Calcareous nannofossil size as a proxy for the Messinian Salinity Crisis dynamics

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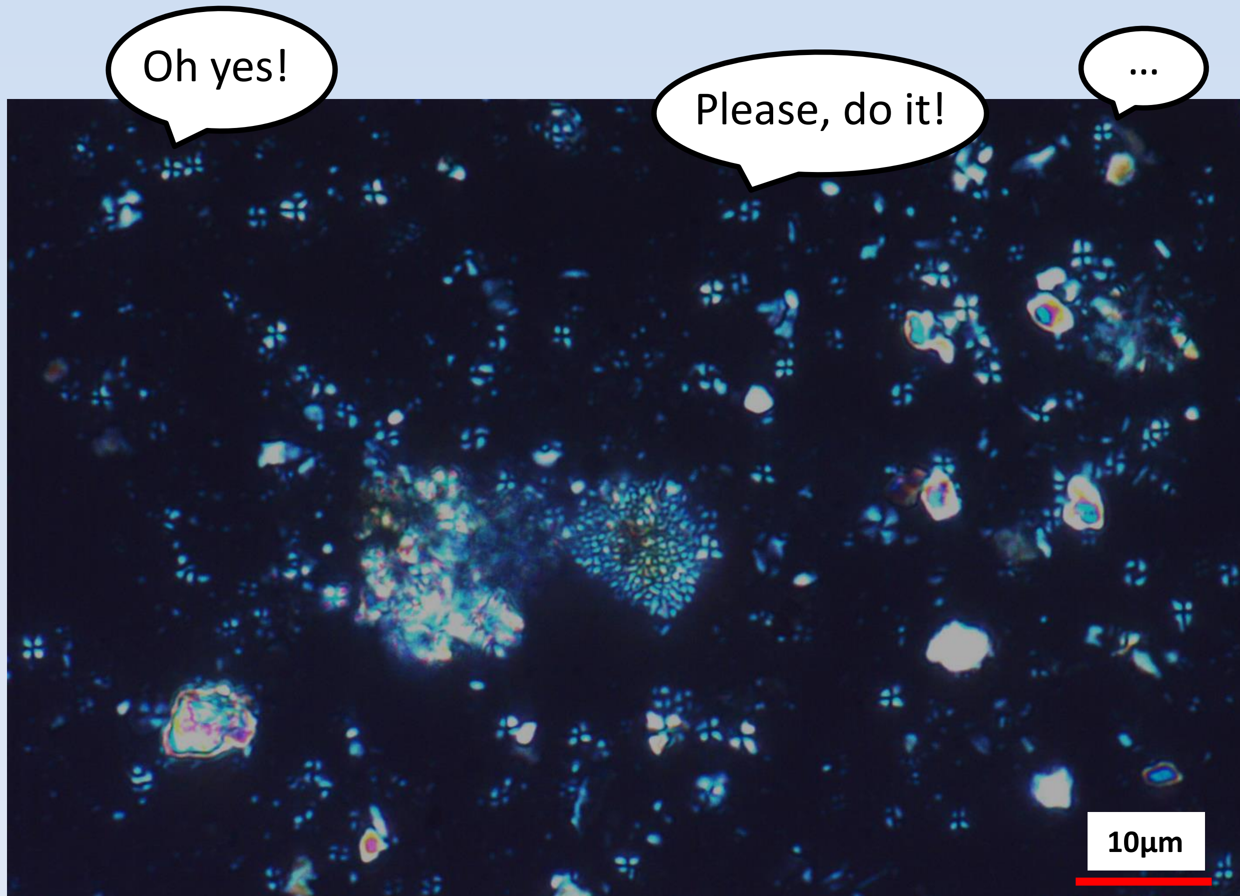
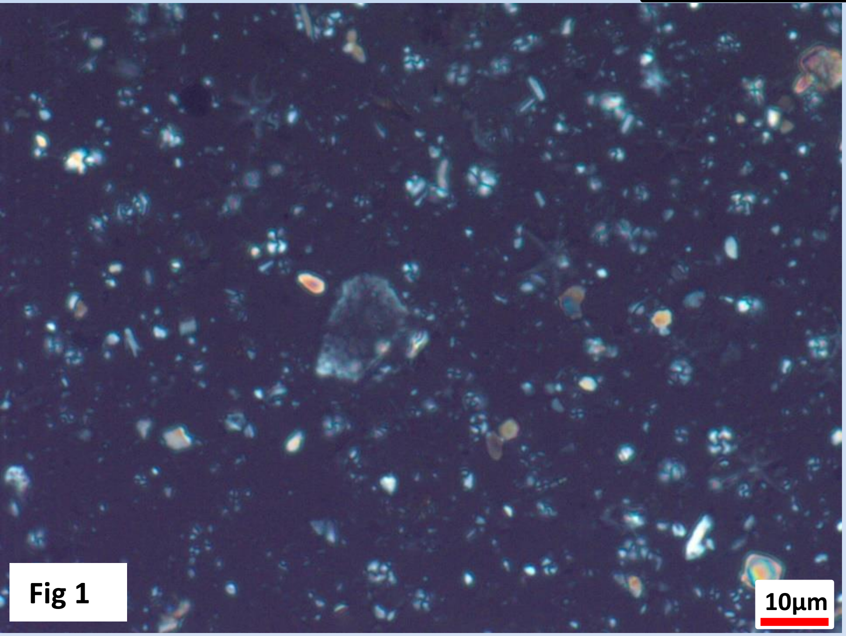
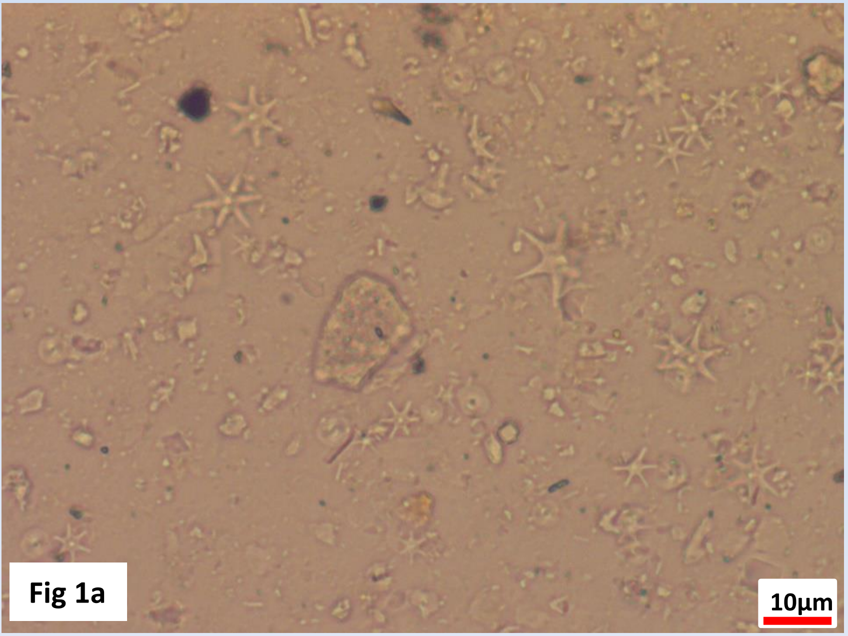


INTRODUCTION





What are the calcareous nannofossil?

