



The early Toarcian (early Jurassic) ostracod extinction events in the Iberian Range: The effect of temperature changes and prolonged exposure to low dissolved oxygen concentrations

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ABSTRACT

The early Toarcian extinction event, once regarded as spanning in the late Pliensbachian–early Toarcian boundary period, actually occurred in two distinct phases in the early Toarcian of the Iberian Range. The first episode occurred in the Mirabile Subzone, Tenuicostatum Zone and is characterised by the disappearance of about 12% of ostracod species and one suborder, the Metacopina (Superfamily Healdioidea). This study shows that this suborder disappears during stratigraphical intervals that are considered to be representative of low oxygen conditions in the Iberian Range. The collapse of marine ecosystems (affecting up to 40% of ostracod species) in the Elegantulum Subzone, Serpentinum Zone was most likely triggered by a sudden and widespread lethal increase in seawater temperature. These combined processes of oxygenation and temperature change are considered to be responsible for the profound changes in marine environments that resulted in the early Toarcian ostracod extinction in the Iberian Range.

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1. Introduction

Out of the proposed five major Phanerozoic extinction peaks, the Pliensbachian–Toarcian boundary extinction episode has prompted many questions about its magnitude and speed, and selectivity of the extinction triggering mechanisms (Little, 1996; Hallam and Wignall, 1997). Ostracods dwell in every aquatic environment and, in spite of their notable adaptive capability, many marine species were affected by the early Toarcian (early Jurassic) biological crisis in the Iberian Range (Arias, 2008a). Arias and Whatley (2009) recognised an important increase in the ostracod species diversity from the Hettangian to the Pliensbachian, reaching maximum diversity values in the Spinatum Zone (around 60%). This peak was followed by a sharp diversity decrease through the Tenuicostatum and Serpentinum zones, and then a gradual increase through the remainder of the Toarcian (Arias and Whatley, 2004; Arias, 2008a).

Thus, an important ostracod crisis seems to have occurred at the close of the beginning of the Toarcian. Trying to understand all these changes, this paper analyses the ostracod extinction pattern in three sections in the Iberian Range (Spain), where it is possible to

analyse multiple replacements, disappearances and appearances in the continuous ostracod record across the Pliensbachian–Toarcian boundary. The three sections provide one of the most complete ostracod record not only in the Iberian Range, but also in western Europe and can be helpful for understanding ostracod faunal change at the beginning of the Toarcian.

With a relatively low extinction rate, Ostracoda is one of the best fossil groups for studying those factors influencing this kind of important biological crisis. With many potential causes, the early Toarcian ostracod extinction has caused much debate in the scientific community for over twenty years (Lord, 1982; Arias, 2000; Boomer et al., 2008). Extrinsic causes have long been favoured (e.g. sea-level changes, warming episodes, fluctuating low oxygen levels and/or nutrient dynamics) which led to decimation of marine ostracods (Arias, 2000; Arias and Whatley, 2004, 2005). However, none of these hypotheses have been totally convincing, in part because they could not account for some critical aspects of the ostracod record, such as the selective nature and variable rates of extinctions, the stepwise extinctions, and the timing between a specific environmental condition and the early Toarcian extinction episode. This problem is particularly relevant in the case of extinction processes affecting the ostracods of the Iberian Range. A comprehensive review of the voluminous literature on early Toarcian mass extinctions is beyond the scope of this study (Lord, 1982; Arias, 2007, 2008a; Boomer et al., 2008; Arias, 2009). This research focuses on some of the most potential critical mechanisms of extinction: low oxygen levels in the water and changes in water temperature.

