

Impact of the Middle Eocene Climatic Optimum on Planktic Foraminiferal Resilience in the Atlantic Ocean

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1. CLIMATIC CONTEXT AND AIMS

Middle Eocene Climatic Optimum (MECO)
A global warming event occurred 40 Ma, lasting 500 kyr

A break in the cooling trend
Temporarily interrupted the long-term global cooling after the Early Eocene Climatic Optimum (EECO, ~49 Ma)

Key unresolved aspects

- No clearly identified trigger mechanism
- Greater than expected sea carbonate dissolution
- Lack of clear biotic response, particularly in planktic foraminifera → **FOCUS ON THIS GAP**

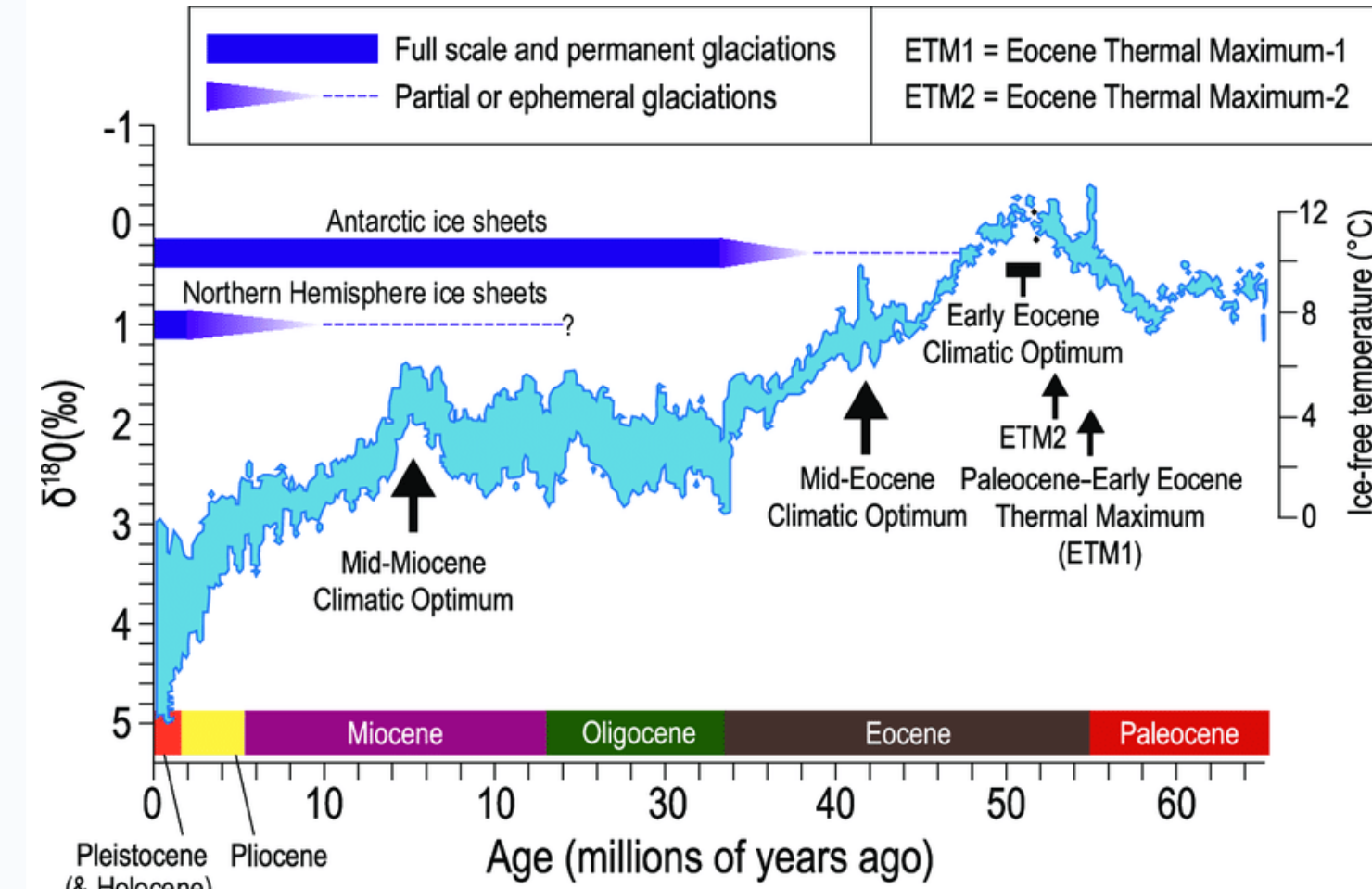


Fig.1 Cenozoic paleotemperatures and pCO₂ (mod. from Zachos et al., 2008).