Calcareous nannofossil are very small fossil remains, made up of calcite, that are produced by marine organisms, mostly by Coccolithphores

Why are they so important for the paleoenvironmental reconstruction?

Firstly because they are preserved in the fossil record. Their assemblage, morphological features as well as the isotope/trace elements of their calcite potentially reflect the environmental condition in which they lived.
Consequentelly, the calcareous nannofossil are effective tools for paleoenvironmental reconstruction purpose

Calcareous nannofossils are often used to track the past (as well as the present…) environmental dynamics, especially during extreme events

Fig. 1, 1a: light microscope photographs (1: crossed polarizers, 1a. Parallel polarizers) showing calcareous nannofossil assemblage

Calcareous nannofossil response to extreme event

Fig 2

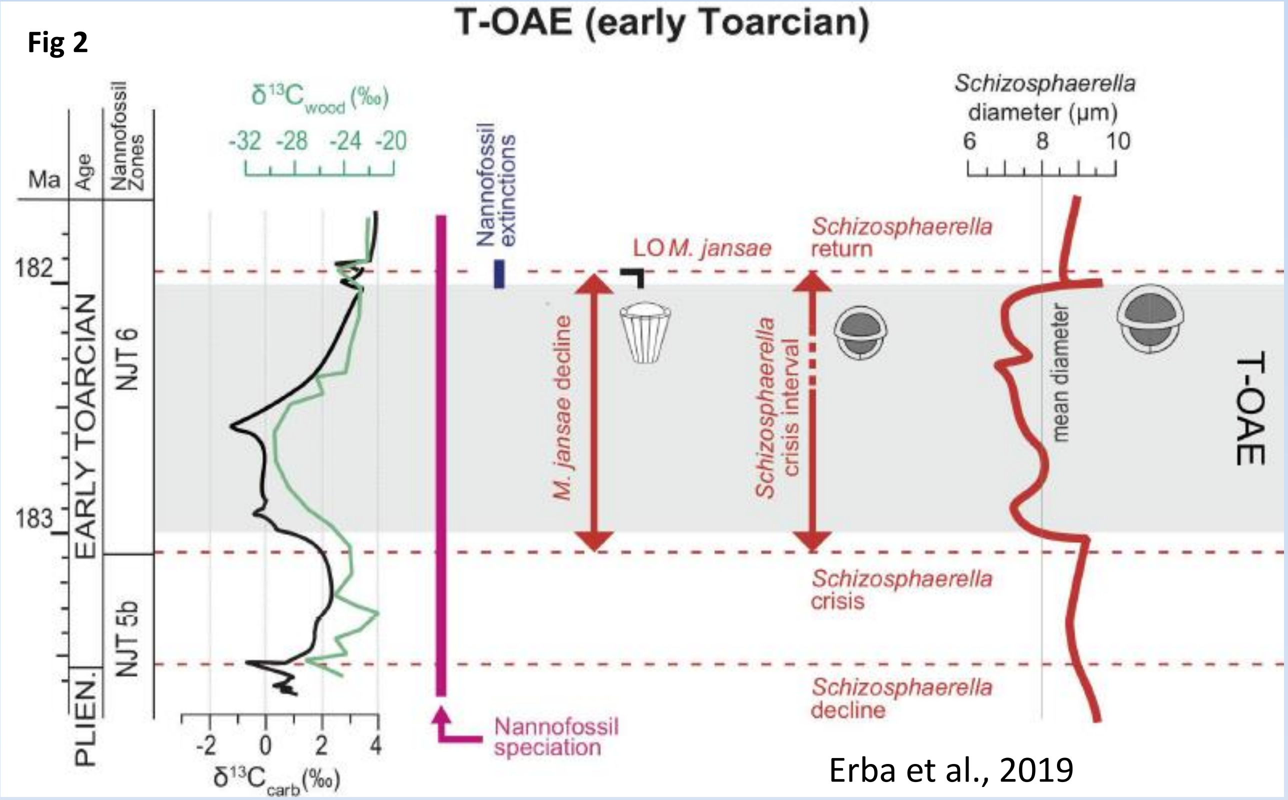
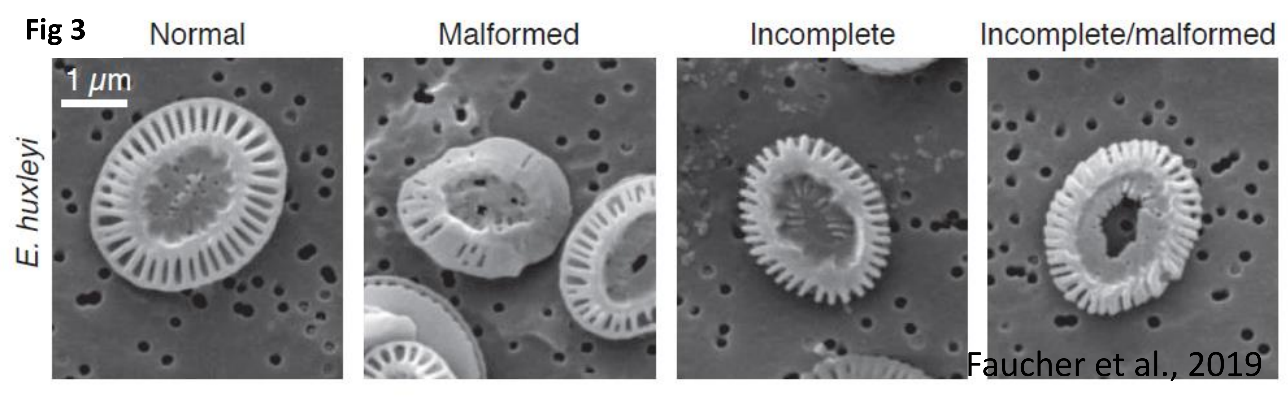


Fig 3



The aftermath of extreme events, greenhouse warming, eutrophication, shallowing/shrinkage of the basins and volcanic events, frequently result in an overall size reduction affecting the marine biota (Tremolada et al., 2008; Mattioli et al., 2009; Keller and Abramovich, 2009; Erba et al., 2010; Lubke et al., 2015; Ferreira et al., 2017; Salaviale et al., 2018)

