Symbiont bleaching in planktonic foraminifera during early Eocene hyperthermal events

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Summary

By comparing carbon isotope values in planktonic foraminifera across size fractions, latitudinal range, and hyperthermal events we can evaluate the link between temperature changes and bleaching.

Introduction

Most modern symbiont-bearing foraminifera rely on their symbionts to provide nutrients in oligotrophic environments and to support reproduction and growth[1]. Temperature stress can cause symbiont-bearing taxa to expel their symbionts in 'bleaching' events that can be lethal to the host[2]. Past global warming events can provide case studies in biotic response to similar environmental disturbances.

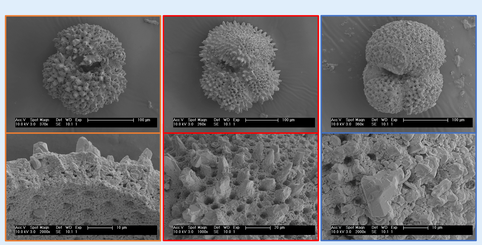

Figure 1: 1209 specimens show poor-moderate preservation (recrystallization and calcite overgrowth). Overall, all species appear frosty. *Subbotina* show mild test wall peeling. Preservation at 1209 is stable throughout[3]. Preservation at 401 and 610 is better[4,5].

Methodology

Analyzed $\delta^{13}C$ and $\delta^{18}O$ of asymbiotic (*Subbotina eocaena* and *S. triangularis) and* symbiont-bearing foraminifera (*Acarinina soldadoensis, A. coalingensis,* and *Morozovella subbotinae)*. Targeted 30 of each species in 6 size fractions.

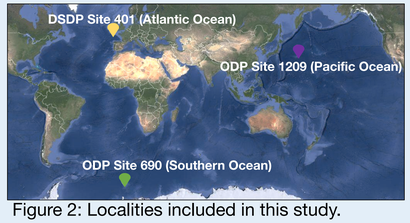

Figure 2: Localities included in this study.

