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Original article

Benthic foraminiferal paleoenvironmental reconstruction from the Upper Coniacian-Lower Campanian succession in north-western Tunisia

Zaineb Elamri [a,*], Sherif Farouk [b], Dalila Zaghbib-Turki [c]

[a] *University of Kairouan, Institute of Arts and Crafts, 1200 Kasserine, Tunisia*
[b] *Egyptian Petroleum Research Institute, Exploration Department, 11727 Nasr City, Egypt*
[c] *University of Tunis-El Manar, Faculty of Sciences, Department of Geology, Campus universitaire 2092, Tunisia*

Abstract

Quantitative analysis of benthic foraminifera is used to characterize the paleoenvironments of the Upper Coniacian-Lower Campanian succession in the Jbil section of north-western Tunisia. Foraminiferal parameters and benthic foraminiferal assemblages show that the studied section includes four distinct paleoenvironmental phases. From oldest to youngest, these are as follows: (1) an interval with a *Praebulimina reussi* assemblage with infaunal ratios as high as 96.1%. High abundances of *P. reussi*, reflecting an increase in organic matter flux to the seafloor (meso-to eutrophic) under oxygenated bottom-water conditions. (2) An interval characterized by a *Gavelinella costulata* assemblage with mixed infaunal/epifaunal foraminifera with higher Fisher's alpha values (ranging from 4 to 15.2), reflecting mesotrophic conditions in an outer shelf environment. (3) An interval with a *Gaudryina laevigata* assemblage indicative of a middle to outer shelf environment; there is a considerable increase in infaunal agglutinated foraminifera, as well as a relatively abundant and moderately diversified oxic/suboxic foraminifera. (4) The final interval occurs in the lower Campanian (the *Globotruncana ventricosa* Zone) and includes a *Bolivinoides decoratus* assemblage reflecting an outer shelf to upper bathyal environment. It contains a higher planktonic percentage and biodiversity with a slight increase in dysoxic species; the mixed infaunal/epifaunal content (57.6 to 73.3%) reflects mesotrophic conditions. Four well-recognized major sea-level falls are matched by the dual signatures of eustatic sea-level changes. These are coincident with the results of this study, which represent the first documentation of these events in Tunisian faunal and paleoenvironmental changes, at the following boundaries: Coniacian/Santonian, intra-Santonian, Santonian/Campanian, and intra-early Campanian.

Keywords: Santonian; Santonian/Campanian boundary; Benthic foraminifera; Paleoenvironment; Tunisia

1. Introduction

Upper Cretaceous successions in north-western Tunisia are characterized by well-exposed and widely distributed deep hemipelagic facies rich in foraminifera and deep macrofauna, especially ammonites and inoceramids. These successions include the Cretaceous/Paleogene (K/Pg) Global Boundary Stratotype Section and Point (GSSP) in El Kef, Tunisia. Therefore, numerous studies have examined the Upper Cretaceous stratigraphy of Tunisia, mainly using planktonic stratigraphy (Molina et al., 2009; Elamri et al., 2014; Elamri and Zaghbib-Turki, 2014; Farouk et al., 2017). Comparatively, few studies have focused on smaller Santonian benthic foraminifera and their boundaries (Salaj, 1980, 1996, 1997; Matmati et al., 1991). Little is known about these palaeoenvironments and their relationship to changes in relative sea level. Benthic foraminifera are highly sensitive to environmental changes, including productivity, oxygen content, and other changes to the seafloor (Sen Gupta and Machain-Castillo, 1993; Van der Zwaan et al., 1999; Dimiza et al., 2016). Furthermore, the Santonian/Campanian Stage Boundary is still debated and remains to be defined.

Here, we present the first quantitative study of Santonian benthic foraminifera from El Kef, in north-western Tunisia. The present study attempts to fill gaps in knowledge by quantitatively and qualitatively assessing the benthic foraminiferal species distribution during the Upper Coniacian-Lower Campanian succession, based upon benthic foraminiferal assemblages and biodiversity. Biodiversity indices relate species richness

* Corresponding author.
E-mail address: zaineb_amri@yahoo.fr (Z. Elamri).

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(S) to the number of individuals (*n*). Species richness generally increases from the shoreline to the edge of the continental shelf and then remains the same or declines on the continental slope (Bandy, 1953; Buzas and Gibson, 1969; Gibson and Buzas, 1973; Gräfe and Wendler, 2003). In general, the species diversity increases with palaeo-water depth (Murray, 2006; Murray and Alve, 2011; Nagy et al., 2000, 2011). In addition, the relationship between the different microhabitats of benthic foraminifera and the epifaunal/infaunal ratio can indicate changes in the ecological factors controlling benthic foraminiferal assemblages. The relative abundance of benthic foraminiferal species can be used to establish changes in bottom-water conditions and thus climatic changes (Kaiho, 1994). We used these variables to understand the paleoenvironment and infer paleobathymetry, as well as characterising faunal changes across the Coniacian/Santonian and Santonian/Campanian boundaries.