Calcereous nannofossils respond to extreme events decreasing their size and/or showing malformation (Erba et al., 2010; Faucher et al., 2019)

The calcareous nannofossils response to extreme event is species specific

Fig 2: Calcareous nannofossil biometric response to T-OAE

Fig 3: Emiliania huxley normal morphotype Vs malformed morphotype

Calcareous nannofossil response to the Messinian Salinity Crisis

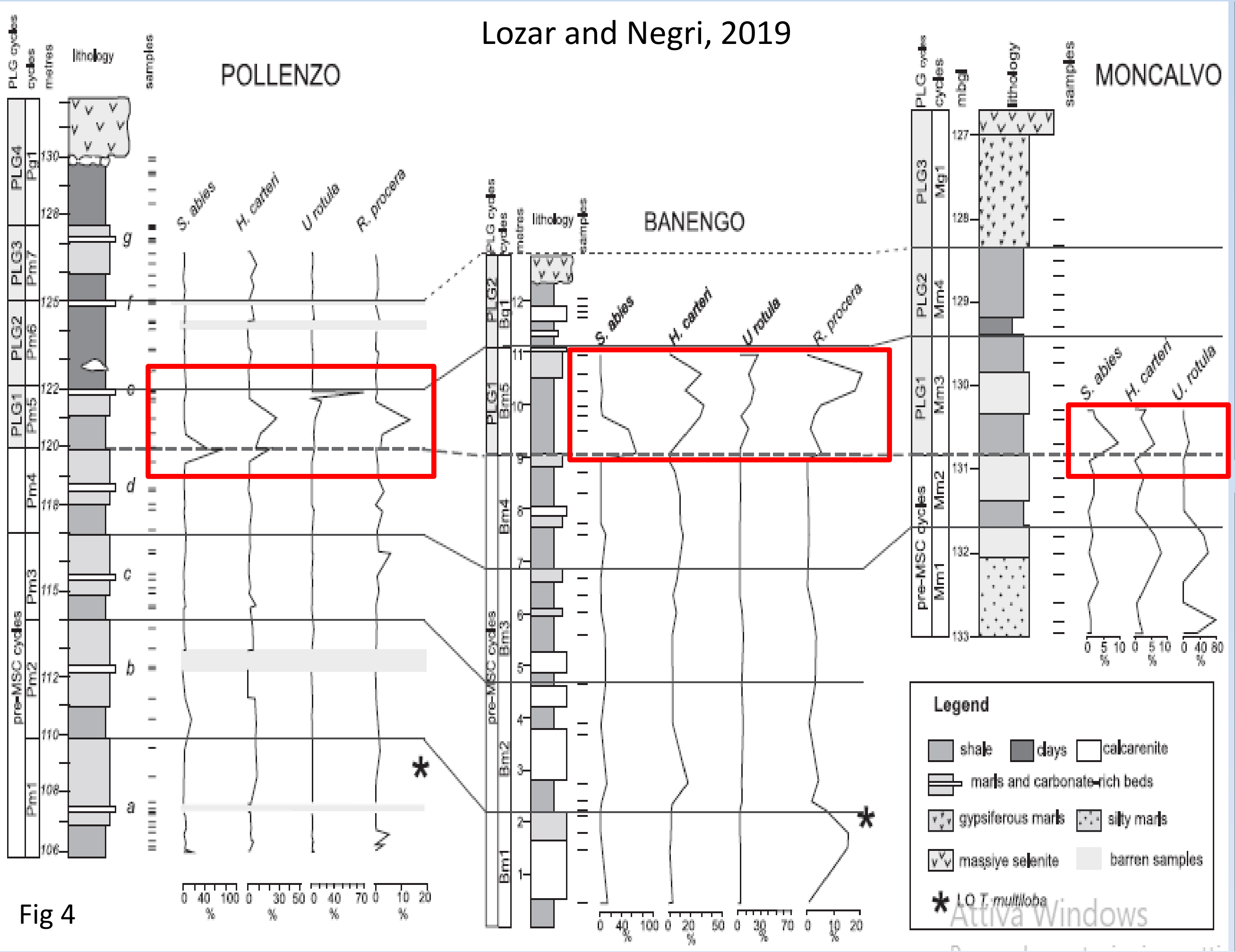


Fig 4

To date, no study adressed biometric response of calcareous nannofossil to one of the most recent and extreme event affecting the Mediterranean Basin: The Messinian salinity Crisis (MSC)

The sensitivity of the calcareous nannofossils during this time interval is demonstrated by a peculiar fossil signal recorded in several successions approximating the MSC onset

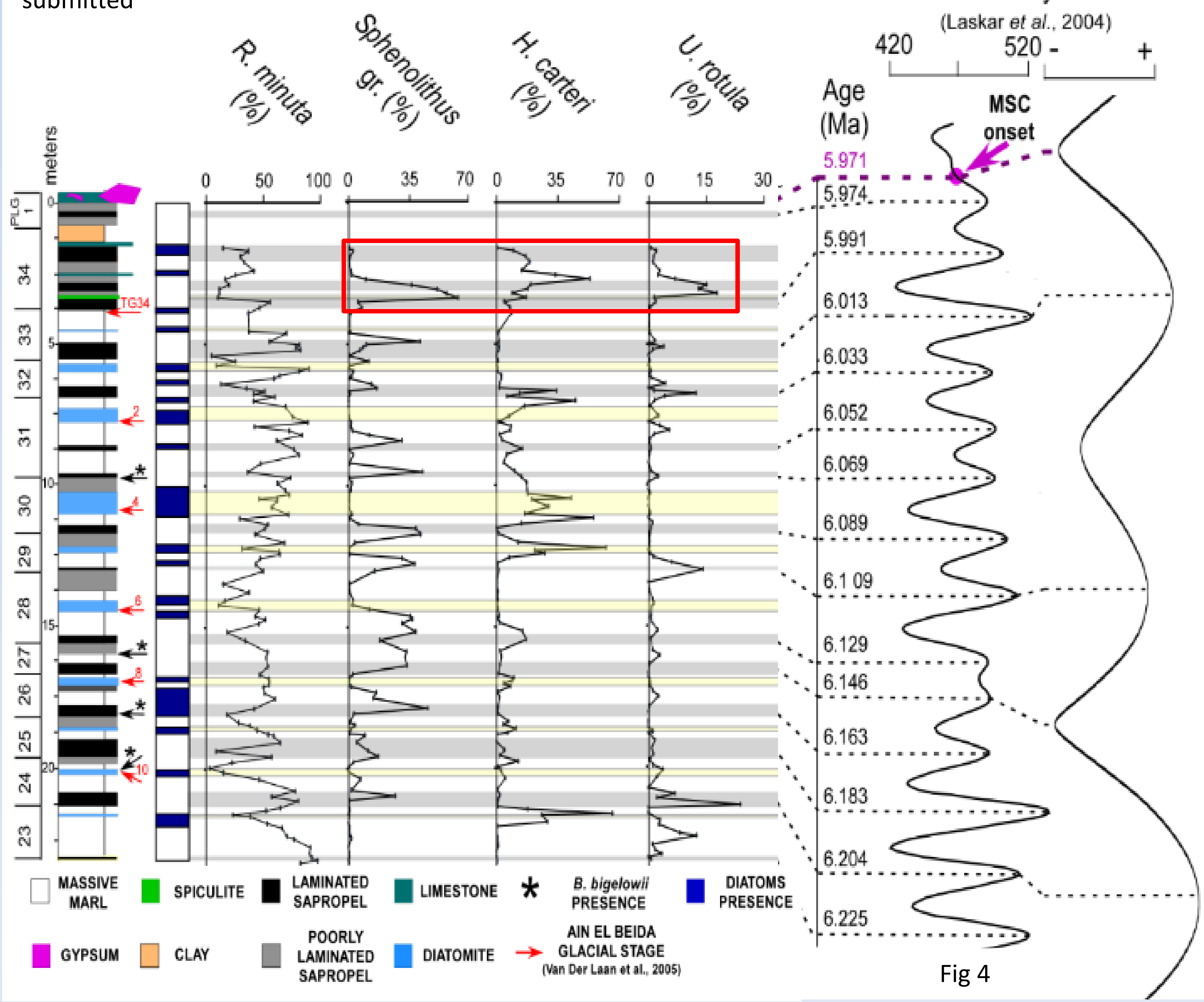
This event was recently named "MSC onset bioevent" and it is composed by a succession of peaks in abundance of the species *Sphenolithus abies*, *Helicosphaera carteri*, *Umbilicosphaera rotula* and *Rhabdosphaera claviger*