2. PLANKTIC FORAMINIFERA ECOLOGY

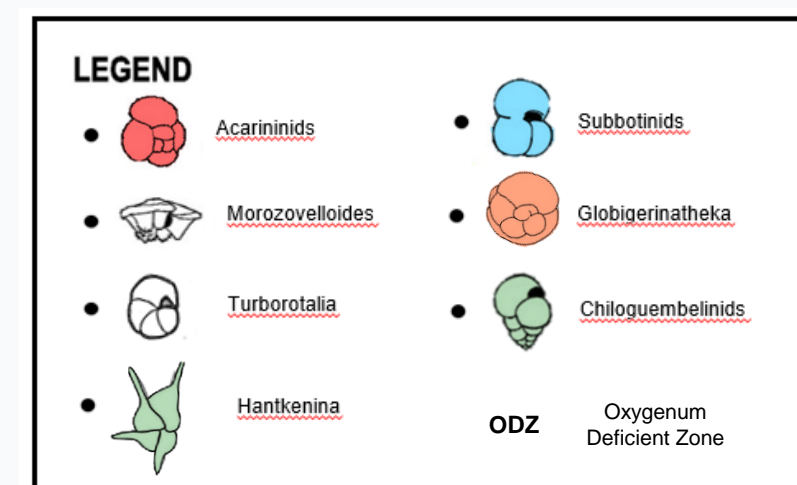
