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Original article

Ammonite-benthic Foraminifera turnovers across the Lower-Middle Jurassic transition in the Lusitanian Basin (Portugal)☆

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ABSTRACT

This paper describes and characterises the co-occurrence of ammonite and benthic foraminiferal assemblages across the São Gião outcrop (Central Portugal), a reference section for the Lower-Middle Jurassic boundary in the Lusitanian Basin. The upper Toarcian-lower Aalenian marls and marly-limestones in this section provide a precise and detailed ammonite-based biostratigraphic zonation, with a mixed assemblage of northwest European and Mediterranean faunal elements, associated with benthic foraminifera assemblages with northern hemisphere affinities, both correlatable with the Aalenian GSSP at the Fuentelsaz section (Iberian Cordillera, Spain). A total of 447 well-preserved ammonite specimens and 13.116 foraminifera have been studied; no evidence was detected of any taphonomic processes that could have changed the original assemblages. From a biostratigraphic point of view, the ammonite record has enabled four biostratigraphic units to be recognised (the Mactra and Aalensis subzones of the Aalensis Biozone in the upper Toarcian, and the Opalinum and Comptum subzones of the Opalinum Biozone in the lower Aalenian). With regard to the benthic foraminifera, the taxa identified have enabled the *Astacolus dorbignyi* Zone and 11 bioevents to be identified, most of which representing local biostratigraphic proxies. However, the increase in the relative abundance of *Lenticulina exgaleata* Dieni from the upper part of the Opalinum Subzone to the lower part of the Comptum Subzone has a regional value. The constant and continuous ammonite record of northwest European taxa, together with typical Mediterranean taxa – namely Grammoceratinae – throughout the section, the high relative abundance of Miliolina representatives – generally interpreted as foraminifers typical of shallow waters – and the absence of foraminiferal forms typical of cool waters, do not support the inference of cool seawater temperatures attributed to the Early Aalenian, or the global character of the "Comptum cooling event", at least with reference to the Lusitanian Basin.

1. Introduction

Ammonites are the best fossil group for dating Jurassic marine sediments, but when these fossils are poorly preserved, scarce or almost impossible to obtain (e.g., in core samples), alternative biostratigraphic scales based on other fossil groups are needed. In recent decades, there have been some attempts to establish biostratigraphic scales based on benthic foraminifera. The precision and validity of such scales is greater when they can be calibrated with accurate biostratigraphic charts based on ammonites, as done in this work. The stratigraphic range of most of the Jurassic foraminiferal species is relatively wide; therefore, identification of bioevents such as first occurrences (First Appearance Datum, FAD), last occurrences (Last Appearance Datum, LAD) or noticeable changes in assemblage diversity or in the relative abundance of some taxa, can be a useful biostratigraphic tool. Hence, the aim of this work is to describe for the first time the detailed co-occurrence of ammonite and benthic foraminiferal assemblages across the Toarcian-Aalenian boundary at the São Gião section (Lusitanian Basin, Central Portugal), and to recognise the corresponding biostratigraphic units, thus contributing to a better calibration of the biostratigraphic scale for the Lower-Middle Jurassic boundary on the basis of different fossil groups.

The São Gião section is a classical outcrop of the Lower-Middle Jurassic boundary in the Lusitanian Basin, where previous works on ammonites were carried out by Mouterde et al. (1979) and Caloo-Fortier (1985). It is one of the few areas in Europe where this time interval is represented by an expanded section, showing exceptional exposure conditions along highly fossiliferous marly-limestones sediments approximately 45 m-thick, displaying a continuous record of ammonites. Moreover, the relevance of the

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Grammoceratinae content for palaeobiogeographic reconstructions of the western Tethys (Sandoval et al., 2012a), as well as the significant *Pleydellia* and *Leioceras* record, both justified the proposition of the São Gião section as a reference section for the Toarcian-Aalenian boundary in the Lusitanian Basin (Henriques, 1989, 1992, 2000a; Henriques et al., 1996; Goy et al., 2000; Sandoval et al., 2001a; Azerêdo et al., 2003). More recently, other fossil groups in the section have been studied, namely calcareous nannofossils (Henriques and Perilli, 2000), and most particularly benthic foraminifera (Magno et al., 2008; Magno, 2010; Canales et al., 2010). These studies all suggested the importance of analysing the detailed vertical co-occurrence of ammonite and benthic foraminifera assemblages across the Toarcian-Aalenian boundary at the São Gião section, in order to identify major faunal changes both on macrofossil and microfossil assemblages.