Fig 4: The MSC onset bioevent record in 3 sections of the Piedmont Basin. Red rectangles mark the MSC onset bioevent

Calcareous nannofossil response to the Messinian Salinity Crisis

Mancini et al., submitted

Perales section (Sorbas Basin)



The MSC onset bioevent was recently recorded also in the Western Mediterranean, suggesting that the same paleoenvironmental conditions triggered the MSC onset in the whole Mediterranean

The MSC onset bioevent marks a restriction pulse driven by tectonic activity, that resulted in an increase in the sensitivity of the Mediterranean Basin (Mancini et al., submitted)

Fig 5: The MSC onset bioevent record in the Sorbas Basin

Aim of the work

To describe and quantify the biometry and morphology change affecting the calcareous nannofossil toward the MSC onset

To constrain the trigger of eventual calcareous nannofossil biometry and morphometry change

Are they related to orbitally driven climatic/oceanographic changes (i.e. the precession variability)?

Are they related to changes in abiotic/biotic environmental parameters (e.g. Temperature, salinity, productivity, pCO_2)?

Comparison with laboratory culture experiments and the available proxies during the Messinian

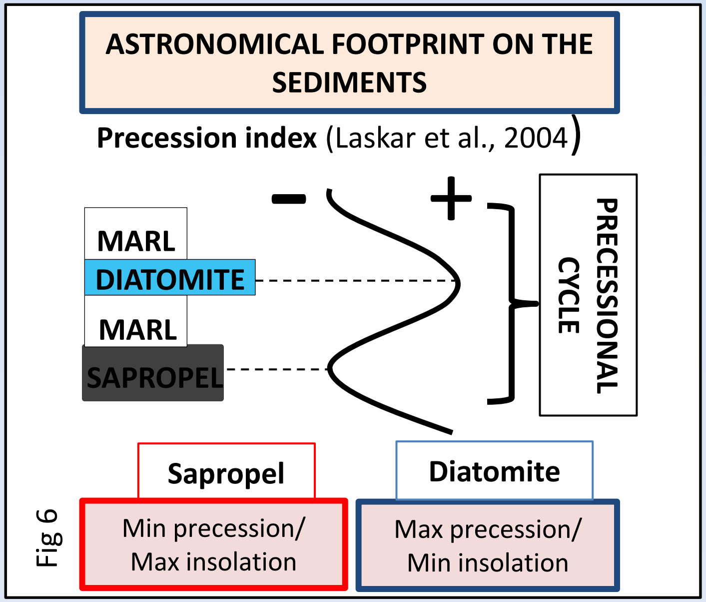


Fig 6: Synthethic scheme illustrating the precession-driven quadripartite cycle in the pre-evaporitic Sorbas Basin

MATERIAL AND METHODS

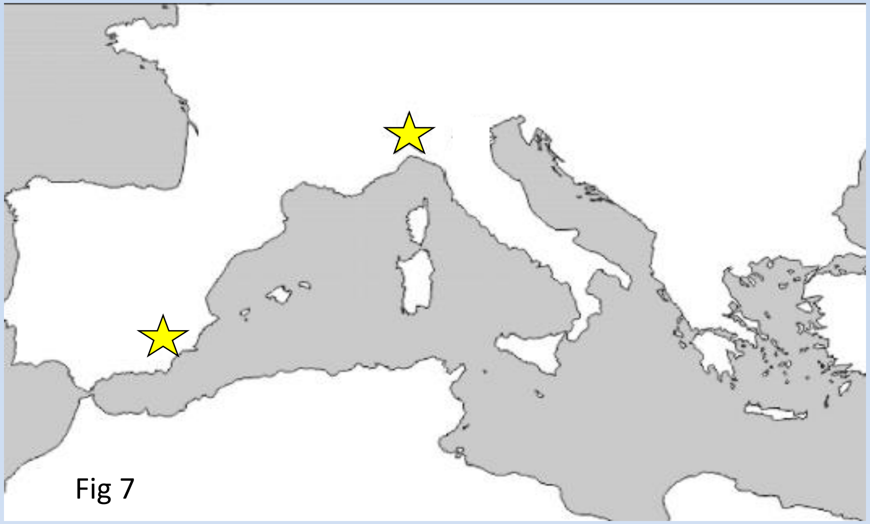
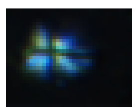
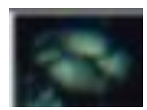
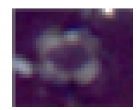


Fig 7

In order to demonstrate that the biometric change affecting calcareous nannofossils are not stochastic, 3 sections were analysed

One section in the Western Mediterranean (Perales section, Sorbas Basin) and two in the Northern Mediterannean (Banengo and Pollenzo sections, Piedmont Basin)

The analysed species → *Sphenolithus abies* | *Helicosphaera carteri* | *Umbilicosphaera rotula* | *Coccolithus pelagicus* | *Reticulofenestra minuta*

Biometry characters measured → Base-Length | Width-Length | Diameter-Central aperture | Width-Length | Length-Mass

