Evolution of reticulate *Nummulites* across the Eocene-Oligocene transition

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Introduction

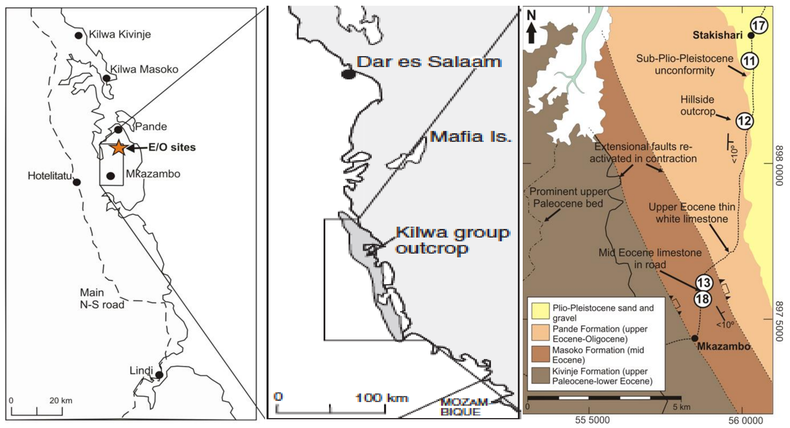
- The Eocene-Oligocene transition (EOT) was a time of climatic cooling and oceanographic change from 33.5-34 Ma[1].
- A biotic turnover is recognised in many organisms including Large Benthic Foraminifera (LBF)[2].
- The reticulate genus *Nummulites* are a group which pass through this transition.
- Preliminary data from the Tanzania Drilling Project show an increasing variation in their morphology thought the EOT[3].
- Work on planktonic foraminifera such as *Turborotalia* has shown that this kind of variation and expansion of morphology often precedes speciation[4].
- We apply similar methods to a high-resolution dataset of reticulate *Nummulites* spanning approximately 2 My across the EOT.
- This is then coupled with climate data from the same samples and physiological data from modern foraminifera to investigate drivers of any possible morphological change.

Objectives

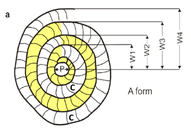
- Examine how reticulate *Nummulites* morphology is changing through the EOT!
- Assess whether morphological changes are driven by environmental factors?
- Do these morphological changes lead to speciation? If so, are these changes discrete/continuous/random?

Materials and Methods

Field Area - Tanzania



Methodology



EOT *Nummulites* specimens from Tanzanian drilling project sites 11,12,17 (see figure above).