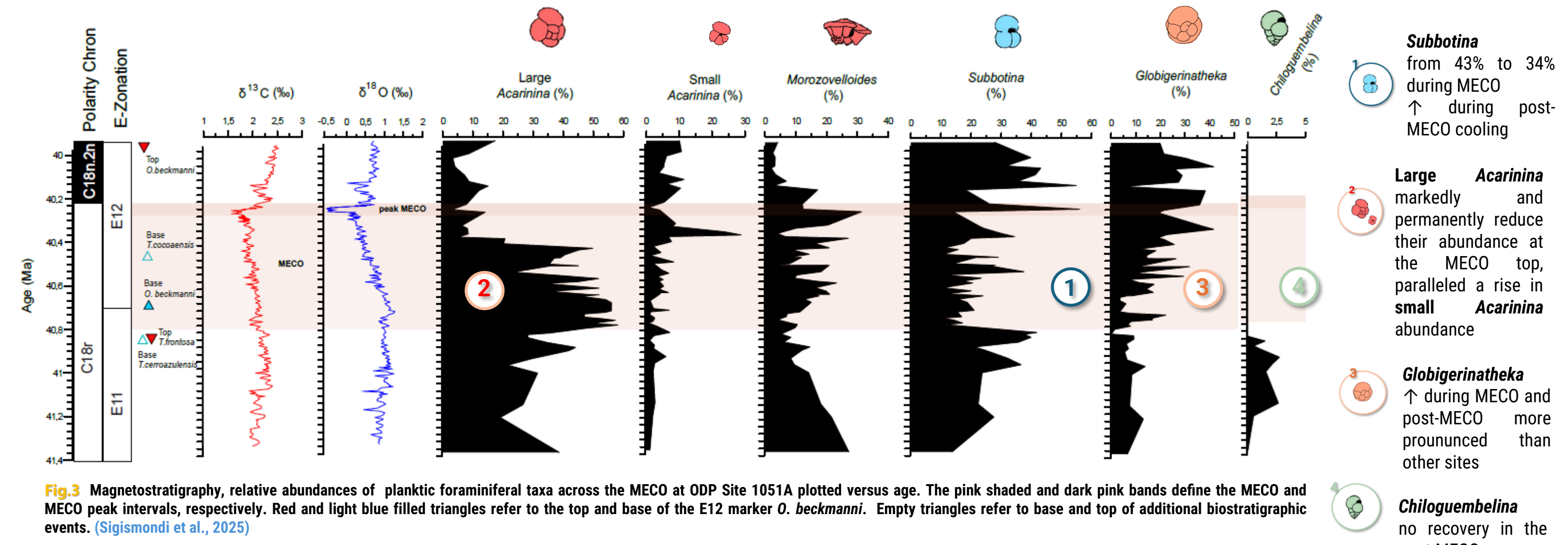
