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Coupled Mg/Ca and clumped isotope measurements at IODP Site U1488 confirm absence of Plio-Pleistocene sea surface temperature cooling in the Western Pacific Warm Pool

NIKLAS MEINICKE[1], MARIA REIMI[2], CHRISTINA RAVELO[2], AND NELE MECKLER[1]

[1]Bjerknes Centre for Climate Research and Department of Earth Science, University of Bergen, Norway
[2]Ocean Sciences Department, University of California, Santa Cruz, CA 95064

Abstract

The Western Pacific Warm Pool (WPWP) as a major source of heat and water vapor has a crucial influence on climate dynamics both in the tropics and globally. Yet, there is conflicting proxy evidence regarding the evolution of WPWP temperatures since the Miocene. On the one hand TEX_{86} data suggest a gradual cooling by ~2°C (O'Brian et al., 2014, Zhang et al., 2014) from the Pliocene to today, while faunal (planktonic foraminifera) sea surface temperature estimates (Dowsett, 2007) and Mg/Ca data measured in planktonic foraminifera (Wara et al., 2005) on the other hand indicate the absence of any long-term temperature trends. It has been suggested that Mg/Ca temperatures could on these time scales be biased by long-term changes of the Mg/Ca ratio of seawater (Evans et al., 2016). To test the influence of the proposed seawater changes on Mg/Ca we combined data from two independent temperature proxies, Mg/Ca and clumped isotopes, measured on two species of planktonic foraminifera from IODP Site U1488 in the central WPWP.

Our study finds good agreement between both proxies thereby verifying the validity of Mg/Ca records from the WPWP and confirming the absence of a Plio-Pleistocene cooling trend for the WPWP. This finding suggests that the persistent disagreement between foraminifer-based proxies such as Mg/Ca and biomarker data might be caused by different environmental parameters being recorded in the two archives.

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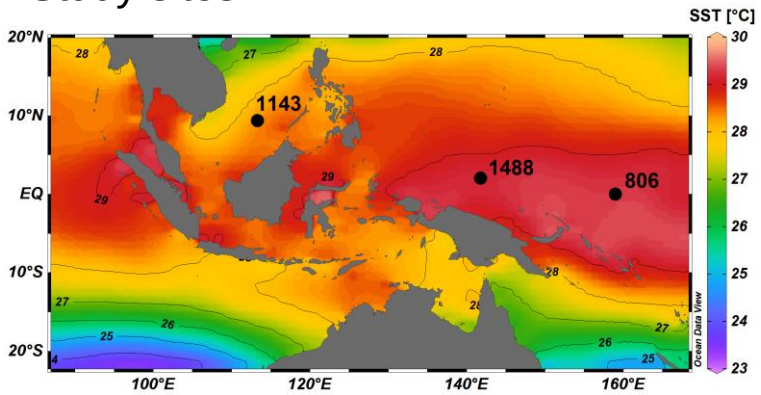
Study sites



Present sea-surface temperatures across the Indo-Pacific Warm Pool (Locarnini et al., 2010).

Motivation

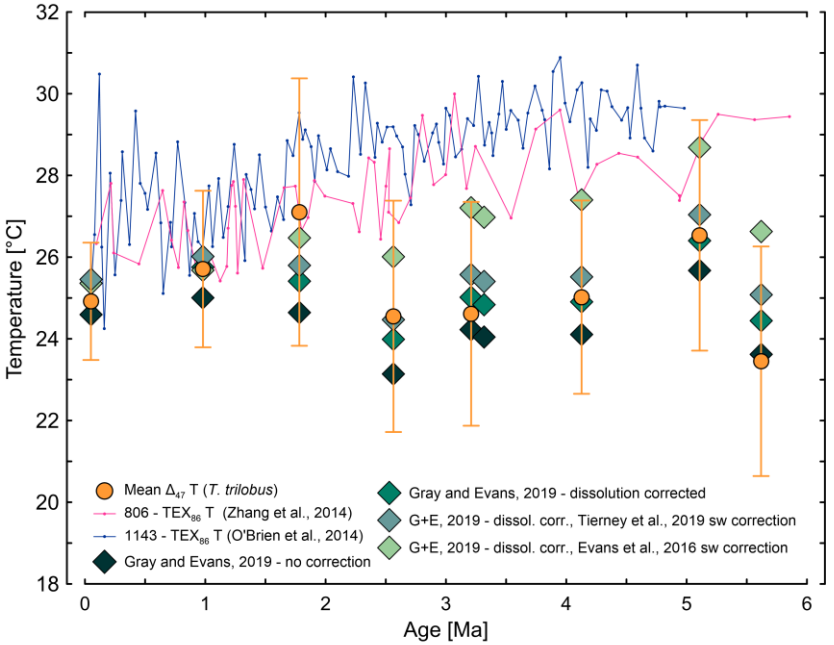
Existing proxy records of Western Pacific Warm Pool SST from the Miocene to present disagree:

$U^{K'}_{37}$ cannot be used for temperatures above ~28°C; TEX_{86} shows a cooling trend; Mg/Ca records indicate relatively stable SST but might be influenced by changing seawater chemistry

This study

- Several time intervals spread out across the last 6 Myrs
- Mg/Ca and clumped isotopes (Δ_{47}) measured on the same samples
- Two species of planktonic foraminifera (*T. trilobus and G. tumida*) to reconstruct mixed layer and thermocline temp.