50 specimens for each sample were measured and the size average and the standard deviation calculated

The absolute abundance (number of nannofossils over gram of dry sediment, CN/g) was calculated for each taxa using the random settling technique (Beafourt et al., 2014)

Fig 7: Map of the studied sections. Stars mark the location of studied section

MATERIAL AND METHODS

Reticulofenestra minuta

Length-Mass

Reticulofenestra minuta is present in all the studied samples

Opportunity to check precession-driven biometry change

An high resolution analysis was performed using SYRACO

SYRACO

Automated system of coccoliths recognition developed by Beafourt and Dollfus (2004). In our study, SYRACO was used for the recognition and the measurement of the length and the mass of *R. minuta* coccolith

97 samples analysed in the Perales section

At least 200 specimens were measured for each sample

In order to test the reliability of SYRACO measures, 10 samples were selected for comparing the automated SYRACO results with classical manual measurements at the light microscope

RESULTS

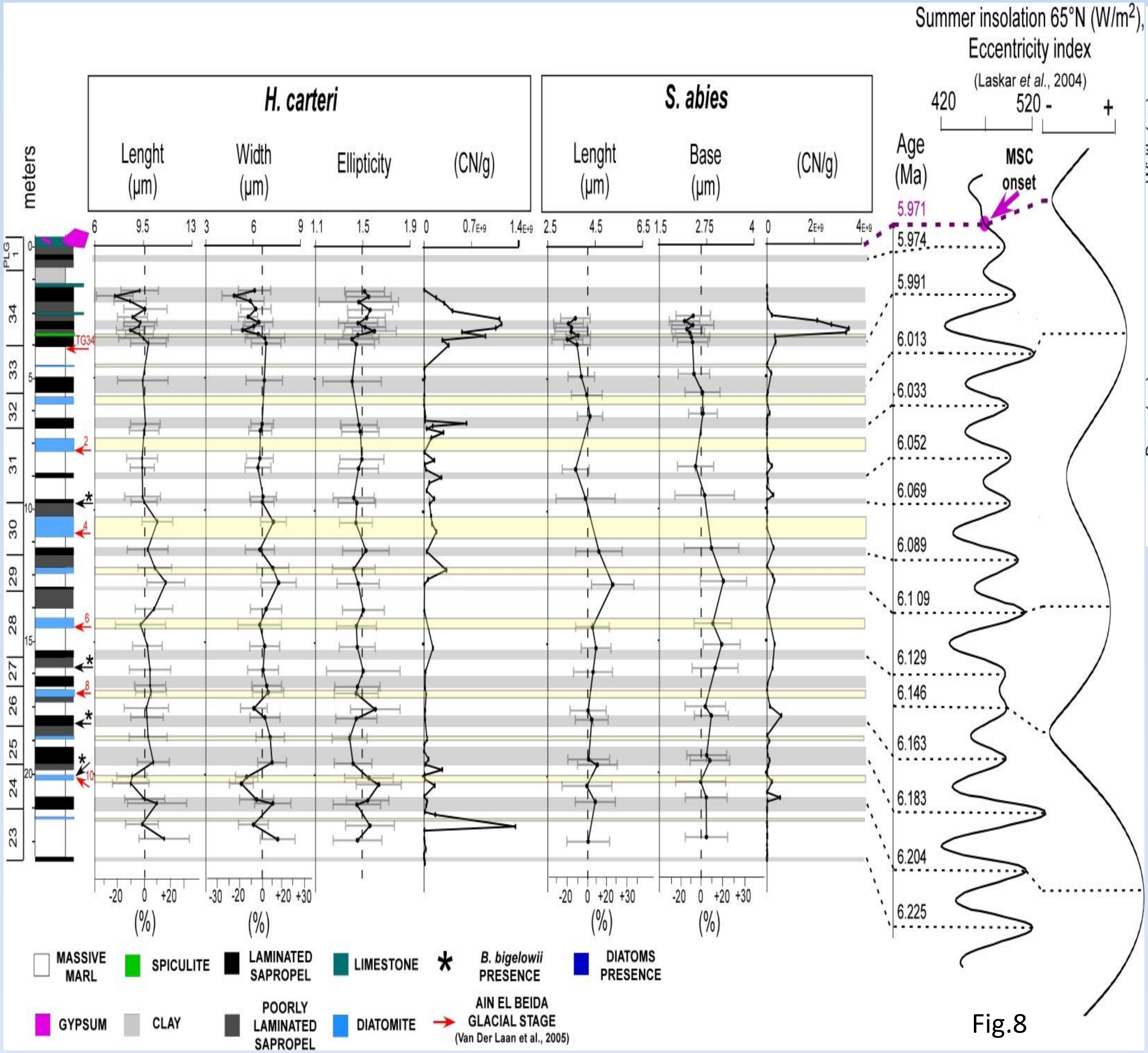


Fig.8

Fig.8: Calcareous nannofossil biometric parameters evolution toward the MSC onset. Dashed lines represent the mean size average