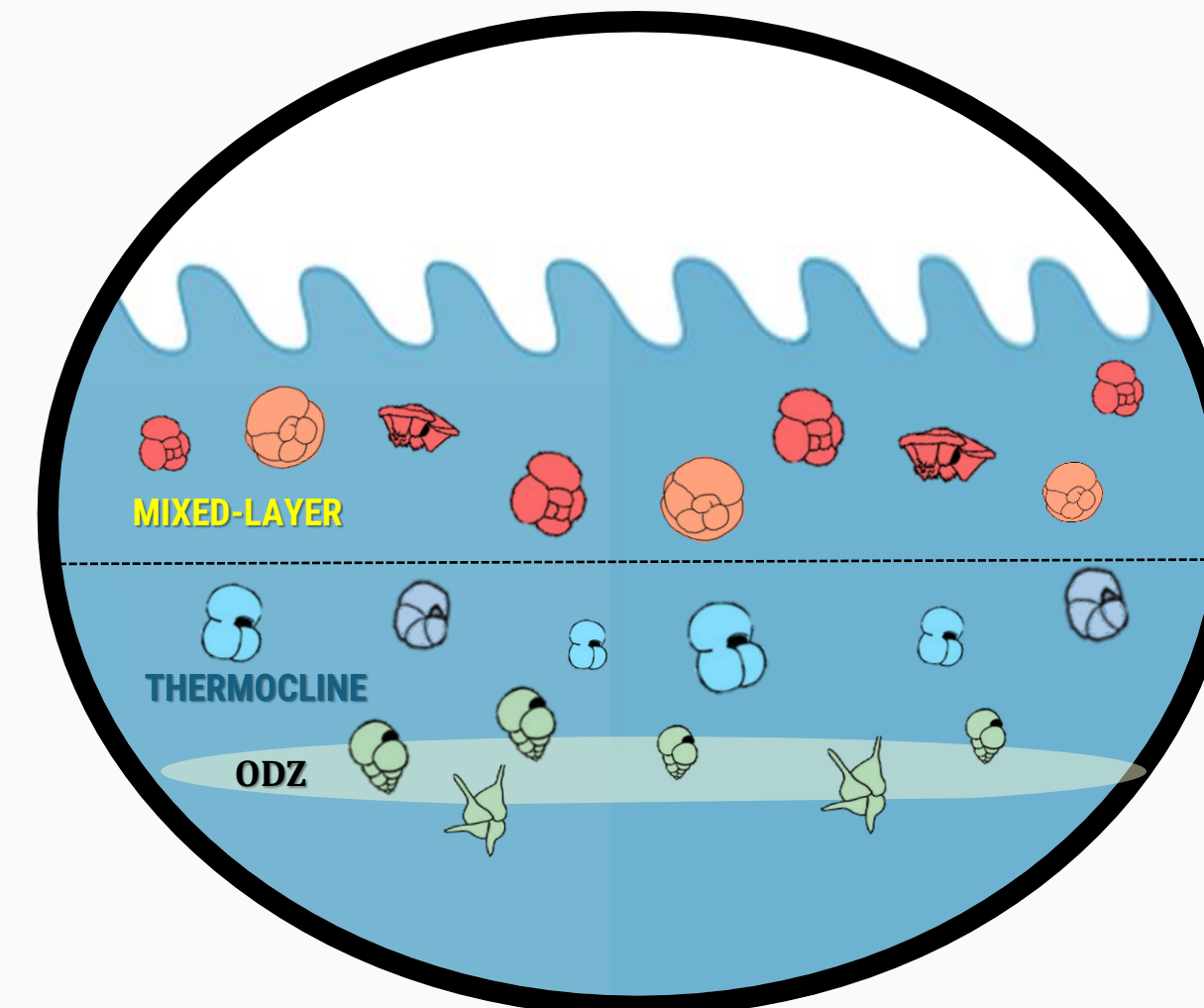
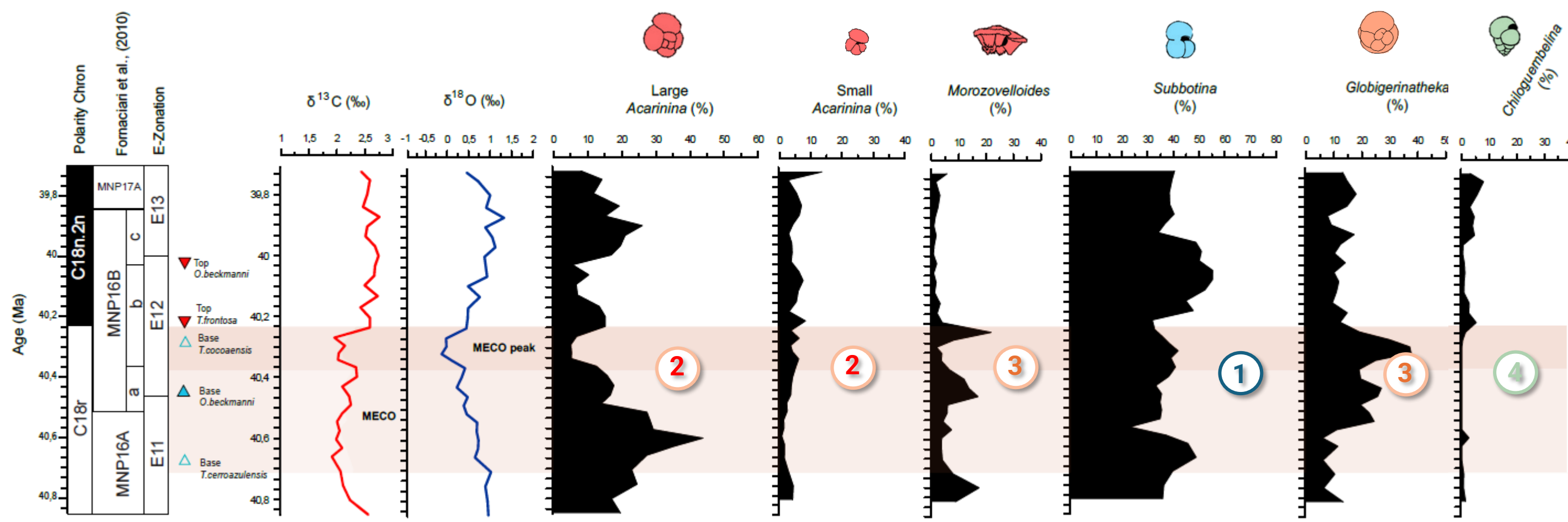


