sheet.
- This is highly unlikely, there are probably other influences on $\delta^{18}$O$_{sw}$
- Bottom water temperatures ultimately cooled to modern temperatures at around ~2.5, when CO$_2$ values dropped.

References