Understanding the Greenhouse World: Stable Isotope Signatures during the Early Eocene Climatic Optimum

Cindy Schrader Prof. dr. Lucas Lourens

Department of Earth Sciences, Utrecht University. C.D.Schrader@uu.nl

Universiteit Utrecht

NESSC NETHERLANDS EARTH SYSTEM SCIENCE CENTRE

ABSTRACT

To understand the complex climate system up to and during the warmest period of the Cenozoic, the Early Eocene Climatic Optimum [EECO], requires detailed, multi-proxy analysis of long, stable and high-resolution records.

Using a deep-sea sediment core from the Walvis Ridge expedition (ODP Leg 208, Site 1263)[1], we aim to produce such a record. Extending the record by Stap et al. (2010)[2], our record will cover the entire interval between the Elmo horizon (ETM2) and the EECO. We intend to measure stable oxygen ($\delta^{18}O$) and carbon ($\delta^{13}C$) isotopes and Mg/Ca on both surface-dwelling and thermocline dwelling planktonic foraminifera.

DRILLING LOCATION

- One of the main aims of ODP Leg 208 was to search for abrupt warming events events within the lower Cenozoic climate record. The cruise was successful. Continuous, undisturbed, multiple hole, lower Palaeogene successions at five sites along a 2-km water depth transect were recovered[1].
- This resulted in the first complete early Palaeogene deep-sea record accumulated at relatively high sedimentation rates. Thus providing perfect material for creating our high-resolution Early Eocene climatic record[1].

