



## **Stepwise larger foraminifera extinction at the Cenomanian-Turonian boundary: a role for nutrients?**

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The Cenomanian-Turonian boundary (CTB) interval is characterised by major perturbations of oceanographic conditions and bio-geochemical cycles, resulting in a global organic carbon burial episode known as Oceanic Anoxic Event 2 (OAE 2). This is also the time of a major transgression and of extreme greenhouse conditions.

The biotic response of calcareous and siliceous plankton to these paleoenvironmental perturbations has been analysed in detail. Comparatively much less is known of the biotic change in shallow-water carbonate facies. Many carbonate platforms drowned at the CTB and the case has been made that drowning was driven by the combined effect of environmental stress, possibly related to the anoxic event, and of peak transgression.

Carbonate platforms of southern Apennines shows at places a continuous shallow-water record across the CTB and therefore they offer the opportunity to look more in detail at the biotic response of the benthic community. We have studied in detail the pattern of extinction of larger benthic foraminifers, using carbon isotope stratigraphy to establish a high resolution chronostratigraphic framework through correlation with the reference curve of the Eastbourne Chalk.

Late Cenomanian high-diversity assemblages, with alveolinids, soritids, nezzazatids, ataxophragmids and lituolids are replaced in the early Turonian by oligotypic associations dominated by small miliolids, discorbids and small lituolids. This biotic turnover occurs in two steps. The first and most severe extinction event can be dated to the geslinianum zone. The few larger foraminifer survivors were wiped out by the second event in the lower part of the juddii zone. Larger foraminifers are notably absent in uppermost Cenomanian-lowermost Turonian levels.

The most illustrious victim of the first extinction event is *Cisalveolina fraasi*. This is a well-known marker for the upper Cenomanian shallow-water carbonates of the peri-mediterranean area. A review of the literature suggests that the extinction of *Cisalveolina* is strictly contemporaneous with that of *Praealveolina*: Cretaceous representatives of the family *Alveolinidae* were completely wiped out by the geslinianum extinction event. Size and morphological complexity of alveolinids suggest that they were the most extreme k-strategists among the late Cenomanian larger foraminifers. K-strategists are successful in oligotrophic conditions but they are severely at risk when nutrient level rises. Interestingly enough carbon-isotope stratigraphy suggests that the extinction of *Cisalveolina* could be strictly coeval with that of keeled planktic foraminifers, dwelling in tropical intermediate to deep waters.

Several independent parameters concur in interpreting the OAE 2 as a high productivity episode driven by elevated nutrient availability on a global scale. This notion has been recently challenged by papers documenting the decline of nannoplankton fertility indicators across the OAE 2 interval. However the pattern of extinction in larger foraminifers supports the hypothesis that a stepwise shift to higher nutrient levels occurred across the CTB interval.