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BOOK REVIEW

Reolid M, Molina JM, Nieto LM and Rodriguez-Tovar FJ (eds): The Toarcian Oceanic Anoxic Event in the South Iberian Palaeomargin

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This is a review of "The Toarcian Oceanic Anoxic Event in the South Iberian Palaeomargin" edited by Reolid, Molina, Nieto, and Rodriguez-Tovar (2018). The special publications, SpringerBriefs in Earth Sciences, are always a pleasure to read and this beautifully-produced book is a delight for researchers interested in the study of major biological and environmental crises. The book deals with one of the most important events of the Lower Jurassic, the Toarcian Oceanic Anoxic Event (T-OAE) which is documented in Jurassic outcrops of the Chain of the Betic Range (Reolid et al. 2018). On over 100 pages, the authors illustrate a very important area of Spain from a geological, palaeontological, and stratigraphical point of view.

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The technical details of the work are as follows: the organization of the volume is clear and subdivided into five chapters, each of them with their own reference list. The bibliography is abundant (263 titles) and the book contains fifty-two excellent illustrations, which are very useful, accurate, and often colorful.

The first chapter introduces the reader to the state of art about the main topic of the volume: the boundary between the Pliensbachian and Toarcian stages and the Toarcian Anoxic Event.

The second chapter shows the geological constraints of the Betic chain in both the Subbetic and Prebetic domains. A description of several stratigraphic sections of the Subbetic domain is given. The discussion about the Spanish Toarcian events covers two sections of the Subbetics: a median and an external one, in a setting of PCP (Pelagic Carbonate Platform, sensu Santantonio 1994) palaeogeographic evolution of a rift margin of the Mediterranean Tethys.

Moreover, a biostratigraphic correlation based on ammonites is given, which have been found in all of the studied outcrops and their presence permits to correlate the outcrops with coeval ones in the Mediterranean–Tethys domain (Cecca et al. 1991).

The median section is characterized by a basin-type succession on a deep area of the pelagic platform, where the stratigraphic sequence is thicker and the sediments are often reworked. The external section is characterized by a so-called high structure, a portion of the shallower pelagic platforms on which the succession is less thick and often lacunose.

The third and fourth chapters describe in detail about the important outcrops and sequences that compose the studied sections, describing their stratigraphy, lithology, geochemistry, and palaeontology. The palaeontology of trace

fossils and microfossils is studied in detail. As the trace fossils represent remains of the living assemblage at the sea bottom during the Toarcian stage and record the variation in the ocean parameters before, during and after the anoxic event, their study may give important information on when the depletion in oxygen started and the return to normality occurred. In the fifth and last chapter, the conclusions about the completeness and importance of the boundary between the Pliensbachian and Toarcian stages and, mainly about the T-OAE sequence are given.

The book by Reolid et al. is very interesting and represents an important contribution to the study of the Pliensbachian–Toarcian boundary and the T-OAE. The described successions are very similar to coeval ones (Centamore et al. 1971; Cresta et al. 1989) in the Apennines in Central Italy. Together with an analog structural model, the same stratigraphic succession suggests that in every place of the Tethys–Mediterranean domain, the geological setting was the same, with only local and minor lateral variations.

We enjoyed reading all the chapters and only some minor comments are needed: the authors used terms such as Domerian (e.g., pages 7, 10, and 15) and Carixian (e.g., page 10) to sub-divide the Pliensbachian and the Middle Toarcian (e.g., pages 18 and 23), but actually these terms have not yet been officially accepted (Gradstein et al. 2004, 2012). The age of T-OAE was recently confirmed at 181.7 Ma by Satolli et al. (2018). On page 19, the term "palynspastic restitutions" should read "Palinspastic restorations" or "Palinspastic reconstructions". Finally, a detailed subject index at the end of the book is missing, which could help when looking for a keyword in T-OAE.