The bioevents recognised in the benthic foraminifera record, accurately calibrated here using ammonite-based biostratigraphic units, represent a proxy that can be used to determinate both the age and depositional environment assigned to core samples (Canales et al., 2010). Moreover, they allow the interpretation of previous data on palaeotemperature changes established for neighbouring basins located around the Iberian Plate, e.g., in the southern and northern palaeomargins (O'Dogherty et al., 2006; Sandoval et al., 2008; Gómez et al., 2009), as well as in more distant, boreal regions such as the Hebrides Basin (Price, 2010), where close relationships between major faunal-flora turnovers and isotopic fluctuations in $\delta^{13}C$ have been recognised (Aguado et al., 2008; Sandoval et al., 2012b).

2. Geographic and geological settings

The São Gião section is located in the northern sector of the Lusitanian Basin (Central Portugal), at about 5 km to the South-Southwest of Cantanhede village, near Zambujal (coordinates: 40°18′12.63″N, 8°37′17.58″W; altitude: 100 m; Fig. 1). The section is composed of greyish marly limestones, more or less compact, in regular beds with thicknesses ranging from 0.10 to 0.30 m, alternating with slightly thicker greyish marl beds organised in shallowing-upward units and deposited in an external marine platform environment. The limestone component progressively increases towards the top of this unit, which corresponds to the upper part of the Póvoa da Lomba Formation (upper Toarcian-upper Aalenian).

The Póvoa da Lomba Formation was firstly informally defined by Barbosa et al. (1988, 2008) as a lithostratigraphic unit named the "Calcários Margosos de Póvoa da Lomba" ("Póvoa da Lomba Marly Limestones"), and later formalised as the Póvoa da Lomba Formation by Azerêdo et al. (2003). It corresponds laterally to the lower part of the Cabo Mondego Formation which outcrops at the west of the basin, the upper part of the Prado Formation outcropping eastwards, and the top of the Fórnea Formation/base of the Barranco de Zambujal Formation which outcrops in the southeast of the basin (Azerêdo et al., 2003; Fig. 2).

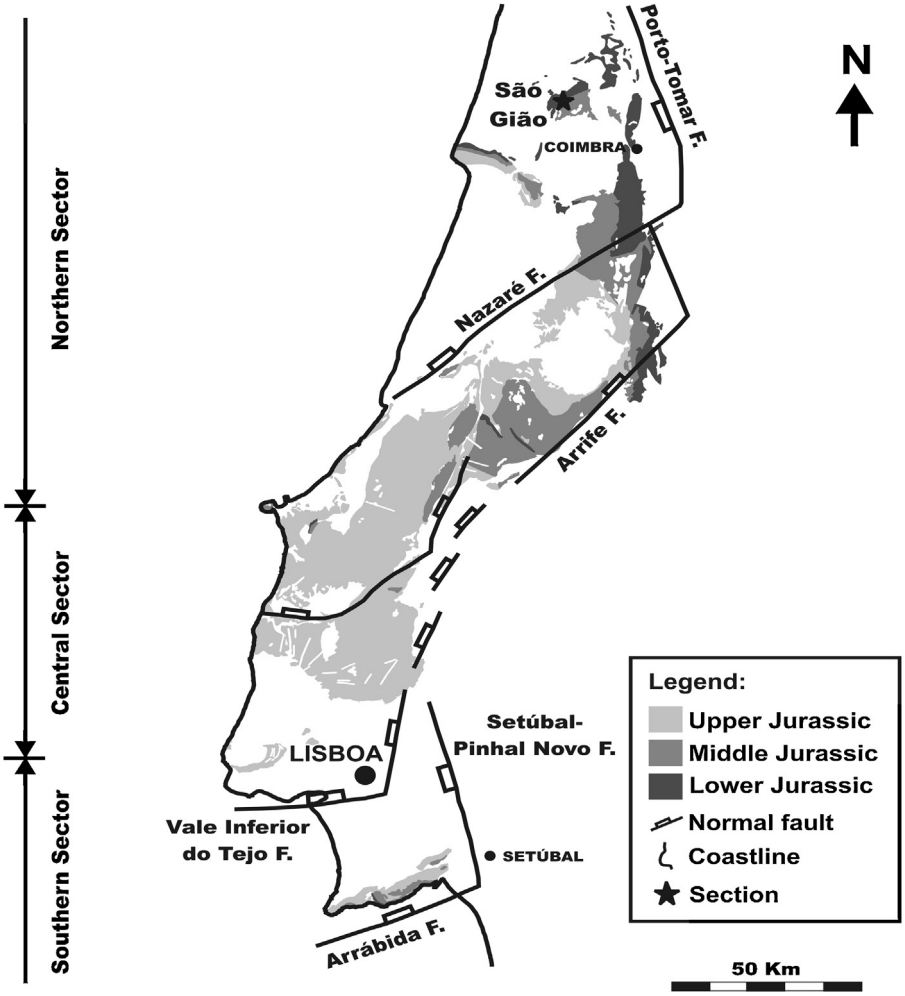

Fig. 1. Geological map of the Lusitanian Basin (West of the Iberian Peninsula) showing the Jurassic outcrops and location of the São Gião section. Modified after Figueiredo (2009).