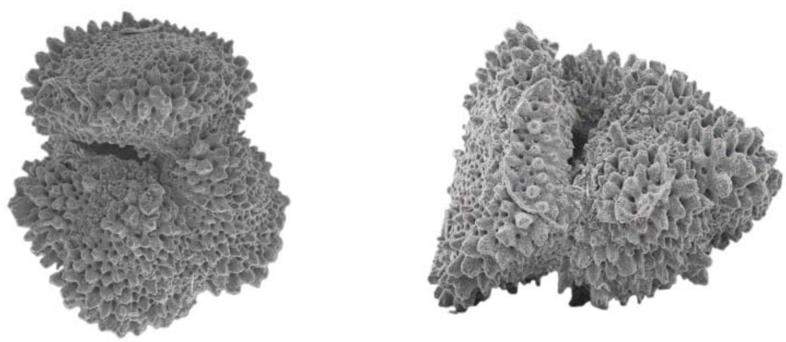
Shari Hilding-Kronforst

Shari Hilding-Kronforst is currently a Ph.D. candidate at Texas A&M University. Born in Illinois, she received a microscope at age 8 and dinosaur models at age 9. She completed a triple B.S. degree in Earth Science, Chemistry, and Biology at the University of Wisconsin. She completed her M.S. degree at Texas A&M and still found time to serve on the Graduate Student Council and complete several oceanographic cruises. She is currently working on her dissertation research involving the middle Eocene (42-44 Ma) refinement and/or recalibration of planktonic biostratigraphy and environmental analysis of IODP cores from Leg 171B western North Atlantic.

Middle Eocene western north Atlantic biostratigraphy and environmental conditions



Acaranina praetopilensis
Figure 1. Site 1051 Eocene planktonic foraminifera SEM. Left image 200 magnification, right image side view 250 magnification.

Rationale

How and why climate transitioned from Eocene greenhouse to Oligocene icehouse is still widely debated. What role did CO_2 play, when did high latitude glaciations commence, was this transition from greenhouse to icehouse abrupt or as recent studies have suggested, occurred in a stepwise manner? Can we correlate middle Eocene biostratigraphy and environmental conditions to other basins? This project will examine the north western Atlantic Ocean planktonic foraminiferal assemblage for refinement of the middle Eocene zonal markers and investigate environmental changes in stable oxygen, carbon and trace element isotopic signatures, resulting in a biostratigraphic and climatic record for the mid Eocene period from 42-44 Ma.

The middle to late Eocene is a critical climatic transition period from the Eocene greenhouse to Oligocene icehouse conditions. Understanding climate dynamics during this period is essential to identifying what drives climate change, and may allow us to better understand our current and changing environmental state. There are presently few, lower resolution Pacific or Southern Ocean records for this interval and there is a need for enhanced biostratigraphy of middle Eocene zones E9-E11.

Relevance

The marine sediment samples used in this study were obtained during Ocean Drilling Project (ODP) Leg 171B Blake Nose in the western North Atlantic Ocean. Blake Nose offers well defined biostratigraphic, magnetostratigraphic, and cyclostratigraphic controls (Quillevere et al., 2008; Wade and Kroon, 2002) which are inherently applicable and relevant to the present day Gulf Coast region as during the time period of this project there was no barrier between Blake Nose and the Gulf Coast. Refinement and/or recalibration of the middle Eocene zonal markers in this region represent a valuable predictive tool for other geoscientists. The foraminifera will also be utilized for $\delta^{13}C$, $\delta^{18}O$, and trace element analysis using an isotope ratio mass spectrometer.

The sea surface is the interface between the ocean and atmosphere with sea surface temperatures (SSTs) representing an important boundary condition for both these circulation systems. Determining SSTs during periods of changing climate is essential to understanding the nature of the global ocean, recognizing changes in ocean circulation that occurred in conjunction with climate change, calibrating climate models, and understanding what controls climate change.

Analysis of foraminiferal oxygen isotope composition ($\delta^{18}O$) is the standard approach for paleoceanographic studies. The $\delta^{18}O$ of calcite from planktonic foraminifera has been shown to reflect both temperature and seawater $\delta^{18}O$, itself an indicator of global ice volume and salinity (Emiliani, 1955; Shackleton and Opdyke, 1973). For this reason, foraminiferal $\delta^{18}O$ indicates changes in global ice volume/climate. Mg paleothermometry provides an independent approach to estimate past water temperatures. Mg/Ca ratios in foraminiferal calcite show temperature dependence due to the partitioning of Mg during calcification. In addition, measuring both Mg/Ca and $\delta^{18}O$ in the same foraminifera shells makes it possible to separate the magnitude and timing of SST and $\delta^{18}O_{water}$ changes (e.g., Elderfield et al., 2000; Lea et al., 1999; N• rnberg et al. 2000; Rosenthal et al., 2000).

The oxygen isotopic values will be used to reconstruct a temporal record of global climate/ice volume; the carbon isotopic values will be used to construct a record of carbon cycling; and the Mg/Ca ratios will be used to reconstruct a regional SST record of western North Atlantic Ocean climate. With this higher resolution biostratigraphic, paleoclimate and paleoenvironmental data, this study represents a valuable predictive tool for other geoscientists allowing for correlation between ocean basins further enhancing our understanding of this dynamic and variable period.