2. Materials and methods

A total of 44 samples collected from the Jbil section, approximately 6 km east of the city of El Kef (36°10′2.9″N, 08°45′3.1″E) (Fig. 1), were prepared for quantitative and qualitative benthic foraminiferal analysis. Quantitative studies and species richness calculations were based on representative splits of approximately 100 to 300 specimens of benthic foraminifera larger than 63 μm (Table 1). The total counts depended on the benthic foraminiferal percentage and richness in the studied samples. To separate the foraminifera tests, samples were soaked in a Na_2CO_3 solution, then sieved to 250, 125 and 63 μm. The 63–250 μm fraction was examined qualitatively and quantitatively under a binocular zoom stereomicroscope and used as a proxy for the paleobathymetry and paleoenvironment. The most important foraminifera were photographed using scanning electron microscopy at the Geological Survey of Egypt (Figs. 2–3). A total of 51 species belonging to 29 genera were recovered from the studied interval. The resulting samples and picked fossils are maintained at the Institute of Arts and Crafts in Kasserine, Tunisia under the collection number JSHTu2014. Identification and systematics of the foraminiferal taxa were based on studies by Aubert and Berggren (1976), Loeblich and Tappan (1988) and Bolli et al. (1994).

3. Stratigraphy

The Upper Coniacian-Lower Campanian succession in the Jbil section occurs within the upper part of the Kef Formation (Fournié, 1978) and underlies the Abiod Formation (Burollet, 1956). The studied succession is within the south-eastern part of the Kef Syncline. It can be divided into four units from base to top (Fig. 4); these are described in the following paragraphs. The biostratigraphy of the studied interval is based on planktonic foraminifera, which were classified according to the scheme of Elamri et al. (2014). The zones of this interval are characterized by the following species, from oldest to youngest: *Dicarinella concavata, Dicarinella asymetrica*, *Globotruncanita elevata/Globotruncana arca* and *Globotruncana ventricosa*.

Unit 1 (samples 1 to 9): This unit is mainly composed of dark grey marls intercalated with argillaceous limestone containing ammonites and inoceramids. The unit includes the upper part of the *D. concavata* Zone and the lower part of the *D. asymetrica* Zone. The *D. concavata* Zone is defined by the lowest occurrence (LO) of *D. concavata* to the LO of *D. asymetrica*. Elamri et al. (2014), Elamri and Zaghbib (2014) and Farouk et al. (2017) attributed this zone to the late Coniacian.

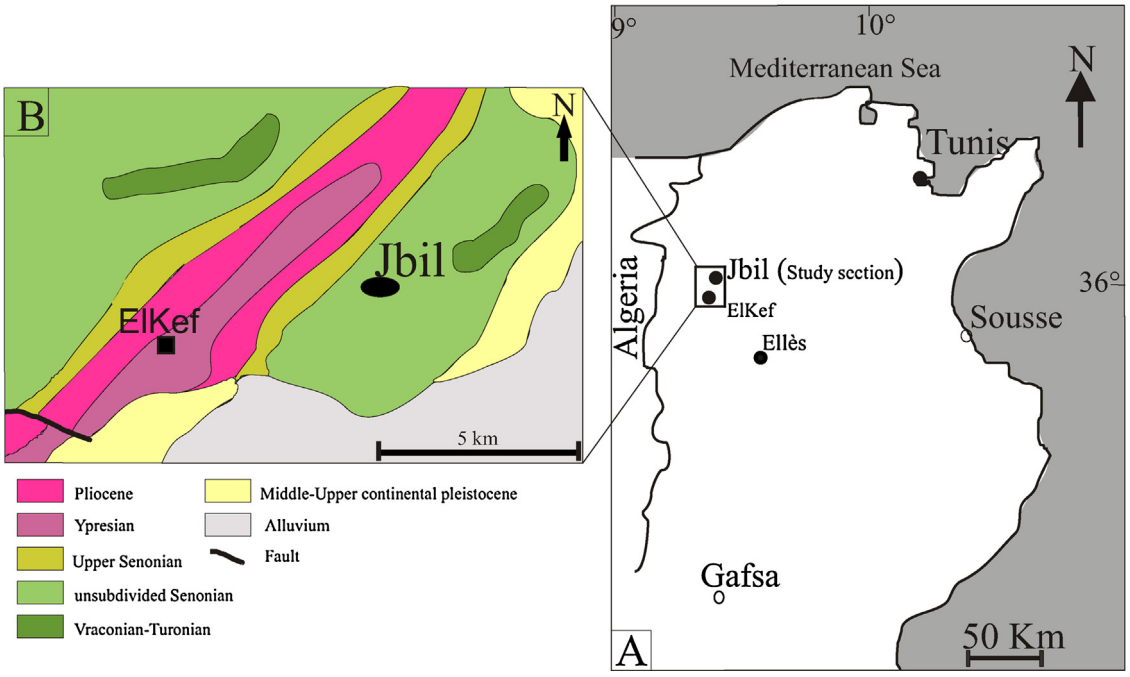

Fig. 1. A. Location map of the studied sections. B. Geologic map after http://www.erlm.tn/lithotheque/IMG/pdf/carte_geologique_500_000.pdf.

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