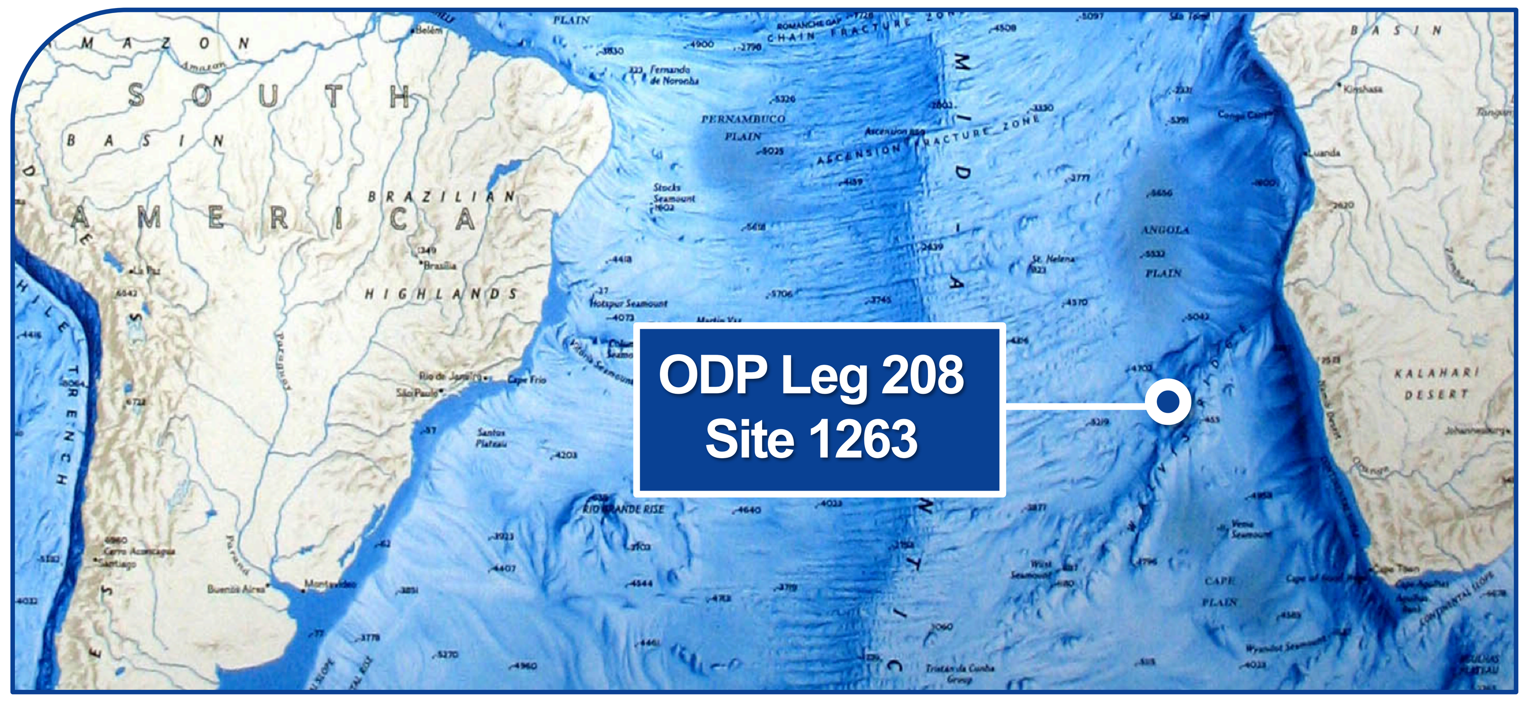

Figure 1. Location of ODP Leg 208 Site 1263 on the Walvis Ridge.

- Site 1264 is located at a water depth of 2507m near the crest of a north-south–trending segment of the Walvis Ridge and was drilled in April 2003, as the shallowest site of ODP Leg 208[1].