Strategy

In a completed pilot study of 20 sediment samples from Leg 171B site 1051 cores 16 through 25, there was a significant lack of benthic foraminifera but abundant and well preserved planktonic foraminifera (Figure 1). This study was revised to utilize planktonic foraminifera and an additional 126 samples from Site 1051 cores 14H through 30X were requested from International Ocean Drilling Program (IODP) Atlantic Core Repository. These cores encompass planktonic foraminiferal Zones E 9-11. The resolution of this study involved sampling every 1.5 m down core and spans the mid Eocene from 42 to 44 Ma (Figure 2).

Each sample has been cleaned and the planktonic foraminiferal assemblage is currently being examined, and identified to allow for refinement of the zonal markers as well as for calibration to the paleomagnetic data. These foraminifera will also be utilized for $\delta^{13}C$, $\delta^{18}O$, and trace element analysis using an isotope ratio mass spectrometer. Once the values for the proxies are obtained, they will be used several ways. First, the $\delta^{18}O$ data will provide the chronology for the sediment cores, and will be used to reconstruct a temporal record of global climate/ice volume. Second, carbon isotopic values will be used to construct a record of carbon cycling. Third, Mg/Ca ratios will be used to reconstruct a regional SST record of western North Atlantic Ocean climate. The combination of proxies will provide the history of the middle Eocene climatic dynamics in a regional and global context.

The objective of any environmental study is to examine and interpret the relationship between the biota and their environment. The ecological behavior of mid Eocene planktonic foraminifera at Blake Nose depends on biological, chemical and physical factors. A change in any of these elements drives changes in behavior that can be interpreted. Changes in marine sediment color (L* not shown) and magnetic susceptibility data (Figure 3) are proxies for changes in lithology. This cyclic variation in the record is a result of Milankovich orbital cycles, the primary effect of which are changes in seasonality affecting sedimentation rates, and biota recorded in the sediment record. Recognizing that cyclic signature in marine sediments depict changes climate and ocean circulation in response to changes in Earth's orbital configuration, these changes can be used for calibration of other proxies. As this study has retained the fine fraction, we can further analyze the bulk $\delta^{13}C$ to delineate cyclic shifts.

The diversity and preservation of planktonic foraminifera present in this study interval (select species shown in Figures 1 and 2) in addition to the number of species with first and/or last occurrence within this time period will allow refinement and recalibration of the foraminiferal Zones E9-11. In addition, it is noted that for *Globigerinatheka* "there is a pressing need for better calibrated ages for this genus." (Premoli Silva 2006). This biostratigraphic and environmental study provides an important tool through the middle Eocene, correlation with isotope records provides chronostratigraphic control and enhances our understanding of this dynamic and variable period.

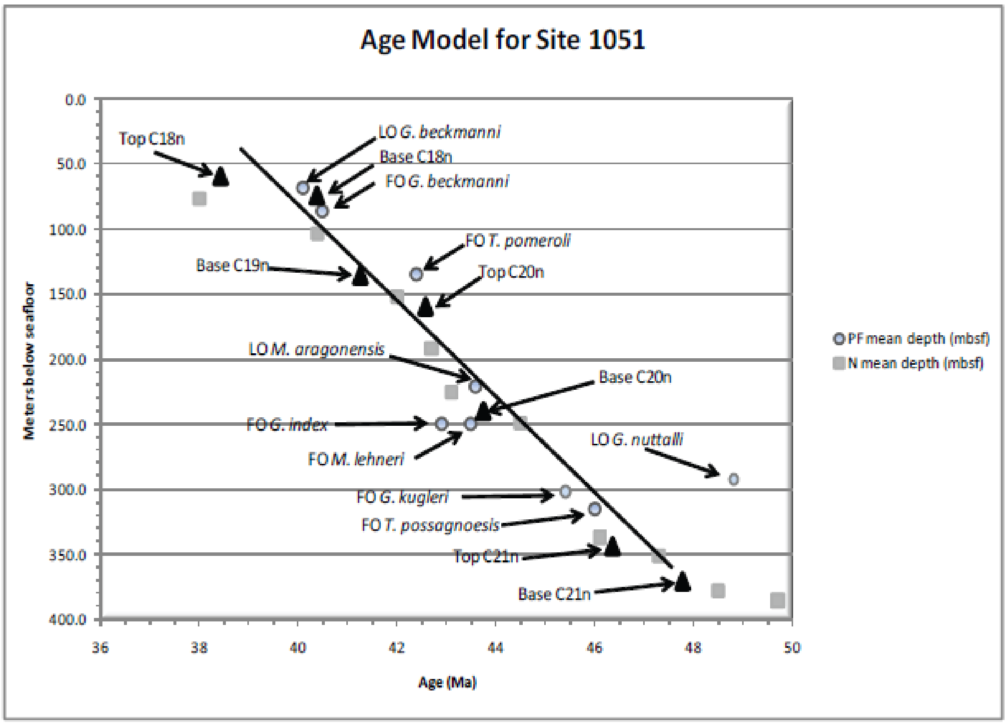


Figure 2. Age model for Site 1051 based on planktonic foraminifera (PF) and nannofossil (N) data compiled from Norris and Kroon (1998); Ogg and Bardot (2001).

