

Significant ocean heat content reduction caused by subsurface cooling after 0.8 Ma in the central and southern margins of the Western Pacific Warm Pool

*Li Lo¹, Shital Paulu Godad¹, Yi-Hseuh Tsai¹, Shih-Yu Lee², Thibault de Garidel-Thoron³, Chia-Shiuan Chu⁴, Chuan-Chou Shen¹, Ludvig Löwemark¹, Horng-Sheng Mii⁴, Yuan-Pin Chang⁵

1. Department of Geosciences, National Taiwan University, Taipei, Taiwan, 2. Research for Environmental Changes, Academia Sinica, Taipei, Taiwan, 3. Aix-Marseille Université, CNRS, IRD, INRAE, CEREGE, Aix-en-Provence, France, 4. Department of Earth Sciences, National Taiwan Normal University, Taipei, Taiwan, 5. Department of Oceanography, National Sun Yat-sen University, Kaohsiung, Taiwan

Growing evidence indicates a rapid expansion of the Western Pacific Warm Pool (WPWP), characterized by annual sea surface temperatures exceeding 28°C, in both area and upper ocean heat content (OHC) over the past few decades, potentially increasing typhoon activity, coral bleaching, and ecological disruptions if OHC continues to rise. To better understand future unprecedented changes, paleo-records offer valuable insights for assessing potential scenarios. Most previous regional studies have focused on surface reconstructions or shorter timescales, with limited data extending beyond 0.5–0.3 million years (Ma). In this study, we present 1.75 Ma reconstructions of surface and subsurface temperatures based on planktonic foraminiferal Mg/Ca ratios (*Globigerinoides ruber* and *Neogloboquadrina dutertrei*) from the central and southwestern margins of the WPWP. The data were obtained from core MD97-2140 (2°02' N, 141°46' E) and ODP Hole 1115B (9°11' S, 151°34' E), respectively. Our findings reveal distinct glacial/interglacial (G/IG) cycles in OHC at both sites, underscoring the significant influence of global climate boundary events on the WPWP. Across the middle Pleistocene transition (MPT), as the dominant climate periodicity shifted from 41-kyr to 100-kyr cycles, changes in the periodicities and amplitudes of G/IG OHC variations were also observed. Notably, OHC in both central and southwestern WPWP regions has been declining since approximately 0.8 Ma, driven primarily by a gradual subsurface cooling of 2–3°C. During “warmer-than-present” periods, such as Marine Isotope Stages 5e, 11, and 31, OHC exceeded Holocene averages. The findings indicate that ocean circulation and greenhouse gas forcing play a more significant role in driving OHC changes than direct orbital-induced insolation forcing. However, the long-term stability of surface SSTs in both central and southern marginal warm pool regions does not clearly support a sustained decline in greenhouse gas radiative forcing, suggesting the existence of more complex feedback mechanisms that require further exploration. This research helps refine energy budget estimates and improve the calibration of numerical models. Additionally, it emphasizes the importance of subsurface water circulation in connecting the WPWP to climate systems in mid- and high-latitude regions.

Keywords: Western Pacific Warm Pool, Ocean heat content, Orbital cycles, Mid-Pleistocene Transition