Foraminiferal paleoecology and paleotemperature estimates for the Cenomanian (100-94 Ma) at high southern latitudes

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REU Site, OCE-1560088

INTRODUCTION

Due to an incomplete recovery of pelagic sediment cores from previous ocean drill sites, there is a gap in paleoclimate data for the Cenomanian time interval (101-94 million years ago) at southern high-latitudes[1]. During International Ocean Drilling Project (IODP) Expedition 369 in 2017, a nearly complete sequence of high-latitude Cenomanian sediment was recovered from the southeast Indian Ocean. This project is focused on examining the foraminiferal assemblages recovered from the Naturaliste Plateau (Figure 1) during IODP Expedition 369 in order to better understand the changing oceanic environment and water temperature during the Cenomanian. Foraminifera are a type of single celled marine organisms and are extremely sensitive to fluctuations in the environment. Both benthic and planktonic species secrete a test, usually calcium carbonate, allowing for preservation in the fossil record. Samples from three drill holes (U1513A, U1513D, U1516C) were examined for relative abundance, percent planktonic foraminifera, and stable oxygen and carbon isotope analysis. All sites were located at ~60^{0}S during the Cenomanian.

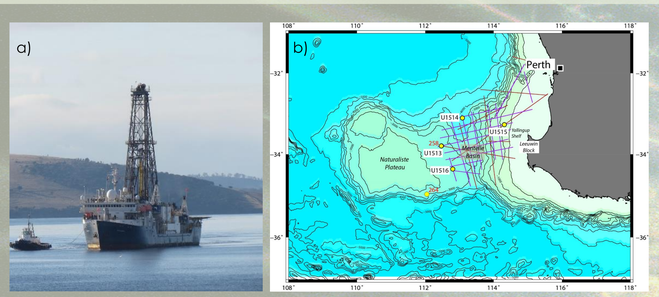

Figure 1: a) IODP drill ship JOIDES Resolution *coming into Hobart, Tasmanian harbor at beginning of Exp. 369 (photo: Brian Huber) b) Location of IODP Exp 369 drill sites off the SW coast of Australia: U1513, U1514, U1515, and U1516.*

MATERIALS & METHODS

- Each interval of sediment was wet-sieved with a >38 µm sieve, dried, and examined under a stereomicroscope (Figure 2).
- Planktonic abundance counts and %planktonic foraminifera were achieved by splitting the >63 µm fraction of each sample to ~300 planktonic specimens. The number of each planktonic taxa present and number of total benthic foraminifera was then counted and recorded.
- Foraminifera were picked from >125 and >250 µm sieve fractions and mounted on microslides for stable oxygen and carbon isotope analysis.
- The following benthic species and genera were picked for analysis: *Gyroidinoides globosus*, *Angulogavelinella* sp., *Berthelina* sp., *Planulina* sp., and *Lenticulina* sp. The following planktonic species and genera were picked for analysis: *Microhedbergella praeplanispira*, *Shackoina cenomana*, and *Whiteinella* sp.
- ~50 µg of each species or genera were picked for analysis; samples weighed using a CAHN 29 Automatic Electrobalance

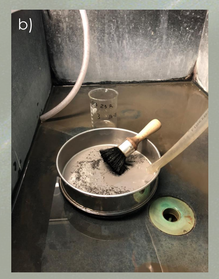

Figure 2- a) Nikon SMZ-U light microscope used for examination of foraminiferal assemblages. b) Wet-sieving process with >38 µm sieve. (photos: Becca Goughnour)

SE INDIAN OCEAN CLIMATE HISTORY

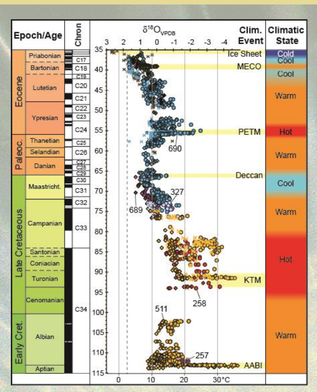

Figure 3- Southern high latitude (>60^{0}S paleolatitude) oxygen isotope paleotemperatures, including Site 258 (red data) published by Huber et al. (2018). Graphic shows Cenomanian data gap prior to the Cretaceous Thermal Maximum (KTM). Drill sites U1513-16 aim to determine if Cenomanian temperatures ever reached those documented in the KTM, providing a much needed climate record for the southern high latitudes.