CENOZOIC CLIMATE

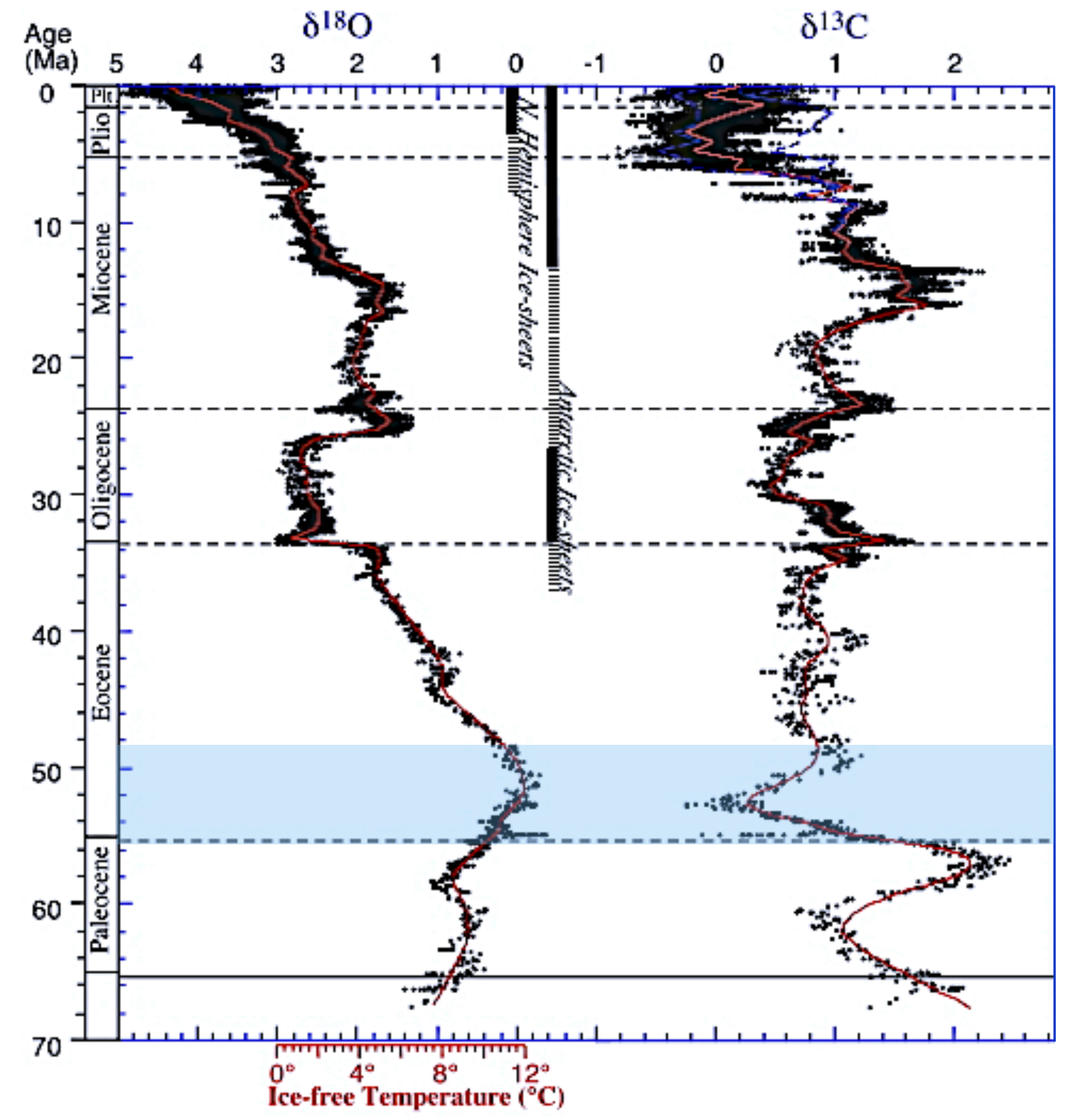

Figure 2. Global deep-sea $\delta^{18}O$ and $\delta^{13}C$ records based on data compiled from more than 40 DSDP and ODP sites[3]

- The Late Paleocene to Early Eocene climate was characterized by a prolonged warming trend between 55 and 50 Ma. Superimposed on this trend was a series of abrupt global warming events know as “hyperthermals”. These events can be recognized by a sharp negative excursion in the $\delta^{18}O$ and $\delta^{13}C$ records, as well as large-scale carbonate dissolution in the deep-sea sediments. This indicates a rapid temperature increase co-occurring with the release of large amounts of isotopically light carbon and a rise of the CCD.
- Of these events, the Paleocene-Eocene Thermal Maximum (PETM) was the most intense, followed by the ETM2 (Elmo event) and the ETM3 (X-event). The re-occurring of hyperthermals throughout the Early Eocene, though less dramatic, strengthens the hypothesis of a common nature. By generating high-resolution records we can investigate the role of orbital forcing on the timing of hyperthermals.
- Also, by creating multiple stable isotope records based on the same samples, while using foraminifera with different calcification depths, makes it possible to investigate what the species-specific effects are on the stable isotope signals, as well as possible variability due to differences in water masses.