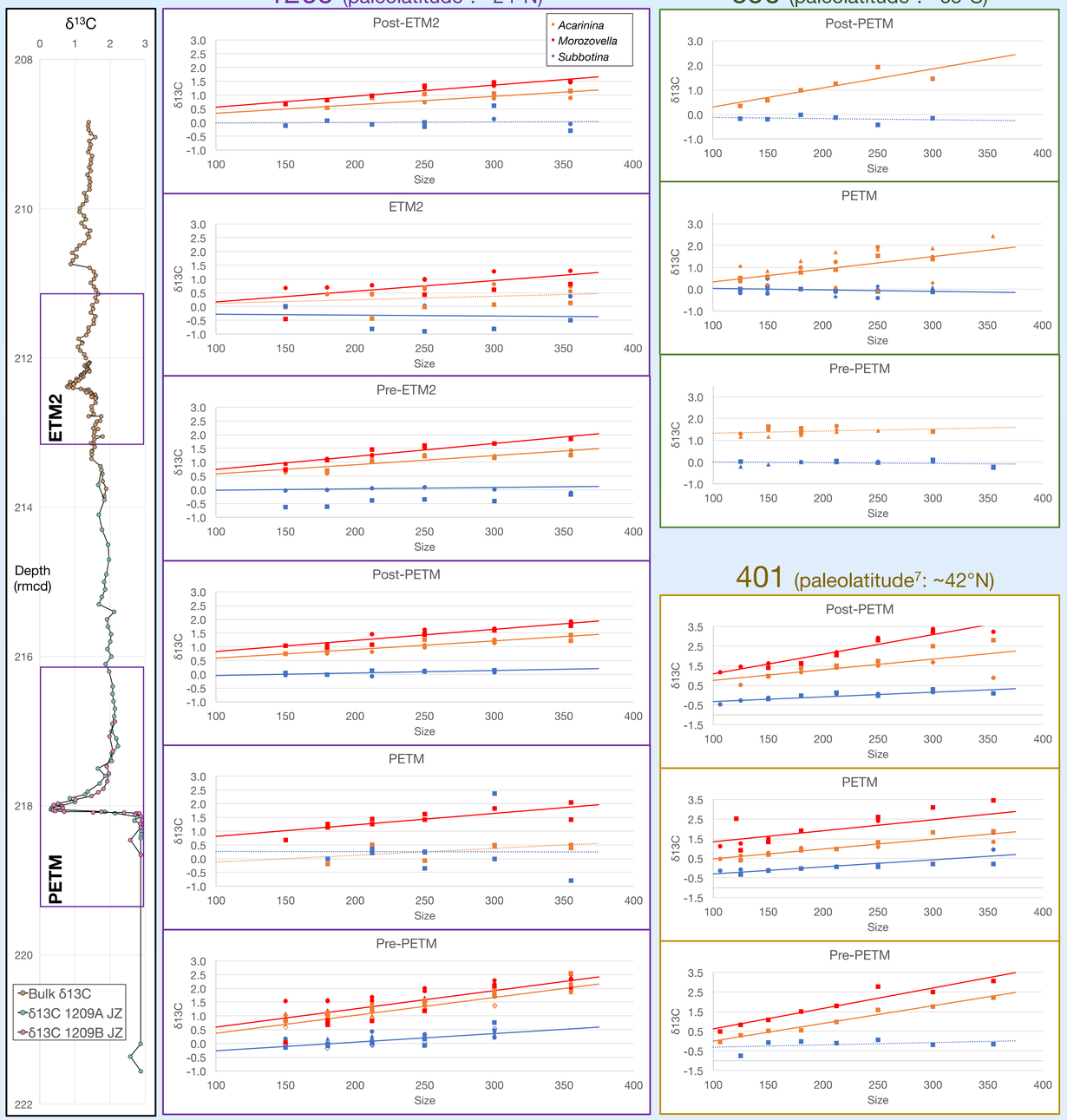

Figure 3: (Left) Isotope profile from 1209[6], samples utilized in this study fall within the respective boxes. (Center) Trends in $\delta^{13}C$ versus sieve size fraction at ODP Site 1209 (Pacific Ocean). Different symbols indicate different samples. All species data normalized relative to $\delta^{13}C$ values of *Subbotina* from the 180-212 µm size fraction within the sample. Dashed regression lines are not statistically significant ($p>0.05$). (Right) Stable isotope data by size of planktonic foraminifera from Sites 401 and 690, collected by Norris. Data from Site 690 includes *A. coalingensis* and *S. triangularis*.

Conclusions

- Significant positive correlation between test size and $\delta^{13}C$ in symbiont-bearing foraminifera before and after hyperthermals.
- Strongest correlation at 401 and weakest relation at 690.
- Potential causes of decreased $\delta^{13}C$ slopes in symbiont-bearing foraminifera found coincident with hyperthermals:
  1. Bleaching: Loss of symbionts due to temperature change, leading to reduction in $\delta^{13}C$.
  2. Respiration outpacing photosynthesis: greater temperature sensitivity of respiration during the PETM and early Eocene climatic optimum.
  3. Habitat changes: Foraminifera migrate deeper in response to changing water conditions.
  4. Symbiont adaptation: Symbiont switching or microevolutionary change in response to warming.

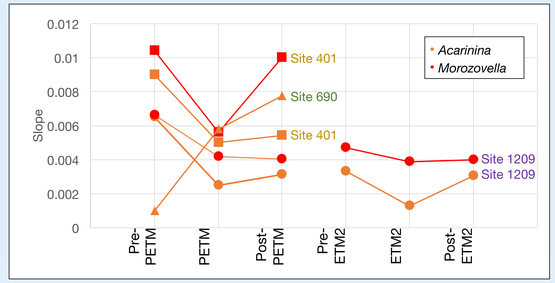

Figure 4: Size-isotope trend slopes in symbiont-bearing foraminifera at Sites 1209, 401, and 690.

Acknowledgements

Supported by NSF grant OCE 1232413 to Ellen Thomas.
A special thank you to the Hull Lab and to the Yale Analytical Stable Isotope Center for their continued support, advice, and constructive criticism.

References

[1] Norris, R. D. (1996). Symbiosis as an evolutionary innovation in the radiation of Paleocene planktic foraminifera. *Paleobiology*, *22*(4), 461-480.
[2] Schmidt, C., Heinz, P., Kucera, M., & Uthicke, S. (2011). Temperature-induced stress leads to bleaching in larger benthic foraminifera hosting endosymbiotic diatoms. Limnology and Oceanography, 56(5), 1587-1602.
[3] Petrizzo, M. R., Leoni, G., Speijer, R. P., De Bernardi, B., & Felletti, F. (2008). Dissolution susceptibility of some Paleogene planktonic foraminifera from ODP site 1209 (Shatsky Rise, Pacific Ocean). *The Journal of Foraminiferal Research*, *38*(4), 357-371.
[4] Bornemann, A., Norris, R. D., Lyman, J. A., D'haenens, S., Groeneveld, J., Röhl, U., ... & Speijer, R. P. (2014). Persistent environmental change after the Paleocene–Eocene Thermal Maximum in the eastern North Atlantic. Earth and Planetary Science Letters, 394, 70-81.
[5] Kelly, D. C. (2002). Response of Antarctic (ODP Site 690) planktonic foraminifera to the Paleocene–Eocene thermal maximum: faunal evidence for ocean/climate change. Paleoceanography, 17(4).
[6] Gibbs, S. J., Bown, P. R., Murphy, B. H., Sluijs, A., Edgar, K. M., Pälike, H., ... & Zachos, J. C. (2012). Scaled biotic disruption during early Eocene global warming events. Biogeosciences, 9(11), 4679-4688.
[7] McInerney, F. A., & Wing, S. L. (2011). The Paleocene-Eocene Thermal Maximum: a perturbation of carbon cycle, climate, and biosphere with implications for the future. Annual Review of Earth and Planetary Sciences, 39, 489-516.