Fig.2 Cartoon illustrating the distribution pattern of main middle Eocene planktic foraminifera genera in water columns. In our quantitative data we kept separated the Large *Acarina* (>150) from the Small *Acarina* (<150) as they show a different response from the Tethyan realm (Luciani et al. 2010; D'Onofrio et al. 2021). The former group includes *A. primitiva*, *A. mcgowani*, *A. rohr* while the latter group comprises *A. echinata*, *A. medizai*, *A. collettei*. In red warm symbiotic bearing taxa, in orange warm taxa, in blue cold genera and in green ODZ taxa.



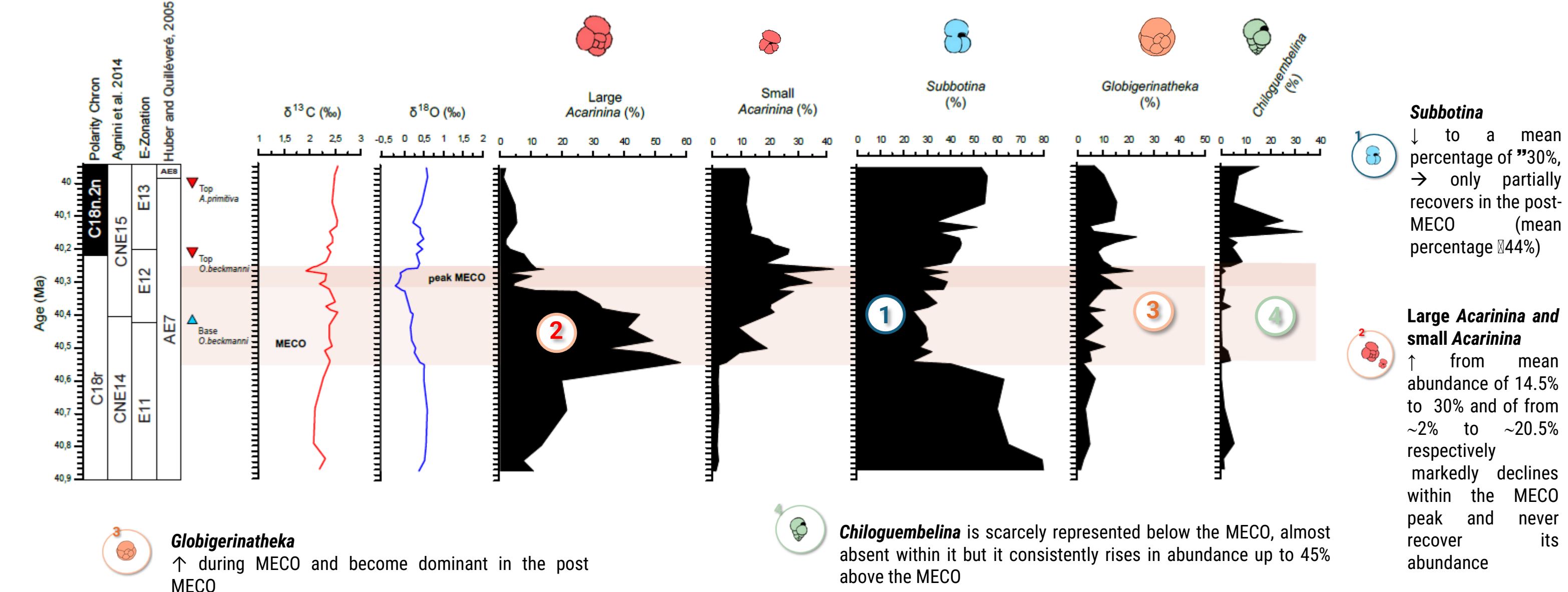
3.2 RESULTS: Site 1263

Fig.4 Stable isotope records from Westerhold et al. (2020), relative abundances of planktic foraminifera assemblage across the MECO at ODP Site 1263 plotted versus age. (Sigismondi et al., 2025).



3.3 RESULTS: Site 702

Fig.5 Magnetotratigraphy, bulk stable isotope records from Rivera-Cuesta et al. (2019) plotted against age and the relative abundances of planktic foraminifera assemblages across the MECO at ODP Site 702. (Sigismondi et al., 2025).



DISCUSSIONS

Palaeogeography, Palaeoclimatology, Palaeoecology
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Evaluating planktic foraminiferal resilience during the Middle Eocene Climatic Optimum (MECO) in the Atlantic Ocean

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- Well-stratified water column with relatively abundant cold-water taxa like *Subbotina*, *Turborotalia*, *Hantkenina* and *Chiloguembelina*
- Increase in warm index taxa such as *Acarinina*, *Morozovelloides*, and decline in subbotinids, reduced water-column stratification
- Warm-water taxa like *Globigerinatheka*, *Morozovelloides* and small *Acarinina* become more abundant during the MECO
- Partial recovery of cold water and ODZ taxa, with the genus *Globigerinatheka* generally dominating the warm index communities.

GLOBIGERINATHEKA INCREASE

Did Globigerinatheka take over Acarinina's ecological niche?

