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Foraminiferal assemblages and geochemistry for interpreting the incidence of Early Toarcian environmental changes in North Gondwana palaeomargin (Traras Mountains, Algeria)

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ABSTRACT

The Early Toarcian was characterised by important environmental changes and a mass extinction event usually related to a global oceanic anoxic event. The analysis of ecostratigraphic fluctuations of foraminiferal morphogroups, elemental geochemical proxies and C and O stable isotopes of the Mellala section (Tlemcen Domain, North Algeria) makes it possible to determine the incidence of the anoxic event in this sector of the north Gondwana palaeomargin. The end of the Pliensbachian is characterised by a diverse foraminiferal assemblage with equilibrium species suggesting good oxygen and nutrient availability. The beginning of the Toarcian (Polymorphum Zone) evidences major changes in foraminifera with the disappearance of species, decreasing proportions of epifauna and shallow infauna, and fluctuations in diversity and dominance of *Lenticulina toarcense* and *Lingulina tenera* confirming a perturbation in the palaeoecological conditions in the sea-bottom. Redox proxies (Co/Al, Cr/Al and V/Al) with local maximum values suggest a decrease in oxygenation degree. A negative excursion of $\delta^{13}C$ is recorded right at the Polymorphum/Levisoni Zone boundary, and the subsequent disappearance of epifauna, decreasing diversity and abundance of foraminifera (foram/100 g) would be related to the accentuation of stressing conditions. Also at the Polymorphum/Levisoni Zone boundary, suboxic waters at the sea-bottom indicate the maximum values of redox proxies (Co/Al, Cu/Al, Cr/Al and V/Al). The upper part of the Levisoni Zone is more calcareous, with increasing diversity of shallow infauna and a decrease in potentially deep infauna related to more favourable conditions. The incidence of the Toarcian Oceanic Anoxic Event in this context was very low in comparison with the Saharan Basin (Raknet El Kahla section, Saharan Atlas), where a benthic barren interval, higher total organic carbon and redox proxies are recorded. The low incidence of the biotic crisis and the rapid recovery of assemblages in the Tlemcen Domain is compared with the high incidence and delayed recovery in the Saharan Basin, where the palaeogeography determined restricted water circulation between the Saharan Craton and the Oran Massif.

1. Introduction

The Early Toarcian was characterised by important environmental changes and a global mass extinction event (e.g., Hallam, 1986, 1987; Little and Benton, 1995; Harries and Little, 1999; McArthur et al., 2000; Bailey et al., 2003; Wignall et al., 2005), usually interpreted as a global oceanic anoxic event known as the Toarcian Oceanic Anoxic Event (T-OAE) (Jenkyns, 1985, 1988). This mass extinction event had a significant impact on many marine organisms living in the whole water column: benthic groups, including bivalves (Aberhan and Baumiller, 2003), brachiopods (Vörös, 2002; Ruban, 2004; García-Joral et al., 2011), foraminifera (Nikitenko and Mickey, 2004) and ostracods (Arias and Whatley, 2005; Arias, 2009); nekto-benthic and nektonic faunas, such as ammonites (Macchioni and Cecca, 2002; Cecca and Macchioni, 2004); and planktic forms, like dinoflagellates (Bucefalo-Palliani et al., 2002). In most of the T-OAE sections worldwide, the event is associated with a negative carbon isotopic excursion and organic-rich sediment, interpreted as having been deposited under anoxic conditions (e.g. Jenkyns, 1988; Jenkyns and Clayton, 1997; Hesselbo et al., 2007). The stronger incidence of the T-OAE is registered in the boundary of subboreal Tenuicostatum–Falciferum zones and sub-Mediterranean and Mediterranean Polymorphum–Serpentinum zones and Polymorphum–Levisoni Zones, and ended essentially at the boundary of the Exaratum and Falciferum

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Subzones (Levisoni/Falciferum Subzones in the Mediterranean biozonation). Originally, the T-OAE was considered as a global phenomenon based on the record of facies rich in organic matter and anoxic conditions in many places around the world (Jenkyns, 1988). However, it has since been demonstrated that there is great geographic variability in the organic matter content and oxygen conditions in the sea-bottom (e.g. Hermoso et al., 2009). Recent analyses have evidenced the role of local and regional factors (palaeogeography, topography of the basin, tectonics) that produce interferences in the manifestation of the T-OAE (McArthur et al., 2008; Rodríguez-Tovar and Uchman, 2010; Reolid et al., 2013a,b; Rodríguez-Tovar and Reolid, 2013).

In the Traras Mountains (Tlemcen Domain, Northern Algeria), the Toarcian Oceanic Anoxic Event remains scarcely studied. The selected Mellala section (Fig. 1) is one of the very few examples of continuous and monotonous sedimentation through the Pliensbachian–Toarcian boundary (Elmi et al., 2009). In large regions of Europe, but also in numerous areas within the Tethys Domain, eustatic and tectonic events occurring near the Pliensbachian/Toarcian boundary impede good preservation of the transitional beds (see Guex et al., 2001; Sandoval et al., 2012). In western Algeria and in Morocco, the boundary is often located at a major lithostratigraphic change, as evidenced in the classic Talghemt section of the Moroccan High-Atlas, with the passage of the Ouchbis Limestone Fm into the Tagoudite Marl Fm (Sadki, 1996; El-Kamar et al., 1998). The Pliensbachian/Toarcian boundary occurs under the last beds of the Ouchbis Fm, within a sedimentary unit. This situation is widespread in Tethys and in the succession in Peniche (Portugal) where the proposed GSSP is located at the top of Lemede Fm (Elmi, 2006). The Mellala section was selected for this research because of the advantage of exposing a continuous transition located within a monotonous succession of marl-limestone rhythmite forming the hemipelagic Bayada Fm (Ameur, 1999). No sedimentary event perturbs the chronological and faunal record.

