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The Toarcian Oceanic Anoxic Event in the South Iberian Palaeomargin

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Chapter 1
Introduction

The Early Toarcian Oceanic Anoxic Event (T-OAE) was one of the most important environmental changes of the Mesozoic, resulting in a mass extinction event of benthic and pelagic groups in marine ecosystems (Hallam 1996; Wignall et al. 2005). Typically, the T-OAE is characterised by the record of organic-rich sediments associated with a negative excursion in $\delta^{13}C$ (Jenkyns and Clayton 1997; Cohen et al. 2004; Hesselbo et al. 2007; Suan et al. 2008; Hermoso et al. 2009; Bodin et al. 2010; Gómez and Arias 2010; Littler et al. 2010; Izumi et al. 2012; Ait-Itto et al. 2017; among others).

There is no consensus about the genesis of the T-OAE. Proposals include the massive enrichment of isotopically light carbon and its transfer between the different reservoirs, now interpreted in light of diverse phenomena such as a massive dissociation of methane hydrates in marine sediments (e.g., Hesselbo et al. 2000, 2007), or the production of thermogenic methane during the concomitant intrusive eruption in the Karoo-Ferrar province (e.g., McElwain et al. 2005). Several environmental changes may have been involved in the mass extinction event, including generalised anoxia, the enhancement of greenhouse conditions and a warming trend, and/or the incidence of sea-level changes (e.g., Hallam 1986, 1987; Elmi 1996; Hylton and Hart 2000; McArthur et al. 2000; Bailey et al. 2003; Ruban and Tyszka 2005; Wignall et al. 2005; Gómez and Goy 2011; Suan et al. 2011). Although considered as a global phenomenon, the expression of the T-OAE varies worldwide as revealed, for example, by the diachronous record, the associated facies, and the distinctive incidence on benthic and nektonic environments between the Tethyan and Boreal provinces (Wignall et al. 2005).

The South Iberian Palaeomargin during the Pliensbachian and Toarcian was a complex context, where the deposits are actually represented by the Subbetic outcrops (Betic Cordillera, southern Spain). The Toarcian deposits of the Subbetic represent a hemipelagic marine setting close to the Hispanic Corridor, a passage between the Western Tethys and the Proto-Atlantic seaway (Aberhan 2001; Bailey et al. 2003; Rodríguez-Tovar and Reolid 2013), at an approximate palaeolatitude of 30° N, near the Iberian Meseta (Osete et al. 2011). The fragmentation of the

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palaeomargin during the Late Pliensbachian and the configuration in different tilted blocks with variable subsidence determined differences in thickness and facies during the Toarcian. In this context, the record of the T-OAE is not homogeneous in the palaeomargin and is very different to the typical black shales of the central and North Europe sections. Nevertheless, data from the Subbetic allow understanding the evolution of this part of the Western Tethys, being essential for the advance of the knowledge of the complexity of the global T-OAE. In this book we report the state of the art for the T-OAE in the Subbetic from the analysis of well studied reference sections of the Subbetic taking into account the biotic and abiotic signals.

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Chapter 2
The Betic External Zones

The Betic Cordillera is the major geological domain situated to the S and SE of the Iberian Peninsula. It is bounded by the Iberian Massif and the Iberian Mountain Range to the N and by the Atlantic Ocean and Mediterranean Sea to the SW, S, and SE (Fig. 2.1). It belongs, along with other mountain ranges of North Africa, to the western segment of the Perimediterranean Alpine Orogen. In the Betic Cordillera, three main geological domains of greater rank are differentiated: the Betic External Zones, the Betic Internal Zones and the Campo de Gibraltar Complex. The general knowledge of the geology of the Betic Cordillera has been shown with in previous works (Sanz de Galdeano 1997; Gibbons and Moreno 2002; Vera 2004) and its exhaustive analysis is not the objective of this publication. However, we will present here a synthesis of the External Zones focused in the Subbetic domain.

2.1 The External Zones and the South Iberian Palaeomargin

The outcropping sedimentary rocks of the Betic External Zones were deposited in the South Iberian Palaeomargin (Western Tethys) during the Mesozoic and most of the Cenozoic, and were mainly deformed during the Miocene, between the Burdigalian and the Late Miocene. García-Hernández et al. (1980) proposed a first model of the palaeogeographic evolution of this margin during the Mesozoic, and established a tectonic and palaeogeographic subdivision in geological units that, with some nuances, is still used nowadays (Vera 2004).

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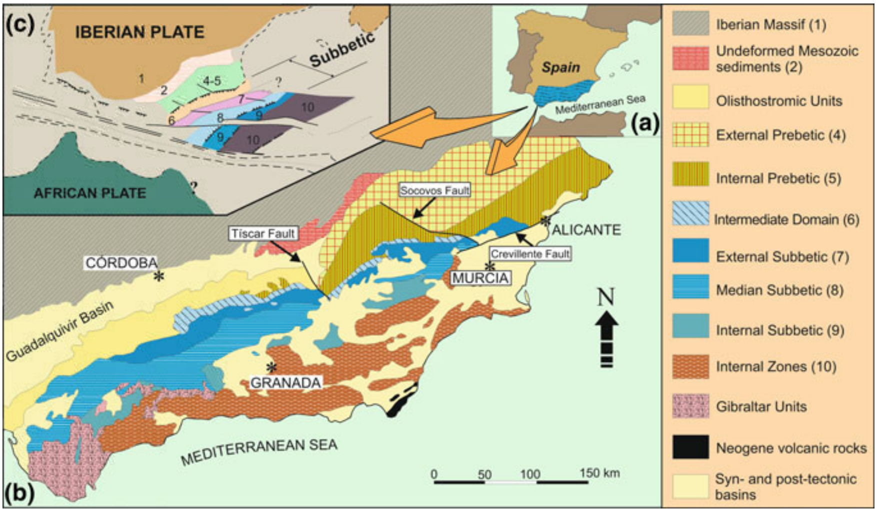

Fig. 2.1 Geological map of the Betic Cordillera

2.1.1 Tectonic Units and Palaeogeographic Domains

In the Betic External Zones units of diverse range have been defined by tectonic and stratigraphic criteria. These units comprise deposits accumulated in the South Iberian Palaeomargin, in palaeogeographic domains individualised throughout the successive stages of its Mesozoic history. The higher rank division of the Betic External Zones is into Prebetic and Subbetic. These terms designate areas clearly differentiated by its regional geographic position as well as by its structural, stratigraphic or palaeogeographic characteristics. This terminology has been used with equivalent meaning since its original definition (Blumenthal 1927; Fallot 1945, 1948; Fontboté 1970). From a tectonic point of view, the Prebetic, located to the north, consists of parauthocthonous or moderately allochthonous sedimentary rocks, whereas the Subbetic allochthony is beyond doubt and the rocks generally more deformed than those of the Prebetic. The Subbetic is relatively well-organised from a structural point of view, but the deformation is locally such intense that large sections of it, predominantly made up of Triassic terrains, have lost their internal coherence and have been transformed into disorganised masses called Subbetic Chaotic Complexes. Part of these chaotic masses was gravitationally slipped and included in the mid-Miocene sediments of the southern edge of the Guadalquivir Basin, forming the Guadalquivir Olisthostromic Complex, or Subbetic Olisthostromic Complex (Pérez-López and Sanz de Galdeano 1994) or Evaporite-bearing Accretionay Complex (Pérez-Valera et al. 2017).

The subdivision in Prebetic and Subbetic is even more necessary from a stratigraphic and palaeogeographic point of view. The Prebetic successions mainly contain shallow marine facies, with important continental episodes, even with