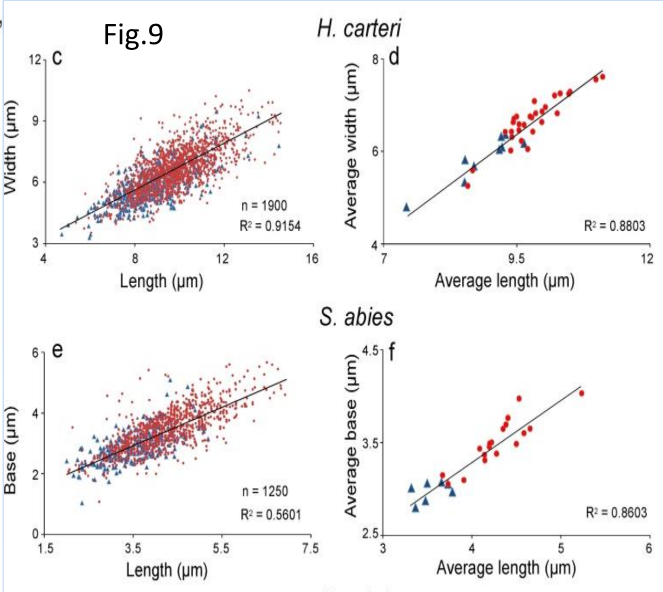
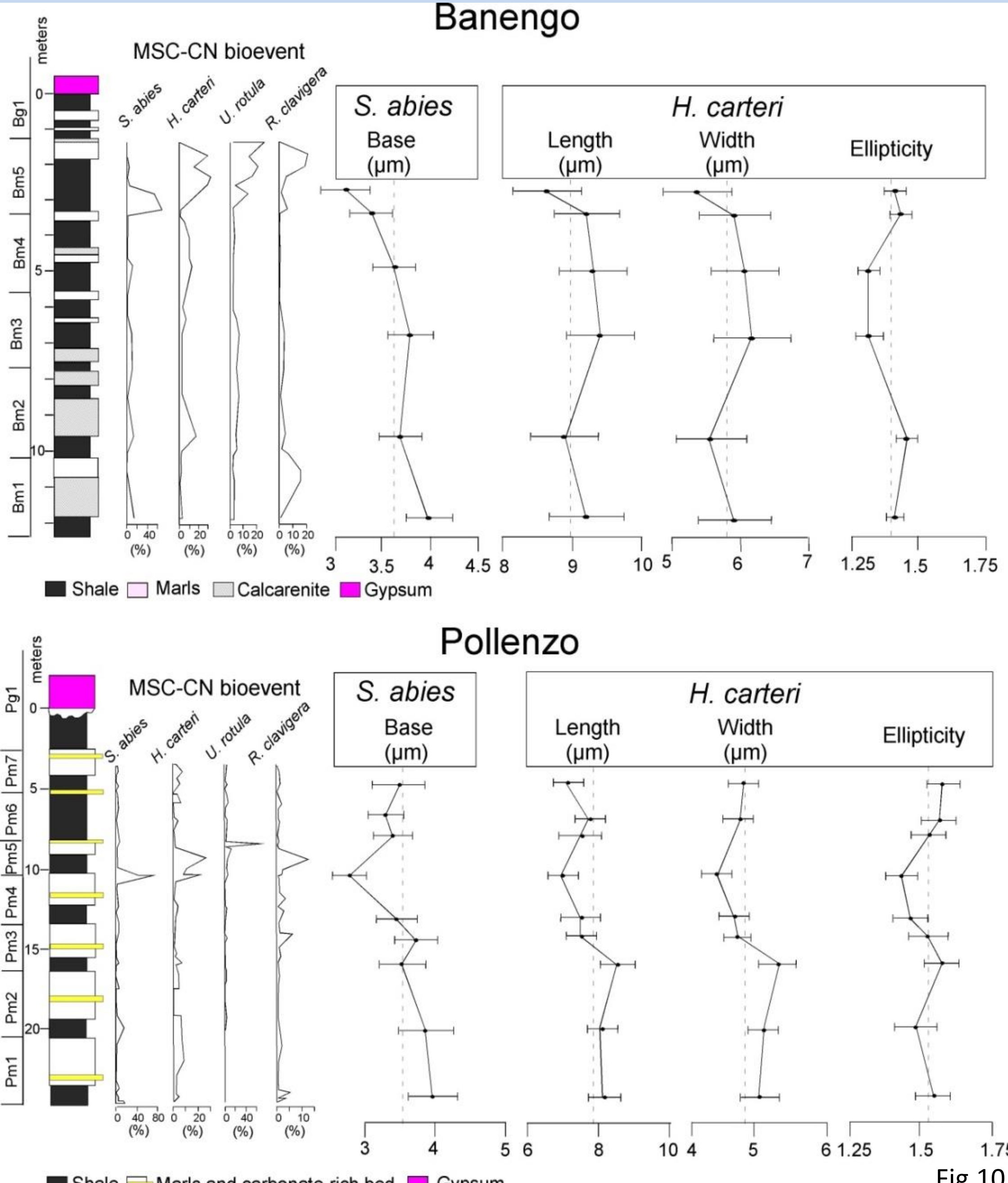
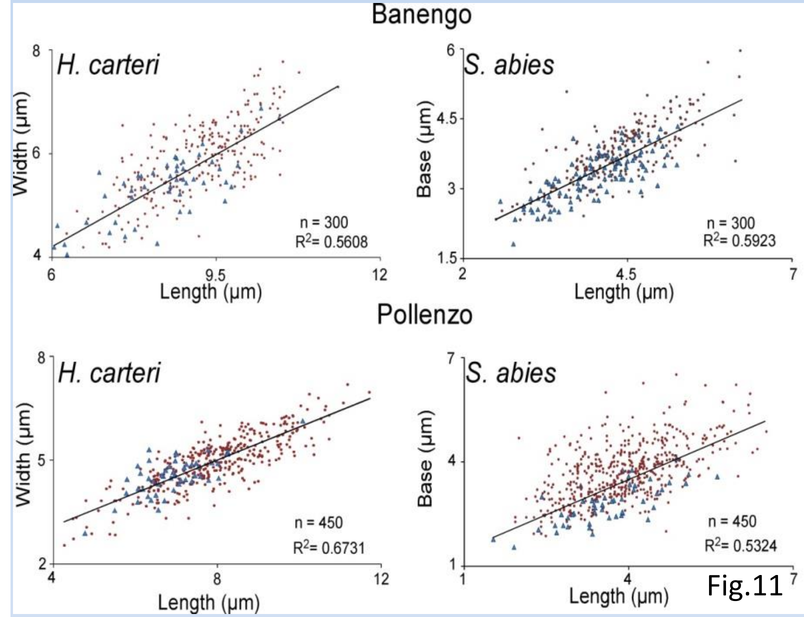


Fig.9: Relationship between the morphometrical parameters measured for each calcareous nannofossil taxa. The blue triangles represent the size during the MSC-CN bioevent

A significant size reduction affected *H. carteri* and *S. abies* during the MSC onset bioevent (cycle 34) in the Perales section





A significant size reduction affected *H. carteri* and *S. abies* during the MSC onset bioevent in both sections of the Piedmont Basin

After the MSC onset bioevent the calcareous nannofossil size fluctuates below the mean average

Fig.10: Calcareous nannofossil biometric parameters evolution toward the MSC onset. Dashed lines represent the mean size average

Fig.11: Relationship between the morphometrical parameters measured for each calcareous nannofossil taxa. The blue triangles represent the size during the MSC-CN bioevent