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2. Material and methods

The ostracods described in this study were recovered from three sections located in the Iberian Range, north-eastern Spain (Fig. 1A, B). These areas were previously studied by Arias (1997) and a new sample collection work has been made in the same sections as part of a new high resolution stratigraphic study carried out by the Jurassic Research Group (UCM Universidad Complutense de Madrid). The Upper Pliensbachian–Lower Toarcian sediments studied (Fig. 2) belong to the Ablanquejo Group, which comprises three formations: the Margas grises del Cerro del Pez Formation, the Calizas Bioclasticas de Barahona Formation and the Alternancia de Margas y Calizas de Turmiel Formation (Gómez and Goy, 2000). The Pliensbachian–Toarcian boundary has been recorded across the last two formations. The Calizas Bioclasticas de Barahona Formation consists of richly fossiliferous and bioturbated brown to yellowish bioclastic limestone, with ferruginous deposits in the upper part. The Alternancia de Margas y Calizas de Turmiel Formation is a sequence of limestone alternating with marl, containing a very rich and diverse fossil fauna of ammonites, brachiopods and bivalves (Fig. 2) (Gómez and Goy, 2005). Three sections have been sampled in detail: two located in the Aragonese Branch (Ariño and Moneva sections) and one section in the Castilian Branch (Perales de Alfambra section) (Fig. 1A). The Ariño section (AR, Fig. 1B) is exposed along two ravines near the village of Ariño, Teruel (Mapa Geológico de España, no. 467 “Muniesa”, scale 1:50,000; Lat: 4° 2′ 52″ N; Long: 0° 37′ 36″ W). The Moneva section (MO, Fig. 1B) is located at the Barranco de la Vega, 6 km south of the town of Moneva, Zaragoza (Mapa Geológico de España, no. 467 “Muniesa”; Lat: 41° 5′ 50″ N; Long: 0° 48′ 15″ W). The Perales de Alfambra section (PA, Fig. 1B) is situated close to the village of Perales de Alfambra at the Sierra Palomera Mountain, Teruel (Mapa Geológico de España, no. 542 “Alfambra”; Long: 40° 38′ 25″ N; Lat: 0° 55′ 45″ W).

Forty one samples were collected from the mudstone and marl of the Calizas Bioclasticas de Barahona Formation (Upper Pliensbachian–Lower Toarcian) and from the marl of the Alternancia de Margas y

Calizas de Turmiel Formation (Lower Toarcian). The sample processing consists of drying, weighting out 100 g samples and dispersing them in a solution of hydrogen peroxide, sodium hydroxide and water. The disaggregated samples are washed through sieves with five meshes of the following diameters >60, 125, 250, 500 and 1000 µm. All ostracods from >125 µm fractions are picked and mounted onto cardboard microscope slides. The fraction >60 µm is always inspected, revealing little influence on diversity and composition. A total of 8510 specimens have been described and assigned to a total of 46 species in the three studied sections (Table 1).

3. Results

The Pliensbachian–Toarcian ostracod record in many European areas is rather poorly represented (Arias, 1997, 2000). The Iberian Peninsula probably displays one of the most comprehensible records of this fossil group through this interval. In the Iberian Range sections, the first pronounced ostracod faunal turnover is recorded in the Mirabile Subzone, Tenuicostatum Zone, when metacopines became extinct (Figs. 3–6). This first crisis is manifested by the replacement of the distinctive late Pliensbachian ostracod assemblages dominated by three species of healdioids (metacopines): *Ogmoconchella adenticulata* (Pietrzenuk, 1961) (Fig. 7.3), *Ogmoconchella aequalis* (Herrig, 1969) (Fig. 7.5) and *Ogmoconchella* aff. *Ogmoconchella aspinata* (Drexler, 1958) (Fig. 7.4) and several large cytheroids, such as *Gramannella apostolescui* (Gramann, 1962) (Fig. 8.2), *Ektyphocythere* aff. *Ektyphocythere vitiosa* (Apostolescu, 1959) (Fig. 8.6) and *Kinkelinella tenuicostata* Martin (1960) (Fig. 8.7); one dominated only by cytheroids, such as *Ektyphocythere dharennsourensis* Boutakiout et al. (1982) (Fig. 8.5), *Kinkelinella sermoensis* (Apostolescu, 1959) (Fig. 8.8–9), and *Kinkelinella* sp. B (Fig. 8.10); and two late Pliensbachian species, *Liasina lanceolata* (Apostolescu, 1959) and *Cytherella toarcensis* Bizon (1960) range through (Fig. 7.6). In the three sections, the lower part of the Barahona Formation is dominated (Figs. 3–5) by two healdioid species *O. adenticulata* (Pietrzenuk, 1961) and *Ogmoconchella*

