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Peculiar architectures in the Cretaceous planktonic foraminifera: links to oceanic anoxic events and major global change

R. Coccioni (1), V. Luciani (2)

Istituto di Geologia e Centro di Geobiologia, University of Urbino, Italy, (2) Department of Earth Sciences, University of Ferrara, Italy

Chamber elongation represents a peculiar morphological architecture recurring in Cretaceous and Cenozoic planktonic foraminiferal evolution suggesting that the clavate body-plan takes advantage through particular environmental conditions. Planktonic foraminifera with radially elongated chambers became a consistent component of foraminiferal assemblages in coincidence with the deposition of the main prominent Cretaceous organic carbon-rich horizons. Due to this correspondence, chamber elongation has been recently interpreted as an adaptation to low oxygen levels in the upper water column. However, the exact ecological meaning of elongated chambered forms and related paleoceanographic scenario are not definitively understood.

We investigate the distribution and abundance of elongated chambered planktonic foraminifera in an interval of about 40 myr across the latest Hauterivian Faraoni Event, the late Early Aptian Selli Event (OAE1a), the Albian OAE1b, OAE1c, OAE1d and the latest Cenomanian Bonarelli Event (OAE2) in different well-dated sections from the Mediterranean Tethys. Results of our analysis show that the increased abundance of planktonic foraminifera with elongated chambers is a markedly evident feature across the Faraoni, the Selli and the Bonarelli OAEs. However each event shows its own peculiarities and provides the following main evidences:

a) the first radiation of elongated chambered morphotypes remarkably just predates the oldest Cretaceous anoxic event (Hauterivian Faraoni Event);

b) the Selli Event records the greatest diversification (number of species) of the group bearing elongated chambers suggesting that this event played a fundamental role in

the radiation of this planktonic foraminiferal group;

c) the morphological categories established for the Early Cretaceous radially elongated chambered forms are present in the investigated areas in variable percentages. Thus, local environmental parameters influenced their distribution;

d) the Albian OAE1b, OAE1c, and OAE1c display the lowest abundance and diversity of this group. Conversely, according to the available data, the first appearances of the species *Muricohedbergella simplex* and of the genus *Schackoina* occur close to the OAE1b and OAE1d, respectively;

e) the relative abundance of these forms varies in the different studied areas, probably also controlled by the water depth;

f) the onset and the end of the Bonarelli Event in deep-water settings are characterized by schackoinid assemblage-dominated. According to their morphological features, schackoinids appear more competitive than other radially elongated chambered forms in low-oxygen, eutrophic conditions;

g) the Bonarelli Event record remarkably higher percentages of radially elongate chambered forms with respect to the Selli Event and the other oceanic anoxic events. This record may provide evidence that the strongest intensity of the environmental perturbation was related to the OAE2 and the weakest one occurred during the Faraoni Event.

Our study confirms that the radially elongated chambered are related to the Cretaceous oceanic anoxic events, however, several lines of evidence suggest that water oxygenation could not have been the single controlling factor governing the development of elongate chambers. The role of availability of food and the nature of food has been so far probably underestimated. It is most likely that the interplay of several influential physical-chemical and ecological factors (i.e., dissolved oxygen concentration, temperature, salinity, nutrients, type of food, trace elements) was responsible for such a morphological adaptation. We document linkages between the distribution, abundance, morphometric changes and evolution of the Cretaceous radially elongated chambered planktonic foraminifera and the major igneous, geological, geochemical, climate, nutrification and biotic events and biocalcification trends.