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The Campanian–Maastrichtian of the Aures Basin, Algeria: Paleobiogeographical distribution of ostracods

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ABSTRACT

A detailed biostratigraphic study of four sections (El Kantara, Menaa, Tighanimine and El Gaâga) in the Campanian–Maastrichtian of the Aures Basin in Algeria allows the identification of 109 ostracod species belonging to 50 genera. From a biochronostratigraphic point of view, none of the identified ostracod assemblages are typically restricted to the Campanian or to the Maastrichtian, but rather characterize a range covering the Campanian–Maastrichtian. As regards the paleobiogeography, the presence of species in common between Algeria and other countries or regions enables us to compile four maps showing the distribution of two provinces that developed during the Santonian-Paleocene, i) the South-West and South Tethyan Margins Province, including North Africa, the Middle East and Arabian Peninsula, and ii) the East Atlantic Margin Province, bordering West and Central-West Africa. We can also recognize relationships between the different regions making up these provinces, which remained under more or less arid, subtropical to tropical climates, with ostracods migrating according to the directions of ocean currents during the Late Cretaceous. The dispersal of the ostracods reflects marine communication between these provinces and India, the southern USA and Jamaica, Brazil and Europe.

RÉSUMÉ

Une étude biostratigraphique détaillée de quatre coupes, El Kantara, Menaa, Tighanimine et El Gaâga, relevées dans le Campanien-Maastrichtien des Aurès, Algérie, nous a permis de reconnaître 109 espèces d'ostracodes, appartenant à une cinquantaine de genres. D'un point de vue biochronostratigraphique, nous n'avons pas mis en évidence d'association d'ostracodes typiquement campanienne ou maastrichtienne, mais une association regroupant plutôt ces deux étages. D'un point de vue paléobiogéographique, la distribution des espèces d'ostracodes communes entre l'Algérie et les pays voisins, dans l'intervalle Santonien-Paléocène, nous permet de proposer 4 cartes sur lesquelles apparaissent deux provinces, présentes à chaque étage et série, la Province des Marges Sud et Sud-Ouest Téthysiennes, incluant l'Afrique du Nord, le Moyen Orient et la péninsule Arabique, et la province de la Marge Est Atlantique, correspondant à Afrique de l'ouest et du centre-ouest, avec des relations fauniques entre les différents pays ou régions qui constituent ces provinces, la migration des ostracodes suivant le sens des courants océaniques du Crétacé supérieur, et restant plus ou moins sous un même climat aride, subtropical à tropical. La dispersion des ostracodes montre la présence de communications marines entre ces provinces et l'Inde, le sud des USA et la Jamaïque, le Brésil et l'Europe.

1. Introduction

This study is based on materials collected by S. Benmansour in the framework of a PhD research project, and focuses especially on various aspects of the Aures Basin, such as stratigraphy, biostratigraphy, paleoenvironments, paleobiogeography, basin analysis,

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the Campanian/Maastrichtian boundary, etc.

The present study reports the first data on the taxonomic composition and distribution of microfauna assemblages in four sections of the Aures Basin. The foraminifera and ostracods are well preserved, diverse and numerous, which rules out the possibility of their redeposition. The ostracods are used to indicate the overall paleogeographical setting during the Santonian-Paleocene interval. The degree of dispersal of marine ostracods is generally low, since the larvae are usually benthic and rarely pelagic, while adult ostracods preferentially live on carbonate platforms in low-energy environments. Thus, the ostracod assemblages can differ greatly from one sedimentary basin to another and can be used to define different sedimentary areas and/or zoogeographical or palaeobiogeographic provinces, although their communities are limited by latitude and subject to surface ocean currents. The study of fossil assemblages helps delimit the various sedimentary areas and reveals their possible communications. Indeed, the main objective of this study is the reconstruction of global paleobiogeographic maps, showing the faunal relationships between the different regions or countries, based on the spatial distribution of the recognized Algerian species during the Santonian, Campanian, Maastrichtian and Paleocene.

1.1. Geographical and geological setting

The Campanian–Maastrichtian marine deposits of Algeria are well exposed in the basins of the Atlasic Domain, located in the foreland of the Alpine belt, including the Saharan Atlas and the Preatlasic zone (Fig. 1A). The Oulad Nail, Ziban and Aures-Nementcha ranges form the eastern part of the Saharan Atlas, extending to the northeast towards the Mellegue Mountains and further eastwards into the Tunisian Atlas.

This study is based on four sections (Fig. 1B) exposed in the Eastern Saharan Atlas. The first three are located in the Aures Basin, between the provinces of Biskra: El Kantara section (geographical coordinates GPS = 35°13′57″ N and 5°42′6.93″ E) and Batna: Menaa (GPS = 35°11′08.44″N and 5°59′42.00″E) and Tighanimine (GPS = 35°9′30.19″N and 6°14′29.03″E) sections. The fourth section: El Gaâga (GPS = 35°24′38.6″N and 7°50′17.99″E), located in the province of Tebessa, is presented for purposes of comparison.

