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Long-term benthic foraminiferal culture: Strategies for carbonate-system control and experimentation

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The effect of oceanic pCO_2 and carbonate system chemistry on benthic foraminiferal biomineralization and paleoproxy incorporation is not well understood. Carbonate ion concentration is a significant control of stable isotope incorporation in planktonic foraminifera. Moreover, low calcite saturation state, directly related to carbonate ion concentration, appears to alter trace metal proxy incorporation into foraminiferal calcite. Past laboratory benthic foraminiferal culture studies relied on ambient laboratory or compressed medical-grade air to maintain constant culture seawater pCO_2 and ä$^{13}C_{DIC}$ with limited success. Improvements made to the system over 15 years (e.g., artificial instead of natural sediment substrate; high volume aeration with atmospheric air; and high volume/low velocity seawater flow) have greatly improved the long-term stability of carbonate system and seawater ä$^{13}C_{DIC}$. However, even under stable conditions, we have observed several significant differences in cultured and core-top benthic foraminifera calcite proxy signatures from these two calcification environments (e.g., ä^{13}C, D_{Ba}). Current culture efforts are focusing on alkalinity manipulation to experimentally control carbonate ion concentrations and induce biological responses in the recorded stable isotope and trace metal signatures. In as few as 4 months, foraminiferal reproductive events have been observed in supersaturated (Ù ~ 3) and saturated (Ù ~ 1) treatments with greater than 50% of culture populations thriving in the highly-constrained artificial culture system. Thus, the experimental technique to test carbonate concentration influence on benthic foraminifera stable isotope and trace metal proxies was initially successful. Still, the reliance on atmospheric air for this culture system, with seasonally varying pCO_2 and ä$^{13}C_{CO2}$ may cause significant temporal variation in cultured foraminifera paleoproxy incorporation confounding the results. An unclear record of the calcification environment during precipitation would limit the ability to fully understand the complex interaction of the carbonate system and preserved proxy signatures. Therefore, the next generation of long-term culture techniques for definitively evaluating the role of carbonate system chemistry, paleoproxy incorporation, and preservation may need additional control methods to adequately constrain the calcification environment.

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