Clumped isotope paleotemperature analysis of Turonian and Campanian foraminifera from southeast coastal Tanzania

Olivia Gadson1, Brian Huber2, Matthew M. Jones3, Gabriela Farfan3, Sierra Peterson4
1Department of Biology, Georgetown University, Washington, D.C.
2Department of Paleobiology, National Museum of Natural History, Smithsonian Institution, Washington, D.C.
3Department of Mineral Sciences, National Museum of Natural History, Smithsonian Institution, Washington, D.C.
4Department of Earth and Environmental Sciences, University of Michigan, Ann Arbor, Michigan

Introduction

Foraminifera are abundant microfossils whose calcium carbonate (CaCO₃) shells reflect the chemistry of their environment from the time they were alive, making foraminifera carriers of valuable proxies for paleoclimatic and paleoceanographic conditions. The burgeoning method of carbonate clumped isotope (Δ47) analyses measures the abundance of the heavy isotopologues of carbon and oxygen (e.g., 13C13O16O) in carbonate minerals. This method has gained popularity in paleoceanographic research as its results are independent of the unknown stable isotope compositions of oxygen (δ18O) and carbon (δ13C) in seawater at the time of mineral precipitation. In this project, we used well-preserved benthic and planktic foraminifera from the Lindi Formation (TDP) sites 23 and 36, which are middle Campanian (~75-77 Ma) and lower middle Turonian (92-93 Ma), respectively. We analyzed these samples for Δ47, δ18O, and δ13C values to obtain paleotemperature estimates. To compare to previously obtained δ13C values.

Methods and Materials

- Used a sodium polytungstate (SPT) flotation method for larger samples (>5 g) to better separate foraminifera tests from sediment grains.
- Picked benthic and planktic foraminifera from >250 µm and >125 µm sieve fractions.
- In earlier samples, tests were picked by avoiding those with apparent signs of infilling with secondary calcite.
- In later samples, infilled tests were separated by floating them in water, relying on positive buoyancy to float the hollow tests.
- Completed SEM imaging and EDF light microscopic images on dissected specimens to examine their preservation and identify evidence of infilling in foraminiferal chambers.
- Samples (~2 mg) were analyzed for Δ47, δ18O, and δ13C values on a Nu Perspective dual inlet mass spectrometer.
- Δ47 paleotemperatures were derived from the Anderson et al., 2021 calibration equation:

\[
\Delta_{47} = \Delta_{\text{cal}} \pm 0.0004 \times 10^\text{R2} \pm 0.015 \pm 0.004 
\]

Results

Figure 4. Crossplot of preliminary paleotemperature data derived from Δ47 values against δ13Ccarb values. Points in blue correspond to Campanian values while yellow is Turonian. Circles represent benthic species while triangle represent planktic species values. Points encased in green, dashed boxes indicate values in which we have higher confidence.

Conclusions

- Turonian benthic samples yielded warmer average Δ47 paleotemperatures (32°C) than those from the Campanian (26-27°C).
- Turonian planktic samples yielded average Δ47 paleotemperatures of 31.5°C compared to Campanian planktics (34.5°C).
- These paleotemperatures, though higher than expected, present predicted differences between compared groups and fell near previous temperature estimates, demonstrating Δ47 analysis functions as an effective paleothermometer using foraminifera in geologic time intervals of greenhouse paleoclimate, such as the Late Cretaceous.

Future Research

- Add replicates to samples previously analyzed in this project and complete water floats to investigate if suspicious paleotemperature values are due to infilling.
- Compare infilled and hollow test values to quantitatively investigate how diagenesis impacts geochemical analyses.
- Analyze samples from higher latitudes to expand the record of paleotemperatures (the project focus of YES! Interns Nalia Molina and Meron Abraham).

Acknowledgements and References

We would like to thank Vanessa González, Joan Lascu, and Virginia Power for their support in leading the NHRE Program. We would also like to thank the Smithsonian Institution NMNH for funding this project.