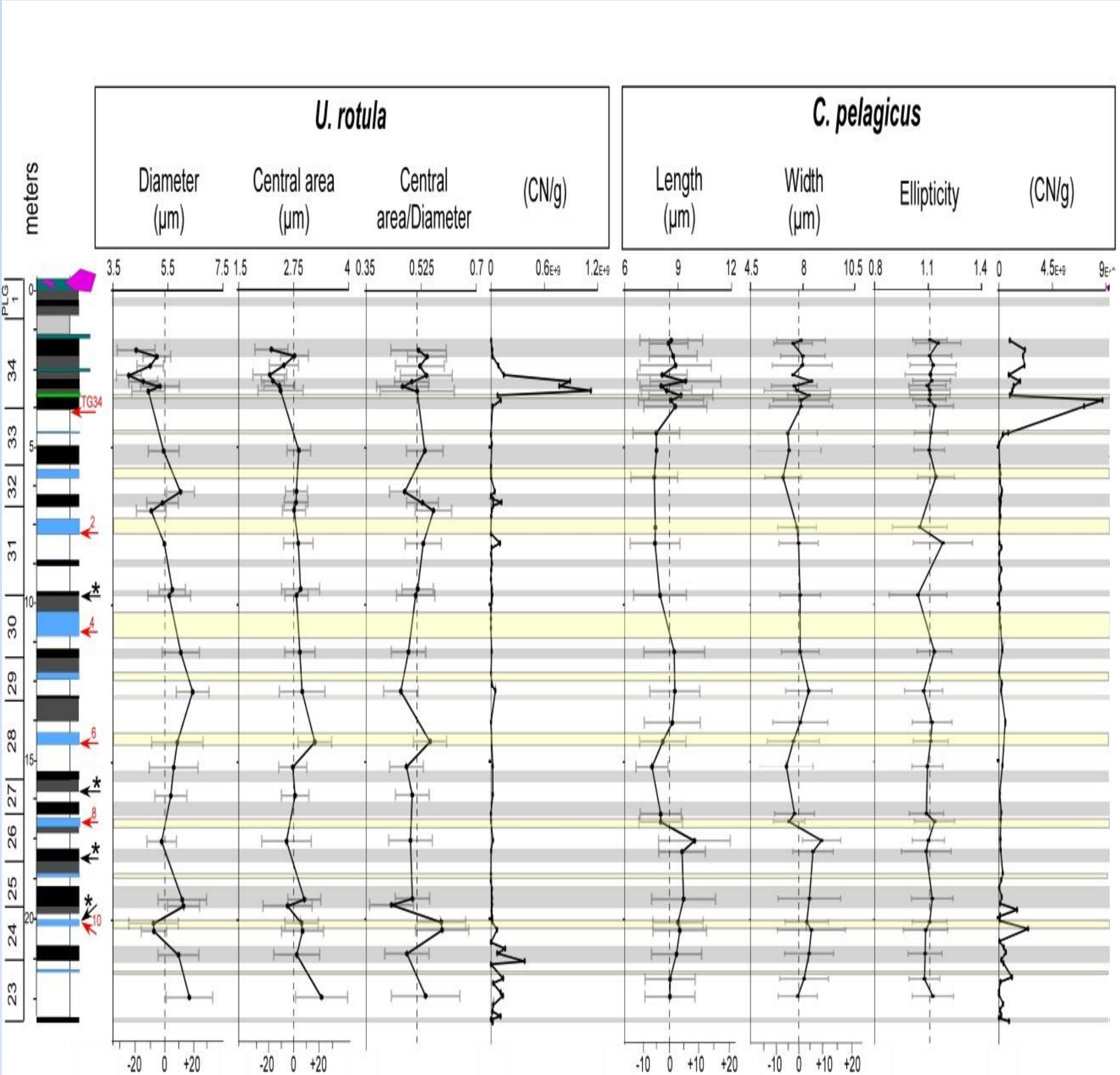


Fig.12

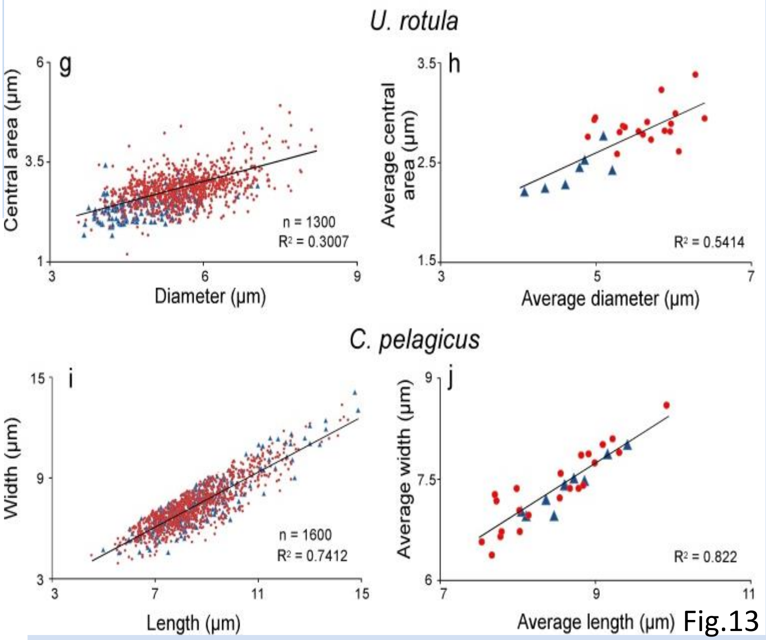


Fig.13

A significant size reduction affected *U. rotula* during the MSC onset bioevent

No significant changes are observed in the *C. pelagicus* size trend

A significant size reduction affected only the species involved in the MSC onset bioevent

Fig.12: Calcareous nannofossil biometric parameters evolution toward the MSC onset. Dashed lines represent the mean size average

Fig.13: Relationship between the morphometrical parameters measured for each calcareous nannofossil taxa. The blue triangles represent the size during the MSC-CN bioevent