FORAMINIFERA

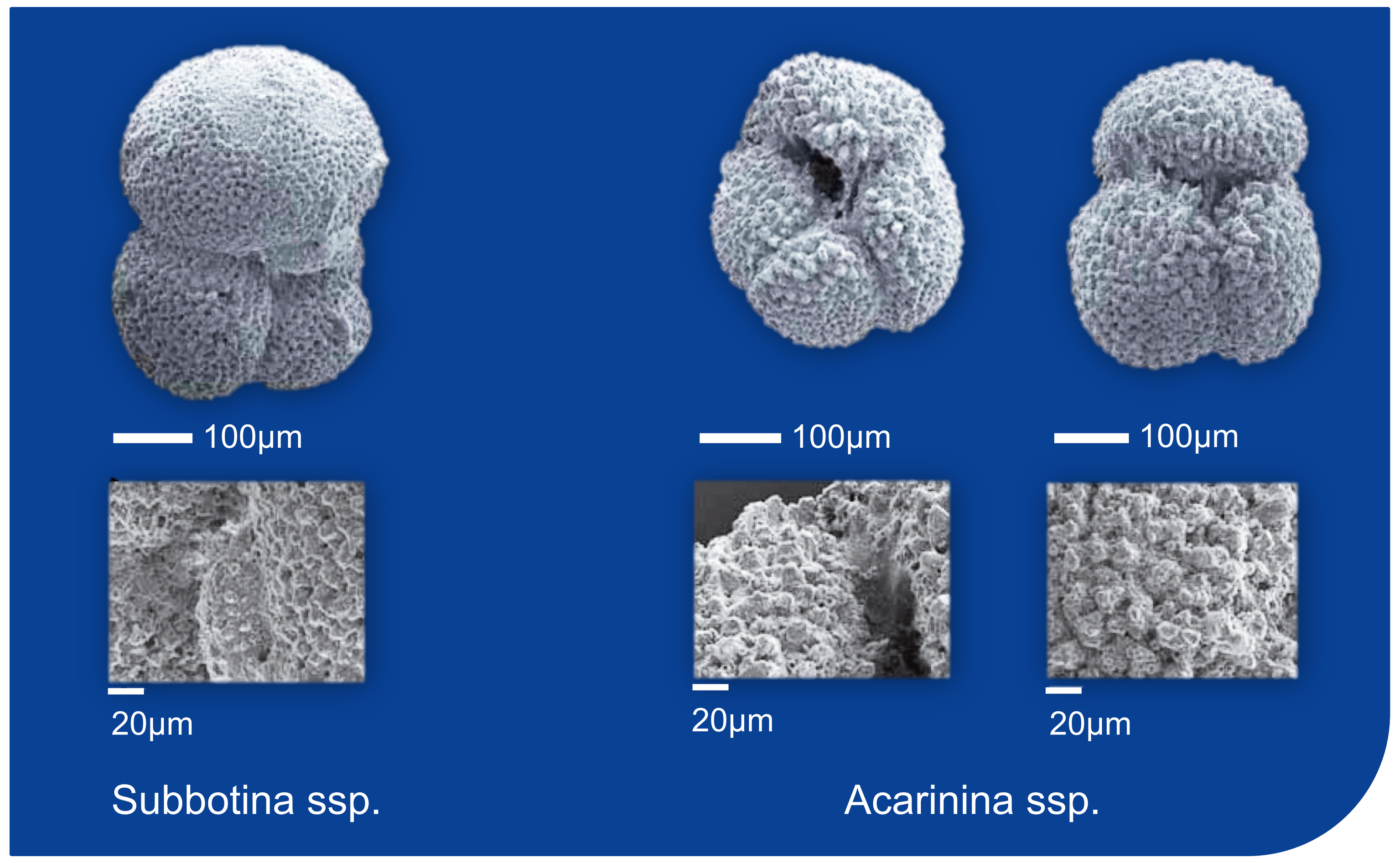

Figure 3. Scanning Electron Microscope [SEM] images of the tests and detailed wall structures of unsonicated specimens of *Subbotina spp.* and *Acarinina spp.*[2]

- Isotopic analysis will be carried out on the surface-dwelling foraminifera genus *Acarinina* and on the thermocline-dwelling genus *Subbotina*[2,4].

FUTURE WORK

- Future work will be focused on comparing our planktic $\delta^{18}O$ and $\delta^{13}C$ records with other data from Site 1263 including:
  - Benthic stable isotope records (to investigate differences in the stable isotope signals due to calcification depth).
  - [Mg]/[Ca] data (to justify the reconstructed temperature based on the $\delta^{18}O$ signature records from other and with a yet to be measured record).
  - Magnetic susceptibility and elemental analysis [XRF] (for conducting a cyclostratigraphic study and age model).
- Other records covering the EECO will also be assessed for a global comparison. For this we will use both data from other deep ocean records (from neighboring sites as well as from other ocean basins) as well as some land-based sections.

REFERENCES

1. Zachos, J.C., Kroon, D., Blum, P., et al., 2004 Proceedings of the Ocean Drilling Program, Initial Reports Volume 208, Ocean Drilling Program
2. Stap, L., Lourens, L.J, van Dijk, Schouten, S., Thomas, E. (2010), Coherent pattern and timing of the carbon isotope excursion and warming during Eocene Thermal Maximum 2 as recorded in planktic and benthic foraminifera, Geochem. Geophys. Geosyst., 11, Q11011
3. Zachos, J., Pagani, M., Sloan, L., Thomas, E. and Billups, K., (2001), Trends, rhythms, and aberrations in global climate 65 Ma to present, Science, 292 (5517) 686-693.
4. D’Hondt, S., Zachos, J.C. (1998), Cretaceous foraminifera and the evolutionary history of planktic photosymbiosis, Paleobiology, 24 (4), 512-523.