Results from IODP Site U1488 (mixed layer)



Mixed layer (T. trilobus) Mg/Ca (green shades) and Δ_{47} (orange) temperatures compared to TEX_{86} temperatures from Sites 1143 (O'Brien et al., 2014) and 806 (Zhang et al., 2014). Error bars for the Δ_{47} values represent 95% confidence intervals.

→ Mg/Ca and clumped isotope temperatures in best agreement with minimal correction for sea water Mg/Ca

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How to explain proxy differences?

Hypothesis 1: Decreasing WPWP temperatures

- Mg/Ca_{sw} changes (e.g. Evans et al., 2016) or dissolution (Regenberg et al., 2006) might bias Mg/Ca towards colder T
- Δ_{47} might be biased towards colder T by diagenesis (e.g. Leutert et al., 2019)
- Both processes would need to occur at the same time and to the same extent in order to explain agreement between Mg/Ca and Δ_{47}

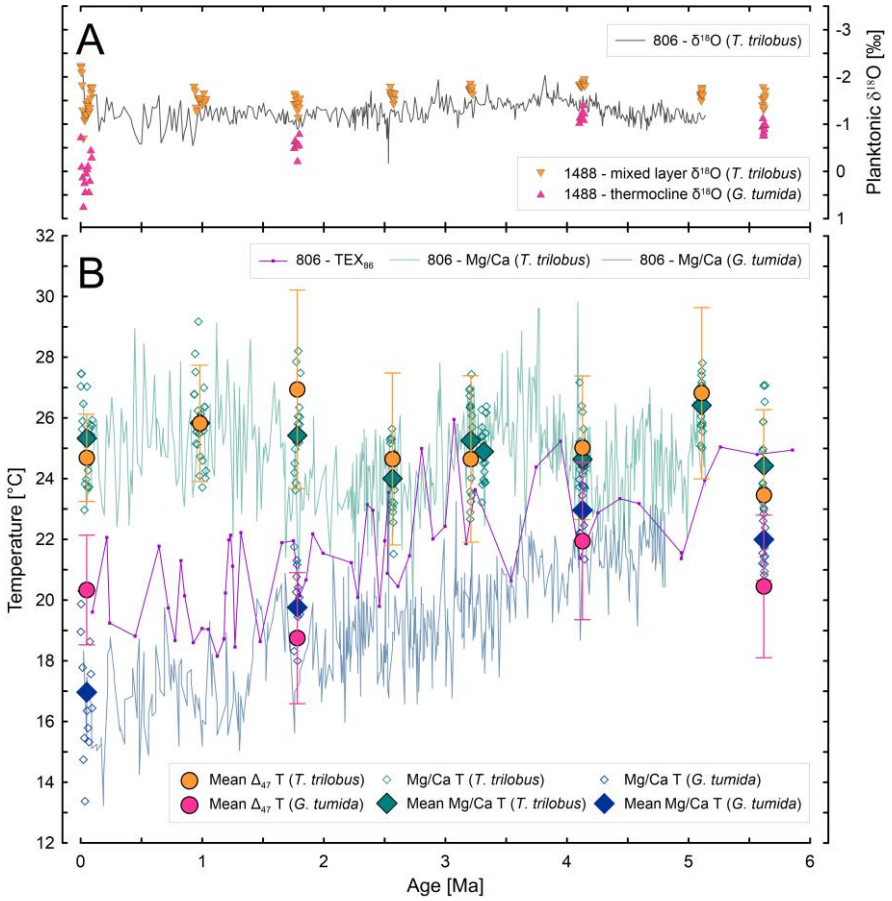
Hypothesis 2: No long-term trend

- TEX_{86} data might integrate over a larger part of the water column (e.g. Kim et al., 2012)

Conclusions

- Mg/Ca and Δ_{47} agree and suggest relatively stable SSTs in the central warm pool during the last 6 Ma
- unlikely that Mg/Ca and Δ_{47} are both biased towards colder temperatures by completely independent processes
- Subsurface (0-200 m) TEX_{86} calibration yields Ts in between foraminifera-based mixed layer and thermocline Ts
- No or minor correction for Mg/Ca_{sw} changes needed

A: Mixed layer T. trilobus and thermocline G. tumida $\delta^{18}O$ against the mixed layer $\delta^{18}O$ record from Site 806 (Wara et al., 2005).



B: Mixed layer (T. trilobus) and thermocline (G. tumida) Mg/Ca and Δ_{47} temperatures compared to TEX_{86} temperatures from Site 806 (Zhang et al., 2014, recalculated to reconstruct subsurface temperatures using Zhang et al., 2018) as well as 806 Mg/Ca temperatures (Wara et al., 2005). Error bars for the Δ_{47} values represent 95% confidence intervals.

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