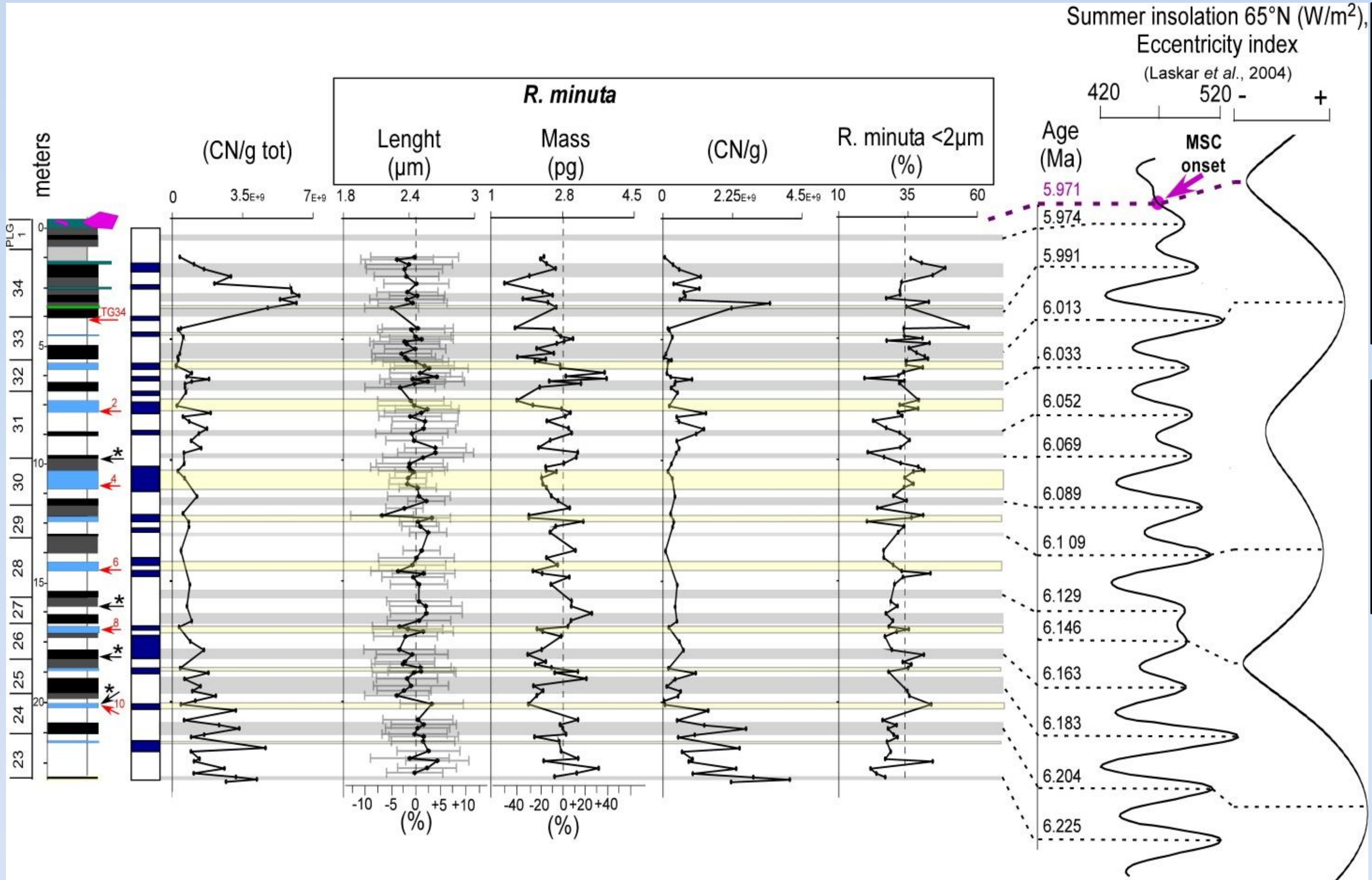


Fig.14

Reticulofenestra *minuta* shows low size and mass values preferentially in the diatomite layer

The fluctuation amplitude increased toward the MSC onset

Highest calcareous nannofossil absolute abundance during the MSC onset bioevent (Cycle 34)

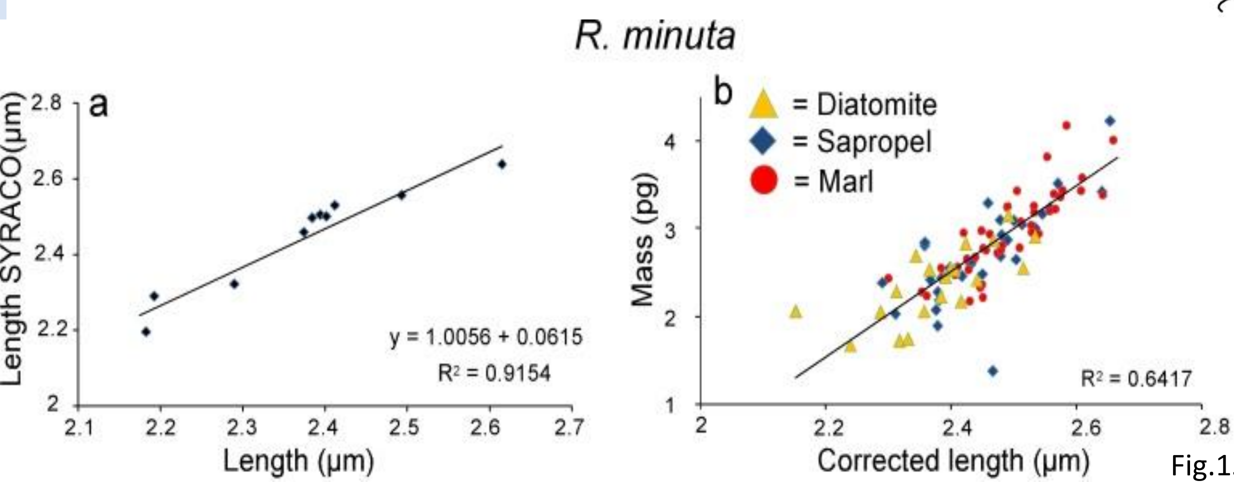


Fig.15

Fig.14: *Reticulofenestra minuta* high resolution analysis and calacreous nannofossil absolute abundance. Dashed lines represent the mean size/mass average

Fig.15a: Comparison between SYRACO and classic length measurements.

Fig.15b: Relationship between mass and length in each lithology

DISCUSSION

A significant size reduction of the species involved in the MSC onset bioevent together with the highest calcareous nannofossil absolute abundance is recorded in the studied sections

High values of calcareous nannofossil absolute abundance reflect high productivity in the water column

Laboratory culture experiments show that during the (not-limited by nutrients) exponential growth phase, characterized by a rapid cell division, smaller coccoliths are produced (Gibbs et al., 2006; Gibbs et al., 2013; Sheward et al., 2017)

Previous observations suggest that *Coccolithus pelagicus* does not reduce its size in response to nutrient enrichment, which is in line with our record

The MSC onset bioevent marks a restriction pulse driven by tectonics activity, that resulted in an increase in the sensitivity of the Mediterranean Basin to the continental run-off and the associated delivery of nutrients, that ultimately results in an increase in calcareous nannofossil productivity and in a size decrease affecting the species involved in the MSC onset bioevent

DISCUSSION

***Reticulofenestra minuta* shows small size and low mass values preferentially in the diatomite layer and toward the MSC onset**

The diatomite depositional environment in the Perales section was characterized by strong seasonality (Mancini et al., submitted), as revealed by micropaleontological record

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Highly unstable environment characterized the diatomitic deposition, especially toward the MSC onset

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Reticulofenestra minuta shifted to a more r-strategy (reproducing faster and decreasing their size) to face the unstable environmental conditions

CONCLUSION

Calcalerous nannofossil morphology was sensitive to the extreme condition dictated by the MSC onset

The causes behind the size reduction during the MSC onset bioevent were likely related to an increase in productivity, that led selected calcareous nannofossil to reproduce faster and decrease their size, as supported by laboratory culture experiments

The trigger of the enhanced CN productivity was a restriction pulse affecting the Atlantic-Mediterranean gateway, that increased the continental run-off and the associated nutrient delivery influence in the Mediterranean Sea

***Reticulofenestra minuta* size and mass trend well correlate with changes in the precessional index, with minimum size and mass during periods of highly unstable environments (during the diatomite deposition in the Perales section and toward the MSC onset)**

THANK YOU

OUR STARS IN OUR SKY…

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