



Foraminiferal biostratigraphy of the Toarcian deposits (Lower Jurassic) from the Middle Atlas (Morocco). Comparison with western Tethyan areas

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ABSTRACT

The Toarcian sediments of the Middle Atlas show hemipelagic facies deposited in platform to basinal environments. They are represented by: (a) marly thick sections that accumulated in troughs under restricted dysoxic conditions, and (b) condensed sections of marly limestones found on fairly high ridges. The micropaleontological study of benthic foraminifera allowed us to establish the biostratigraphic extension of the different registered species. From the stratigraphic distribution of the benthic foraminifera two renewal phases can be characterized: one at the base of the Polymorphum Zone, and the other inside the Bifrons Zone. Five biozones were thus established (*Lingulina* gr. *tenera* and *Marginulina* gr. *prima* Biozone; *Lenticulina obonensis* mg *Planularia* Biozone; *Lenticulina pennensis* mg *Marginulinopsis* and *Ichtyolaria hauffi* Biozone; *Nodosaria pulchra* and *Lenticulina ferruginea* mg *Falsopalmula* Biozone; *Lenticulina dorbignyi* Biozone). These stratigraphic sub-divisions based on the benthic foraminifera are a useful tool when ammonoids are scarce. The Toarcian benthic foraminifera of the Middle Atlas are similar to the foraminiferal associations from neighbouring regions in the Maghreb (Morocco and Algeria) and Southwestern Europe (Spain, France and Portugal).

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1. Introduction

Several geological studies focusing on lithostratigraphy, sedimentology, biostratigraphy and tectonics have been undertaken in the Middle Atlas (El Arabi, 1987; Benshili, 1989; Fedan, 1989; Saadi, 1996; El Arabi et al., 1997, 2000; Mazzouji, 1997; Sabaoui, 1998; El Hammichi, 2002; Nassili, 2006). Most works characterize the Toarcian as a very important period in the evolution of the Middle Atlasic Chain. Biostratigraphic analysis based on Toarcian foraminifera has been carried out in the South Rifian Ridges (Boutakiout, 1990; Boutakiout et al., 1995; El Youssfi, 2000), eastern Morocco (Boudchiche, 1994) and the Central High Atlas (El-Kamar, 1997; Amhoud, 1999). However, a detailed foraminiferal biostratigraphy is not available for the Toarcian of the Middle Atlas. Interest in the foraminiferal biostratigraphy is due to (1) the scarce record of ammonoids with biostratigraphic importance in some sectors or stratigraphic intervals of the Middle Atlas, and (2) the abundance of foraminifera, facilitating the collection of specimens. This study presents the results of analyses of the foraminiferal assemblages of Toarcian age from

the Middle Atlas (Fig. 1). The biostratigraphy of the Toarcian foraminifera allows us to establish certain correlations with the rest of Morocco and other neighbouring regions. Such correlations will prove useful for future study of the evolution of foraminiferal populations throughout the Maghreb.

2. Geological setting

The deposits studied belong to the Middle Atlas, a Meso-Cenozoic intracontinental chain corresponding to the Moroccan Atlasic Chain (Michard, 1976). This region is structurally dominated by four NE–SW trending anticlines that delineate three synclinal troughs of similar orientation. The Middle Atlas is limited by the Saïs Plain and the front of the Rifian Nappes in the North, by the Guercif Bassin in the northeast, by the Moulouya Plain to the southeast, and by the Hercynian Central Massif in the West. The Middle Atlas is mainly constituted by Lower and Middle Jurassic formations.

Toarcian deposits (Fig. 2) generally lie on Upper Pliensbachian bedded limestones or calcareous marls. At the top of the sequence, these deposits are overlain by Aalenian–Lower Bajocian marls and calcareous marls rich in *Zoophycos*. Toarcian sub-divisions can be inferred from ammonoids (Benshili, 1989; Sabaoui, 1998; El Hammichi, 2002). A synthetic column would be characterized by