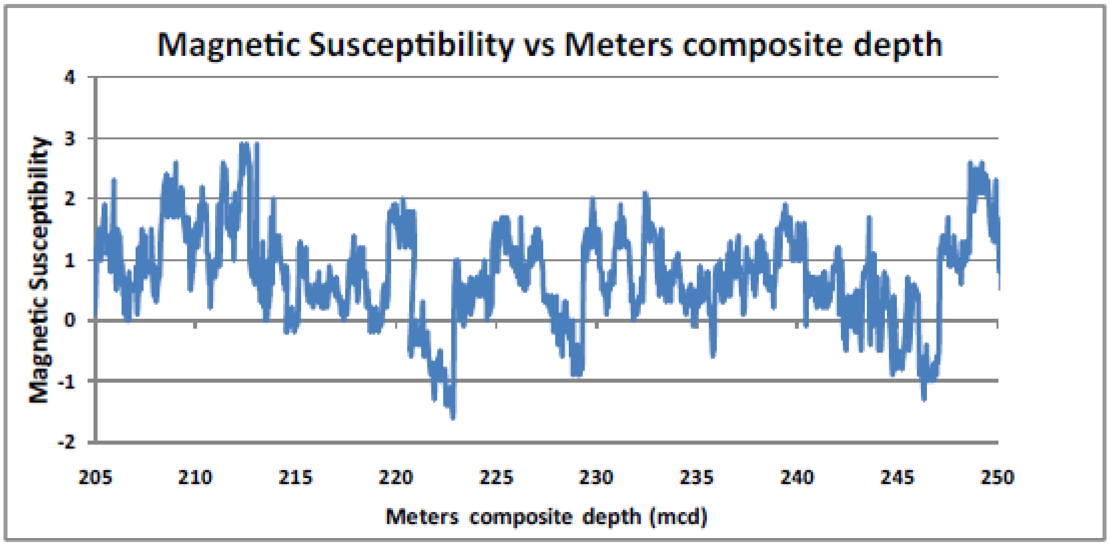


Figure 3. Magnetic susceptibility reflecting cyclicity in percent carbonate within this study interval, data compiled from Norris and Kroon (1998).

References Cited:

Elderfield, H., and Ganssen, G. 2000. Past temperature and $\delta^{18}O$ of surface ocean waters inferred from foraminiferal Mg/Ca ratios: Nature, v. 405, p. 442-445.

Emiliani, C., 1955. Pleistocene temperatures: Journal of Geology, v. 63, 538– 578.

Lea D.W., Mashiotta, T.A., and Spero, H.J. 1999. Controls on magnesium and strontium uptake in planktonic foraminifera determined by live culturing: Geochimica Et Cosmochimica Acta. v. 63. p. 2369-2379.

Norris, R.D., Kroon, D., et al., 1998, Proceedings of the Ocean Drilling Program, Initial results, Volume 171: College Station, Texas, Ocean Drilling Program, 749 p.

Nürnberg, D., Müller, A., and Schneider, R.R., 2000. Paleo-sea surface temperature calculations in the equatorial east Atlantic from Mg/Ca ratios in planktic foraminifera: a comparison to sea surface temperature estimates from $U^{k'}_{37,}$ oxygen isotopes, and foraminiferal transfer function: Paleoceanography, v. 15, no. 1, p 124-134.

Ogg and Bardot in Norris, R.D., Kroon, D., et al., 2001, Proceedings of the Ocean Drilling Program, Scientific Results, Volume 171: College Station, Texas, Ocean Drilling Program.

Premoli Silva, I., Wade, B., and Pearson, P., in Pearson, P., Olsson, R., Huber, B., Hemleben, C., and Berggren W. 2006. Atlas of Eocene Planktonic Foraminifera, Cushman Foundation Special Publication No. 41.

Quillevere, F., Norris, R.D., Kroon, D., and Wilson, P.A. 2008. Transient ocean warming and shifts in carbon reservoirs during the early Danian: Earth and Planetary Science and Letters. v. 265. p. 600-615.

Rosenthal, Y., Boyle, E.A., and Slowey, N., 1997. Temperature control on the incorporation of magnesium, strontium, fluorine, and cadmium into benthic foraminiferal shells from Little Bahama Bank: Prospects for thermocline paleoceanography: Geochim. Cosmochim. Acta. 61, v. 17.Pp. 3633-3643.

Shackleton, N.J., Opdyke, N.D., 1973. Oxygen isotope and palaeomagnetic stratigraphy of equatorial Pacific core V28-238: oxygen isotope temperatures and ice volumes on a 105 and 106 year scale. Quaternary Research 3, 39– 55.

Wade, B.S., and Kroon, D., 2002. Middle Eocene regional climate instability: Evidence from the western North Atlantic: Geology, v. 30, p. 1011-1014.