A Quantitative Solution for the 'Cool Tropics' Paradox of Past Greenhouse Climates: Testing Diagenetic Hypotheses Combining Clumped Isotope and Electron Backscatter Diffraction Data on Foraminifera

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Although climate model simulations of past high pCO_2 intervals indicate warm tropical sea surface temperatures (SSTs), high $\delta^{18}O$ ratios of planktonic foraminifera tests from open ocean successions have been interpreted to reflect carbonate mineral precipitation in cool waters. One argument for solving this "cool tropics paradox" of past greenhouse intervals is that all planktic foraminiferal tests from such settings are extensively recrystallized. Isotopic modeling has been used to argue for substantial (~50%) amounts of diagenetic calcite in tests from tropical and subtropical oozes, with recrystallization occurring in pore-fluids similar in temperature and $\delta^{18}O_w$ to bottom waters (i.e., cold and ^{18}O-enriched). If recrystallization is this pervasive, it calls into question the preservation of most deep-sea sequences and the utility of their absolute $\delta^{18}O$ values in paleoceanography. We use clumped isotope and electron backscatter diffraction data of foraminifera from sites in the tropical Pacific to directly test the hypothesis that $\delta^{18}O$ values from carbonate-rich sequences reflect substantial amounts of recrystallization. Both measurements are inconsistent with extensive fine-scale recrystallization in pore waters and the presence of 50% diagenetic calcite. Our data provide quantitative constraints that enables the accurate reconstruction of SSTs and $\delta^{18}O_w$. We find evidence for warm tropical SSTs that likely led to high rates of evaporation and vapor export, resulting in surface waters in the tropical Pacific that were more ^{18}O-enriched than previously considered. These findings have significance for Earth systems history, including the utility of deep-sea sediments in studying past climate change in response to changing greenhouse gas forcing.