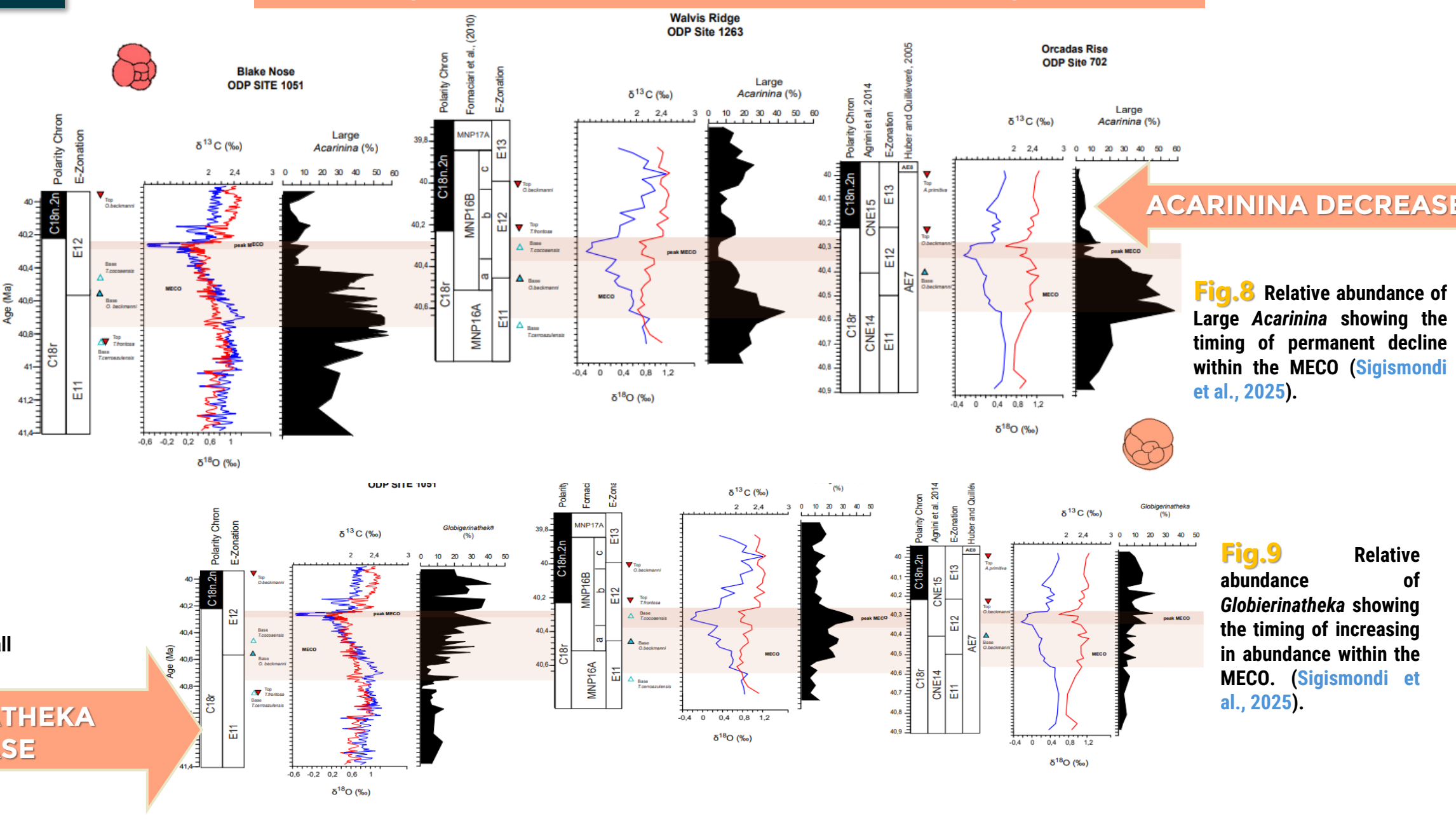


Fig.8 Relative abundance of Large *Acarina* showing the timing of permanent decline within the MECO (Sigismondi et al., 2025).

Fig.9 Relative abundance of *Globigerinatheka* showing the timing of increasing in abundance within the MECO. (Sigismondi et al., 2025).

CONCLUSIONS

1. **RESILIENCE LOSS:** Assemblages did not return to pre-MECO structure, indicating loss of resilience

2. **LARGE-ACARININA DECLINE AT THE MECO: PRE-EXTINCTION EVENT?** Large *Acarina* showed a marked, widespread, and permanent decline during the MECO, also recorded in the Tethys. This possibly reflects changes in symbiotic relationships rather than bleaching. In contrast, Small *Acarina* remained stable or increased, suggesting greater ecological flexibility

3. **SOUTHERN MIGRATION OF WARM INDEX TAXA:** MECO warming drove a southward migration of warm-water taxa (Large and Small *Acarina*, *Globigerinatheka*, *Morozovelloides*), also seen in calcareous nannofossils. At Site 702, planktonic foraminifera responded ~40 kyr earlier than nannoplankton, indicating higher sensitivity to warming, while nannoplankton likely responded more to trophic changes

4. **CHILOGUEMBELINIDS DECLINE: ENHANCED OXYGENATION AT THE OCEAN DEPLETED ZONE?** A marked and widespread decline of the genus *Chiloguembelina* is observed across all studied sites during the MECO, likely linked to improved oxygenation of the ODZ, as also suggested by parallels with other global warming events, although direct nitrogen isotopic evidence for this mechanism during the MECO is currently lacking

5. The MECO marks a shift from cold-water, stratified-column taxa to warmer-water assemblages, with latitudinal migration and increases in ODZ-associated taxa. The new configuration reflects lasting ecological change rather than recovery

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