Palaeontological considerations

To define the beginning of the Toarcian and the T-OAE, Reolid et al. (2018) describe several stratigraphic sections: some of the external Subbetic chain (Fuente Vildriera, Cueva del Agua, La Cerradura) and some of the Median Subbetic chain (Iznallos, Arroyo Mingarrón). Several kinds of fossils have been found and studied. Each group of fossils has its importance and utility to define where and when a paleoenvironment was developed. Some considerations about two of the studied groups: ammonites for biostratigraphic correlations on the one hand and trace fossils for considerations about infaunal biodiversity and depletion in oxygen on the other hand.

Ammonites and biostratigraphy

Continuous findings of ammonites have permitted the authors to create a biostratigraphic scheme that subdivides the sections based on their palaeontological content. This is the only way to correlate disconnected sections characterized by different lithologies (Di Cencio 2007). Moreover, every section may, thus be correlated with the Biostratigraphic Standard Scheme (Cariou and Hantzpergue 1997; Gradstein et al. 2004, 2012).

A biostratigraphic scheme for the Lower Toarcian is proposed by Reolid et al. The authors subdivide the Lower Toarcian into the Polymorphum and Serpentinus ammonite biozones. The same biostratigraphic succession is proposed for both the external and median Subbetic chains. The use of this biostratigraphic sequence is explained below.

The Polymorphum biozone has been used for the bottom of the Toarcian stage in the Mediterranean ammonite biozonation (Cariou and Hantzpergue 1997; Venturi 1999; Di Cencio 2007). The Serpentinus biozone is the second Toarcian stage zone in the North-European Domain (Cariou and Hantzpergue 1997; Pinard et al. 2014; Weis et al. 2018). The North-European biostratigraphic scale is commonly used as Standard Biostratigraphic Scale (Gradstein et al. 2004), while the Mediterranean scheme has a local application. Both scales show a perfect correlation (Cariou and Hantzpergue 1997). Recently, a new correlation was established between Tethyan and Boreal ammonitic biozonations (Gradstein et al. 2012, p. 764), in which Tethyan ammonite biozonation corresponds to the Standard Biostratigraphic Scale of Gradstein et al. (2004). Reolid et al. use a sort of mixed biozonation with a local validity that is correlated with the standard scheme (Sandoval et al. 2012).

Trace fossils and palaeobiodiversity of the Toarcian sea bottom

In every studied section, on both Subbetic sections described, several ichnogenera have been recognized and are described. They show a large variation in size and they are over-imposed on each other, indicating a very important palaeobiodiversity inside the infaunal community. Often trace fossils are connected with hummocky cross stratification (HCS) and they are observable on the lower side of turbiditic layers. In other case, trace fossils are recognizable inside the entire thickness of strata. In some sections, they disappear in correspondence with the T-OAE interval, then they gradually re-occur, maybe when the paleoenvironmental conditions (oxygen content) permitted the life to recover. We have chosen this palaeontological association to underline the palaeobiological crisis and the

revolution, which affected the sea bottom in the Lower Toarcian during the anoxic event.

Conclusions

This comprehensive book constitutes an up-to-date reference and a great deal of knowledge with regard to its academic style and very rich content for researchers who work on or who are interested in the Toarcian transgression and T-OAE. It is an attractive book in an attractive series. Having already made this book a "go-to" in our own research, we expect that this book will remain a standard for palaeontologists working on the Jurassic (especially for the Toarcian Oceanic Anoxic Event, T-OAE) for many years to come.

Book chapters and authors

1. Introduction

Matias Reolid, José Miguel Molina, Luis Miguel Nieto, & Francisco Javier Rodriguez-Tovar

2. The betic external zones

Matias Reolid, José Miguel Molina, Luis Miguel Nieto, & Francisco Javier Rodriguez-Tovar

3. External subbetic outcrops

Matias Reolid, José Miguel Molina, Luis Miguel Nieto, & Francisco Javier Rodriguez-Tovar

4. Median subbetic outcrops

Matias Reolid, José Miguel Molina, Luis Miguel Nieto, & Francisco Javier Rodriguez-Tovar

5. General conclusions

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Compliance with ethical standards

Conflict of interest The authors declare no conflict of interest.

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