The main stratigraphic, sedimentological and structural studies of the Upper Cretaceous successions of the Saharan Atlas and Aures Basins are due to Laffitte (1939), Dubourdieu (1956), Bertraneu (1955), Cruys (1955), Emberger (1960), Guiraud (1973, 1974, 1975), Vila (1980), Bureau (1986), Kazi Tani (1986), Aissaoui (1985), Ghandriche (1991), Addoum (1995) and Herkat (1999).

The Auresian Domain represents the eastern part of the Atlasic Basin, which extends into Tunisia as the Tunisian Atlas (Fig. 1A). The regional paleogeography of the Aures Basin consists of three main domains characterized by a progressive deepening from southwest to northeast. The proximal to intermediate ramp corresponds to a depositional environment with a predominance of alternating marls and limestones generally containing benthic biota. The distal ramp and transition to the basin are characterized by open marine deposits. These latter consist predominantly of marls with benthic and plankticforaminifera, with some locally developed organic-rich pelagic limestones marking the transgressive intervals. The basin itself contains pelagic deposits consisting of marls with planktic foraminifera (Herkat & Guiraud, 2006).

The Aures Basin is characterized by a system of tilted blocks bounded by NW–SE to WNW- ESE-trending faults. Otherwise, NE–SW faults located within the basin are characterized by transtentional movements. During the Campanian–Maastrichtian, the structural evolution in the Aures Basin led to the development of slumps with slip parallel to the dip of the structure limbs, as seen in the upper Maastrichtian formations of the Tebessa Mountains. Also, progressive unconformities of Paleogene on top of the Maastrichtian are developed on the southern flank of the Djebel El Azreg anticline. These features suggest the onset of folding in the Aures anticlines at the end of the Cretaceous. A Palaeocene sedimentary break is observed at Djebel Azreg, in the central zone of the Aures Massif, with the Eocene unconformably overlying the Maastrichtian, whereas farther west this stage is recognized at Djebel Metlili, in the northern part of the Ziban range (Belkhodja & Bignot, 2004).

1.2. Research history

Few biostratigraphic studies have been carried out in the Cretaceous of the Aures Massif (Algeria). The majority of these studies dealt with the Cenomanian-Turonian stages (Benkherouf, 1988; Grosheny et al., 2008; Herkat, 2005; etc.). Laffitte (1939) carried out a general stratigraphic study of the Aures Basin, noting that the Campanian–Maastrichtian boundary is located below the biozone with *Noctoceras polyplocum*. Herkat (1999) showed that the definition of this boundary depends on the correlations used.

The Cretaceous-Paleogene boundary of the Ellès section has been studied in Tunisia by Saïd (1978), who presented her findings in a thesis. This author analysed the limestone-marl alternations at the top of the upper member of the Abiod Formation, along with the marls at the base of the El Haria Formation. Saïd (1978, pp. 11–15) observed the presence of the planktic foraminifera "*Globotruncana stuarti*, *falsostuarti*, *gagnebini* (= *aegyptiaca*), *arca*, *contusa-patelliformis*, *fornicata*, *linneiana*, *ventricosa* and *Rugoglobigerina hexacamerata*", an association characterizing the "lower Maastrichtian", near the top of the upper member. This author also noted that no "*Radotruncana calcarata*" were reported in the marls of the El Haria Formation.

In more recent studies of exactly the same section as discussed below, Li and Keller (1998) and Li, Keller, and Stinnesbeck (1999) state that, in the Ellès section, the upper limit of the "*Radotruncana calcarata*" Zone (the Campanian–Maastrichtian boundary according to these authors) is near the top of the "limestones" that should represent the upper member of the Abiod Formation.

In 1995, at the Brussels Symposium on Cretaceous stage boundaries, the International Subcommission on Cretaceous Stratigraphy recommended the choice of the former quarry at Tercis as the location of a GSSP (Global Standard Stratotype, Section and Point). This GSSP – named PSM (Point Stratigraphique Mondial) by Odin, Gardin, Robaszynski, & Thierry, 2005 – was used to define the Campanian–Maastrichtian boundary (Rawson, Dhondt, Hancock, & Kennedy, 1996), adopting a proposal by the Working Group on the Maastrichtian. In February 2001, the decision was ratified by the International Union of Geological Sciences (*in* Odin & Lamaurelle, 2001).

At the same time, an important monograph volume was published presenting a multi-disciplinary characterization of the Campanian–Maastrichtian transition at Tercis (edited by Odin, 2001), followed by several notes summarizing the main results (Odin, 2002; Odin & Lamaurelle, 2001; Robaszynski, 2002). The Tercis section is interesting because it contains coexisting groups of paleontological key species (ammonites, planktic foraminifera, nannofossils, dinoflagellates, ostracods, etc.) in a continuous limestone succession. Among the biostratigraphic criteria, we refer to those involving ammonites and planktic foraminifera