The impact of the Toarcian Oceanic Anoxic Event (T-OAE) on the radiation of Early Jurassic dinoflagellate cysts in the Lusitanian Basin, Portugal

Vânia F. Correia\textsuperscript{a,b}, James B. Riding\textsuperscript{c}, Luís V. Duarte\textsuperscript{d}, Paulo Fernandes\textsuperscript{a}, Zélia Pereira\textsuperscript{b}

\textsuperscript{a}CIMA – Centro de Investigação Marinha e Ambiental, Universidade do Algarve, Campus de Gambelas, 8005-139 Faro, Portugal, e-mail: vania.correia@lneg.pt
\textsuperscript{b}LNEG, Rua da Amieira, 4465-965 S. Mamede de Infesta, Portugal
\textsuperscript{c}British Geological Survey, Environmental Science Centre, Keyworth, Nottingham NG12 5GG, UK
\textsuperscript{d}MARE - Marine and Environmental Sciences Centre, Faculty of Sciences and Technology, Department of Earth Sciences, University of Coimbra, Rua Sílvio Lima, 3030-790 Coimbra, Portugal

Dinoflagellates, together with diatoms and coccolithophores, form a major element of the marine eukaryotic phytoplankton, and are significant primary producers. The bioproductivity and distribution of dinoflagellates is influenced by several factors, such as light, nutrients, salinity, ocean currents, water depth and temperature (Fensome et al., 1996). The evolutionary position of the Division Dinoflagellata is a subject of intense discussion. Only around 15% of living dinoflagellate species, mostly marine, produce fossilizable cysts and it is assumed that a similar percentage formed resistant organic-walled cysts in the geological past. Based on the fossil record, dinoflagellates appeared in Middle Triassic and during the Early Jurassic (late Pliensbachian) and underwent an important evolutionary radiation episode, with the occurrence of around 40 new species (Wiggan et al., 2018).

The Lower Jurassic is particularly well-developed in the Lusitanian Basin of central western Portugal. This depocentre is filled mainly with marine Jurassic sediments, characterized by marl-limestone alternations. We analysed 214 samples from six Lower Jurassic sections in the Lusitanian Basin. The Pliensbachian–Toarcian succession in the Lusitanian Basin is characterised by relatively low dinoflagellate cyst diversity. Only fifteen taxa were recorded; these are assigned to seven genera. These are \textit{Luehndea, Mancodinium, Mendicodinium, Nannoceratopsis, Scriniocassis, Sentusidinium} and \textit{Valvaeodinium}.

At the base of upper Pliensbachian (\textit{Amaltheus margaritatus} ammonite biozone) the first dinoflagellate cyst appearances in the Lusitanian Basin are recorded, corresponding to the late Pliensbachian radiation event of this group. We identified the inceptions of \textit{Mancodinium semitabulatum, Luehndea spinosa}, which belong to the family Mancodiniaceae, \textit{Nannoceratopsis gracilis} and \textit{Nannoceratopsis senex}, representing the family Nannoceratopsiaceae are also present. This family is confined to the Jurassic and the genus \textit{Nannoceratopsis} is the only representative. These taxa became very common and abundant throughout the remaining late Pliensbachian and early Toarcian (\textit{Dactylioceras polymorphum} ammonite biozone), before the T-OAE.
The T-OAE in the Lusitanian Basin is expressed at the base of *Hildaites levisoni* ammonite biozone and is characterised by the apparent extinction of *Luehndeia spinosa* and the disappearance of all dinoflagellate cyst taxa. During the remaining Toarcian only four new genera and families were identified and the abundance of this group is consistently very low. Apparently, the palaeoenvironmental changes associated with the T-OAE were more extensive in the Lusitanian Basin, compared with coeval basins in northern Europe. Correia et al. (2018, 2019) recognized a recovery of dinoflagellate cysts, both in diversity and abundance, in the early Bajocian in the Lusitanian Basin. Hence, the T-OAE in this basin strongly affected the dinoflagellate cyst evolution patterns. Nevertheless, the late Toarcian of the Lusitanian Basin included an important evolutionary episode, namely the emergence of the first Gonyaulacaceae, due to the appearance of *Sentusidinium*. The family Gonyaulacaceae continued their diversification and became the most abundant family of cyst-forming dinoflagellates in the fossil record (Wiggan et al., 2018).

In conclusion, the late Pliensbachian radiation of dinoflagellate cysts is well documented in the Lusitanian Basin and the T-OAE drastically affected the morphological experimentation period of this group during the remaining Early Jurassic.

**References**