Filling the stratigraphic gap between the Early Cretaceous Warmhouse and the Late Cretaceous Hothouse is important for:

- characterizing the patterns of ocean temperature change prior to the onset of Oceanic Anoxic Event 2 (OAE 2). OAE2 was a short-lived episode of severely depleted oxygen in Earth's atmosphere and enhanced organic carbon deposition occurring at the Cenomanian-Turonian Boundary [2].
- revealing possible forcing mechanism for OAE2 by examining foraminiferal assemblages throughout the Cenomanian
- reconstructing the evolution of deep and surface ocean circulation during the breakup of Gondwana continents

PLANKTONIC ABUNDANCE, $\delta^{18}O$, & $\delta^{13}C$ ISOTOPE DATA

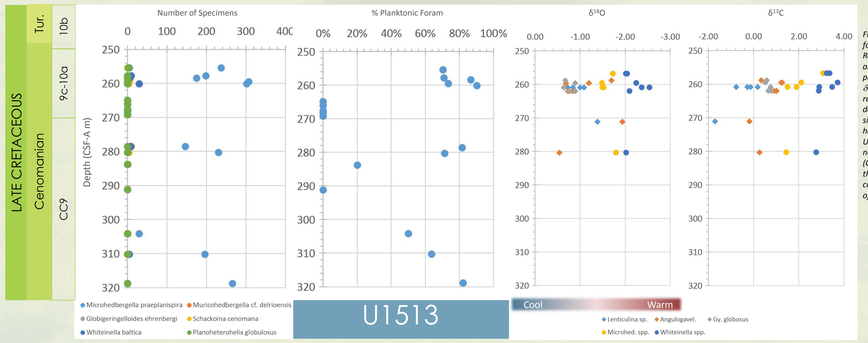

Figure 4: Scatter plots for IODP Site U1513: Relative species abundance, % planktonic forams, $\delta^{18}O$ and $\delta^{13}C$ all with respect to time and depth. Data from drill site contains two drill holes: U1513A & U1513D. Calcareous nannofossil biozones (CC zones) provide the primary age control for correlation of drill sites.

Relative Abundance:

- Counts show that microhedbergellids were the dominant planktonic foraminifer across both sites during the Cenomanian
- Diversity of planktonic foraminifera is uncharacteristically low, even for high southern latitudes, suggesting there was an additional environmental stressor on this region during the Cenomanian

% Planktonic Foraminifera:

- Four intervals barren in hole U1513A, two intervals barren in hole U1513D
- One interval barren in hole U1516C
- Significant changes in % planktics may reflect periodic rising of the Calcium Compensation Depth (CCD)

$\delta^{18}O$ & $\delta^{13}C$

- Both sites indicate cooler Cenomanian temperatures than observed in the early Turonian (Figure 3).
- Data Suggests onset of the Turonian thermal maximum was abrupt and likely triggered by a massive release of volcanogenic CO_2 ~94 Ma.
- OAE2 associated with an excursion in carbon isotopic data

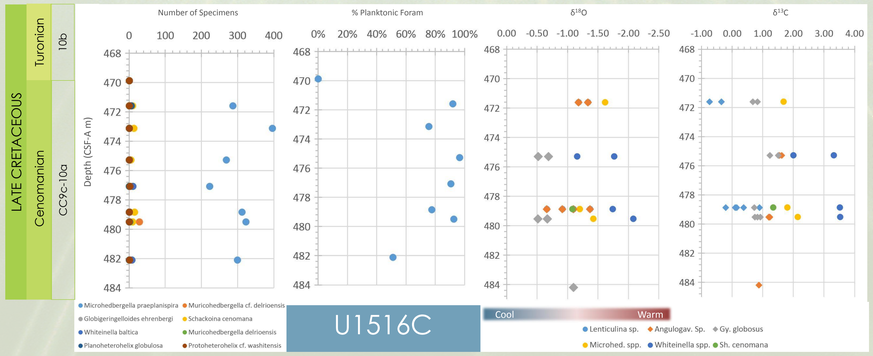

Figure 5: Scatter plots for hole U1516C: Relative species abundance, % planktonic forams, $\delta^{18}O$, and $\delta^{13}C$ all with respect to time and depth. Calcareous nannofossil biozones (CC zones) provide the primary age control for correlation of drill sites.