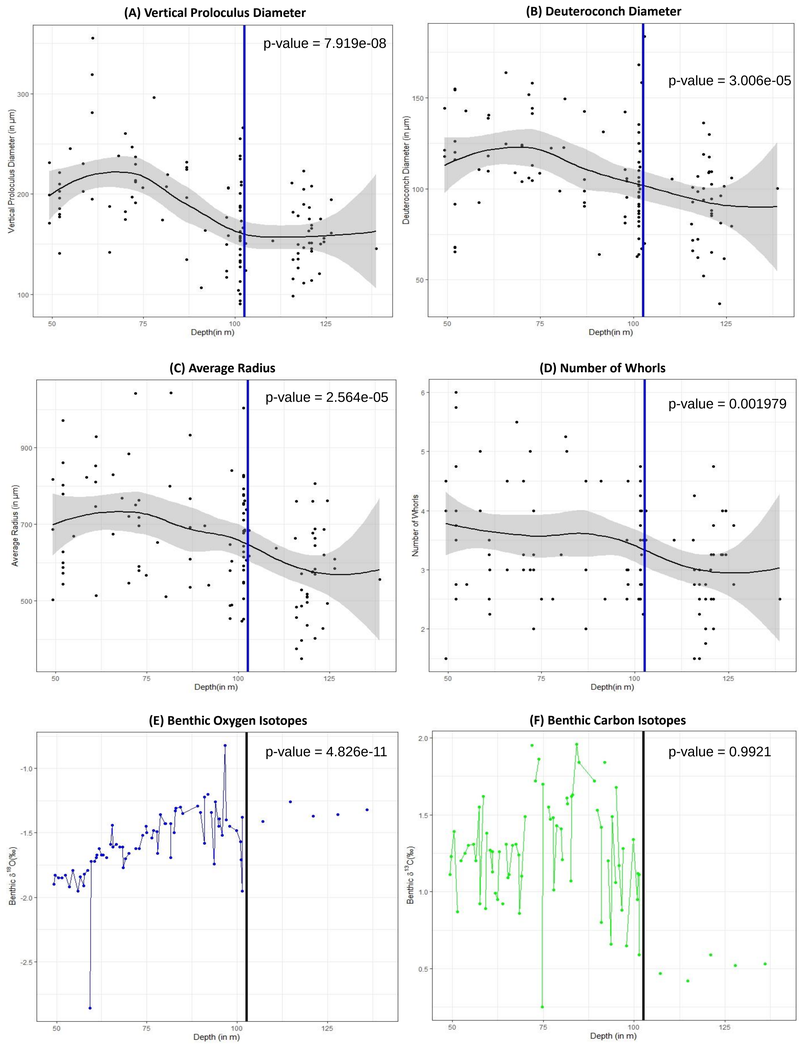
Morphological features (Proloculus diameter; deuteroconch diameter; average radius; number of whorls, number of chambers (c) in each whorl) measured from 2D equatorial sections of *Nummulites* specimens using ImageJ Software.

Oxygen and carbon isotope data from Pearson et al. 2008's study of the same sites.

Data Recorded → Data and statistical analysis in R program

Results

- Clear and similar variations seen in morphological features of reticulate *Nummulites* across EOT.
- Depth in cores analogous to geological ages → 49.32m depth (~33.05 Ma) to 138.69m (~34.07Ma). EOT Boundary established at 102.7m[5].
- Morphological features showing an increase in measures with increasing variations after the EOT boundary.



Figures showing variations in morphological parameters of genus *Nummulites* with depth in cores (~Geological time): Parameter such as Proloculus/Deuteroconch diameter, radius are measured along the same line (R-line) in order to maintain the orientation. The table below shows p-value correlations between morphological features and isotopic data.

Morphological feature (in 2D section)	Benthic $\delta^{18}O$	Benthic $\delta^{13}C$
Vertical Proloculus diameter	0.1104	0.002601
Deuteroconch diameter	0.03024	0.01853
Average Radius	0.02715	0.002411
Number of whorls	0.131	0.1246

Discussions

- Relative prominent change is in proloculus size which is linked to reproduction in these foraminifera. It is possible that morphologically distinct generations of same species can be produced[6].

- Benthic $\delta^{18}O$ → Proxy for temperature; Benthic $\delta^{13}C$ → Proxy for nutrients.
- Morphological variations well related with both climatic variations and nutrient availability (Deuteroconch diameter, Average Radius of the *Nummulites* test), some features (Proloculus diameter) show variations only with nutrients.
- The number of whorls are clearly variable across the EOT but not seen to varying with climatic variations/nutrient availability.

- Clear morphological shifts observed in features across EOT, suggesting this can be a dynamic interval for evolution in reticulate *Nummulites*.
- Feature variations → Important to investigate morphological changes in 3D as well.

Further Investigations

❑ Investigate variations across other 2D morphological features of *Nummulites* specimens.

❑ Variations in (additional) morphological features with environmental conditions to be further explored.

❑ 3D reconstructions (using Dragonfy software) of the whorls of these *Nummulites* tests from certain depths to observe whether there in any information gain/ loss w.r.t the 2D equatorial sections. A previous work on *Nummulites djokdjokartae* from middle Eocene shows increasing asymmetry, complexity in chamber shapes as more whorls develop[7].

❑ Use of select morphological features and their measures from 2D sections and 3D reconstructions to study and understand any possible evolution of species[4].

Acknowledgements

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References

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