This research involves ecostratigraphic and palaeoecologic analyses of foraminiferal morphogroups, as a response to ecosedimentary dynamics during the Early Toarcian, complemented with the analyses of total organic carbon content, geochemical proxies and C and O stable isotopes. This approach allows us to interpret variations in the palaeoenvironmental features and therefore assess the incidence of the T-OAE in this sector of the north Gondwana palaeomargin.

2. Remarks on foraminifera and geochemical approaches to anoxic events

2.1. Foraminiferal morphogroups and anoxic events

Benthic foraminifera are good indicators of physical and chemical features of the sea-bottom. The composition of benthic

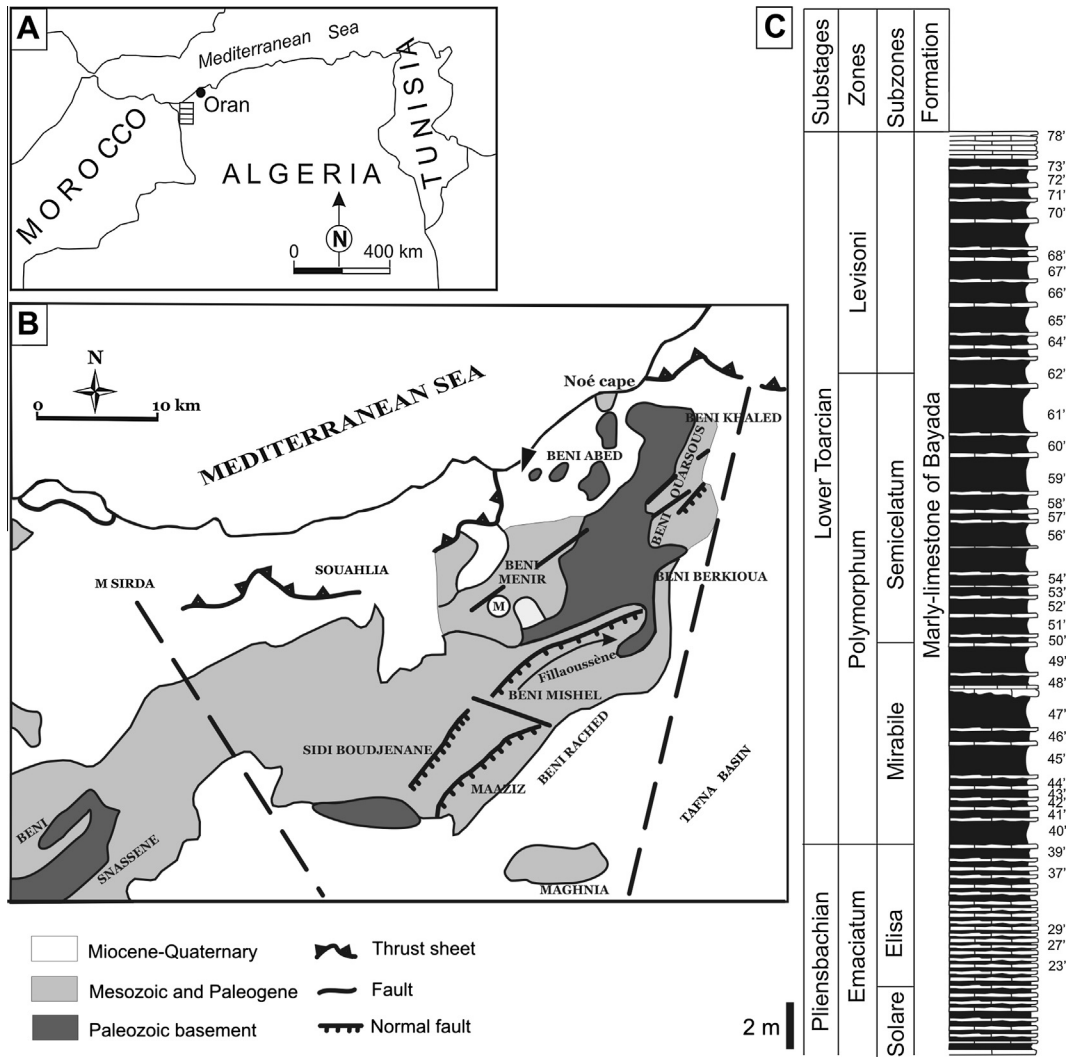

Fig. 1. Geographic location of the studied section in northern Algeria (A) and geological setting (B) where the Mellala sectionis indicated as M, and (C) stratigraphic column with distribution of zones and subzones according to Elmi et al. (2009). Name and location of the samples for foraminiferal assemblages analysis is located in the right side.