BENTHIC AND PLANKTONIC SPECIES IDENTIFIED

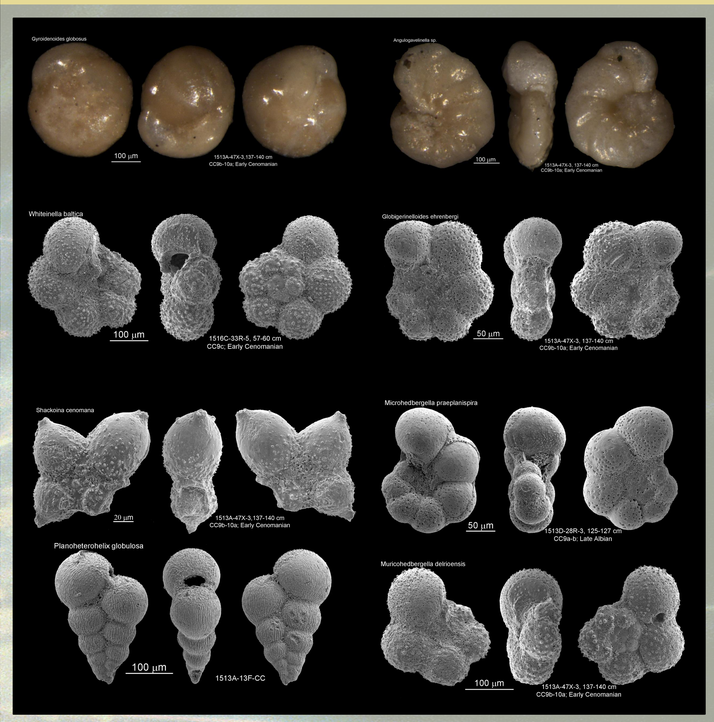

*Figure 6- First row: Cenomanian benthic foraminifera (*Gyroidinoides globosus *and* Angulogavelinella *sp.) identified at both U1513 & U1516; imaged using Nikon light microscope. Second, third, & fourth row: Cenomanian planktonic foraminifera (l-r, t-b:* Whiteinella baltica, Globigerinelloides ehrenbergi, Shackoina cenomana, Microhedbergella praeplanispira, Planoheterohelix globulosa, Muricohedbergella delrioensis*) identified at U1513 & U1516; imaged using Scanning Electron Microscope.*

CONCLUSIONS & FUTURE RESEARCH

This study achieved a better understanding of high southern latitude oceanographic interactions through:

- assessment of Naturaliste Plateau foraminiferal paleoecology at the Cenomanian-Turonian boundary
- interpretation of $\delta^{18}O$ values in order to bridge the stratigraphic gap in ocean temperature data for the Cenomanian
- acquisition of $\delta^{13}C$ values in order to measure the ocean carbon pool at surface and bottom waters during the Cenomanian

Now that the majority of the intervals from each of the holes have been processed, future studies can take advantage of the IODP Expedition 369 sediment samples by:

- evaluating foraminiferal ecology at site U1514
- picking additional intervals at all sites for geochemical analysis in order to provide higher resolution Cenomanian climate trends.
- exploring possible causes of low planktonic foraminiferal diversity as documented at sites U1513 and U1516

ACKNOWLEDGEMENTS & REFERENCES

[1]Huber, B.T., MacLeod, K.G., Watkins, D.K., and Coffin, M.F., 2017. The rise and fall of the Cretaceous hot greenhouse climate. *Global and Planetary Change.*

[2]Huber, B.T., Hobbs, R.W., Bogus, K.A., and the Expedition 369 Scientists, 2018. *Expedition 369 Preliminary Report: Australia Cretaceous Climate and Tectonics*. International Ocean Discovery Program.

We would like to thank the National Science Foundation for their funding of this project, as well as the National Museum of Natural History for the facilities to complete this project. We would like to thank Olivia Gadson and Ibrahim Mohamed for their assistance in processing samples, and JoAnn Sanner and Jennifer Jett for their expertise in imaging specimens. Finally, we would like to acknowledge Virginia Power, Liz Cottrell, and Gene Hunt for their support of the NHRE program.