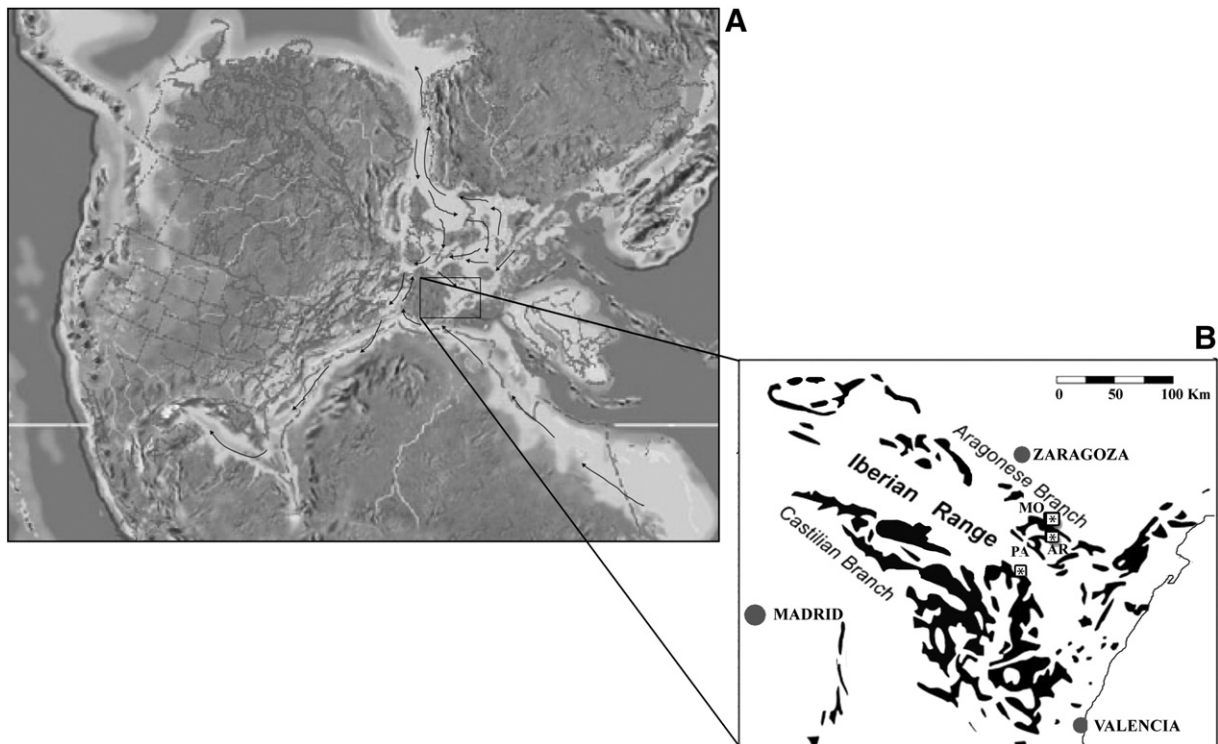


Fig. 1. (A) Palaeogeographic map of NW Europe during the Toarcian (modified after Ziegler, 1990, 1992; Bassoullet et al., 1992; Scotese-Paleomap Project, 2001, 2003; Blakely, 2010) and hypothetical circulation of the Toarcian oceans in Northern Hemisphere summer (modified from Arias, 2006a), (B) Outcrop map of Jurassic rocks (black) in the NW Iberian Range, with location of the sections studied: Ariño (AR), Moneva (MO) and Perales de Alfambra (PA).

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