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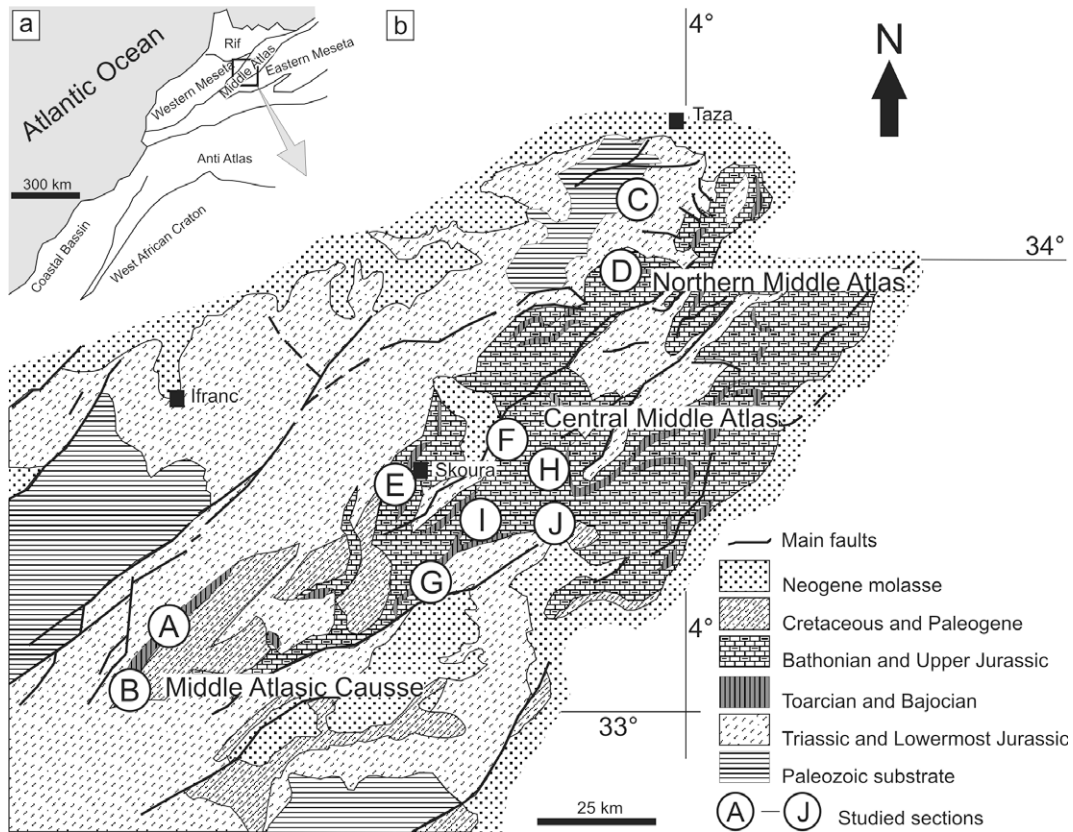


Fig. 1. Geographical and geological sketch. (a) Location of the Middle Atlas. (b) Geological map of the Middle Atlas and sections studied from the Middle Atlasic Causse (A: A Kahla and B: Fellat); the Northern Middle Atlas (C: A n'Tislit, D: Tazarine); and the Central Middle Atlas (E: A Albejal, F: Tizi Issoulietène, G: Anjil Ikhatarn, H: Issouka, I: Tagnamas, J: Sa Arrahim).

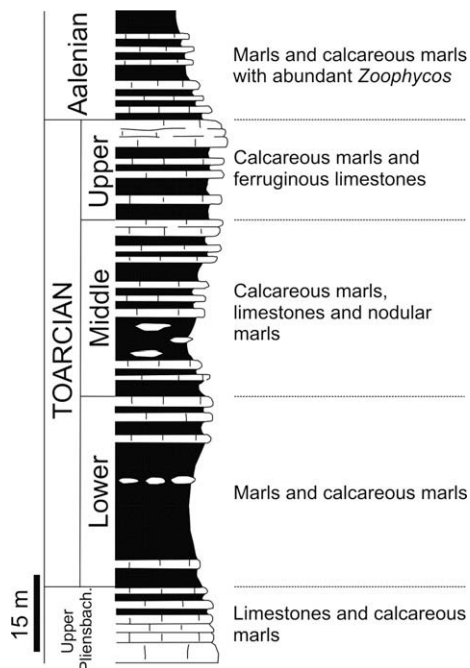


Fig. 2. Synthetic lithostratigraphic column of the Toarcian deposits from the Middle Atlas.

three main stratigraphic intervals. The Lower Toarcian is made up mainly of alternating marls and calcareous marls. The Middle

Toarcian, represented by various facies, is composed by calcareous marls, limestones and nodular marls, with carbonate units becoming more frequent towards the top. The Upper Toarcian sequence is represented by calcareous marls and ferruginous limestones. The Toarcian section as a whole, with overall increasing carbonate content from the base to the top, forms part of a klupfelian-type mega-sequence (Bejjaji, 2007)—that is, a shallowing upward sequence of carbonate deposits, from low energy marls shifting to high-energy carbonates, characterizing the domain of marine deposition of the outer shelf (Dubois and Delfaud, 1998).

3. Material and methods

We studied benthic foraminifera of the Toarcian sediments of the Middle Atlas from three different domains: the Middle Atlasic Causse, the Central Middle Atlas and the Northern Middle Atlas. Ten sections were studied (Figs. 1 and 3), and a total of 254 sampling levels were analyzed. Details of the geographic location of these sections are shown in Bejjaji (2007). The foraminifera belong to the Bejjaji Thèse Collection (Université Ibn Tofail, Kenitra).

– The Middle Atlasic Causse, with a general subtabular architecture, is mainly constituted by neritic carbonates of the Lower Jurassic. The structure is related to the extensive tectonics responsible for the individualization of tilted blocks. Two outcrops were studied in the Bekrit synclinal: Ain Kahla and Fellat (Fig. 1, outcrops A and B). In this sector, the Lower Toarcian is represented by red marls (4–8 m) present gastropods, crinoids, foraminifera and bivalves. The Middle and Upper Toarcian are mainly constituted

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