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Stratigraphie

Modèle de sédimentation au passage Cénomanien/Turonien pour la formation Bahloul en Tunisie

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Résumé

Plusieurs études multidisciplinaires ont été effectuées sur les couches riches en matière organique (MO) de la formation Bahloul. Nos études de terrain et les synthèses géologiques, géochimiques, isotopiques et minéralogiques disponibles ont permis d'apporter des précisions nouvelles d'ordre paléogéographique et paléocéanographique. Ces données ont contribué à l'élaboration d'un modèle de dépôt sous une zone à minimum d'oxygène (ZMO) dans des bassins marins profonds et subsidents de type bathyal, où se sont accumulées et préservées d'importantes quantités de MO (jusqu'à 18,7 % de COT). Le présent modèle a permis la corrélation de la formation Bahloul à d'autres coupes de référence à l'échelle globale, ce qui permet de mettre en évidence que le $\delta^{13}C$ mesuré sur MO serait un meilleur outil de corrélation que le $\delta^{13}C$ mesuré sur carbonates pour reconnaître la limite Cénomanien/Turonien. ***Pour citer cet article : M. Soua, N. Tribovillard, C. R. Geoscience 339 (2007).***

Abstract

Depositional model at the Cenomanian/Turonian boundary for the Bahloul Formation, Tunisia. Several multidisciplinary studies were undertaken on the Cenomanian/Turonian organic-rich Bahloul Formation. These studies, as well as our new data, led to some new palaeogeographic and palaeoceanographic interpretations. Based on these data, a depositional model was elaborated, pointing out that at the C/T transition an oxygen minimum zone (OMZ) impinged onto the South Tethyan margin through the Tunisian intrashelf basins formed during Early Cretaceous. This model allows correlating the Bahloul Fm. to other OAE-2 formations throughout the world. It also indicates that the $\delta^{13}C_{organic\ carbon}$ seems to be a better correlation tool than $\delta^{13}C_{carbonate}$. ***To cite this article: M. Soua, N. Tribovillard, C. R. Geoscience 339 (2007).***

Mots clés : Formation Bahloul ; Géochimie ; Stratigraphie ; EAO-2 ; Cénomanien/Turonien ; Matière organique ; Modèle de dépôt

Keywords: Bahloul Formation; Geochemistry; Stratigraphy; OAE-2; Cenomanian/Turonian; Organic matter; Depositional model

Abridged English version

During the Late Cenomanian–Early Turonian Oceanic Anoxic Event (OAE-2 or Bonarelli event), organic-

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rich black shales were deposited worldwide, coinciding with the strong transgressive period during the Uppermost Cenomanian. New ecological niches were created and favoured intense biological proliferation that induced a massive organic matter (OM) production in surface water [1,10,12,13,19,23]. An oxygen minimum zone (OMZ) impinged onto the South Tethyan margin, where the organic-rich Bahloul Formation (Fig. 1A) is the expression of the OAE-2 event in north-central and south-central Tunisia. Consequently, a great quantity of OM has accumulated in different basinal environments [1,2,5,8,9,22,23,25]. The sealing of Lower Cretaceous structures during a distensive regime has persisted and formed graben systems that promoted organic-rich strata deposition throughout Upper Cenomanian to Lowermost Turonian times (Fig. 2).

Palaeogeographic interpretation suggests that the Bahloul facies distribution is limited to the intermediate deep water mass and could correspond to an OMZ sedimentation environment (Fig. 2) towards the South Tethyan margin [5]. Generally 20 to 30 m thick in average, the Bahloul deposits are composed of dark laminated limestones, alternating with light-grey indurated marls (Fig. 3). This alternation is considered as the expression of a climatic Milankovitch-type cyclicity recording 20-kyr precession [13], which correlates with $CaCO_3$ fluctuations. These deposits correspond to high TOC values, reaching 18,7% [1]. The Bahloul was deposited during the Uppermost Cenomanian (upper part of the *Rotalipora cushmani* Zone) to the Lowermost Turonian (either top *Whiteinella archaeocretacea* Zone or base of *Helvetoglobotruncana helvetica* Zone), and corresponds largely to a basal transgressive system tract (TST). All the studied sections in Tunisia show that its base belongs to either a lowstand system tract (LST) or shelf margin wedge (SMW) [18,23,27].

A triple subdivision (referred to as peaks I, II and III) was based on small variations in the C-isotopic profiles that develop in the majority of the isotopic curves ($\delta^{13}C$) of all the studied sections and are pointed out by several authors [2,5,6,25]. In all the studied sections, except for the Gafsa area, where no foraminiferal studies were performed, the first isotopic excursion (I) always precedes the specialized keeled rotaliporids LO (Figs. 3 and 4). The second isotopic excursion (II) generally occurs above the last occurrence (LO) of *Rotalipora cushmani* and the third one (III) just below the appearance of the *Quadrum gartneri* nannofossil zone marker (Fig. 4). The Cenomanian/Turonian boundary occurs usually slightly above the maximum $\delta^{13}C$ values [19]. Our results also indicate that the $\delta^{13}C_{\text{organic carbon}}$ seems to be a better correlation tool than $\delta^{13}C_{\text{carbonate}}$ for the C/T boundary (Fig. 4).

Nannofossils assemblages [10,25] are characterized by a low diversity, assigned to a combination of hostile conditions and dissolution during the Bahloul deposition. The palaeoecologic data suggest that the C/T deposits in Tunisia were restricted to a bathymetric belt, which corroborates the installation of a small OMZ in North-Central Tunisia and locally in the Gafsa Basin (Fig. 5). This OMZ is marked by decline in the planktonic foraminiferal diversity [29]. These forms are mainly represented by globular forms (*Guembelitria, Whiteinella, Heterohelix, Hedbergella*). The organic-rich Bahloul provinces are characterized by a type-II marine kerogen (IH between 200 and 700 mg HC/g TOC) [22] and TOC values reaching 18,7% [1], indicating excellent hydrocarbons source rock-quality. The OM thermal maturity presents a rather homogeneous distribution, with T_{max} ranging between 430 and 500 °C (Fig. 1B).

In this synthesis dealing with the worldwide OAE-2 expression in the southern Tethyan margin, i.e. the Bahloul Fm., the organic-rich C/T deposits are distributed into three different areas (Fig. 1A), corresponding to small palaeobasins sealed by several palaeohighs (Fig. 2). The established $\delta^{13}C$ isotopic triple subdivision may be used as a high-resolution correlation tool in a global scale (Fig. 4). The depositional model carried out in this work shows that the OM distribution followed the existing paleogeography during the C/T interval (Fig. 5).

1. Introduction

Les événements anoxiques océaniques (EAO) représentent des intervalles de stockage du carbone organique à l'échelle globale. Le terme EAO, proposé par Schlanger et Jenkyns [27] s'applique aux épisodes de distribution globale des *black shales*, laminés et riches en matière organique (>1 % pondéral de carbone organique total ou COT), enregistrés dans des séquences pélagiques de la partie médiane du Crétacé et plus particulièrement, celui d'âge Cénomanien/Turonien *EAO-2* ou *Bonarelli event* [21,27,28]. Les épisodes majeurs de stockage de matière organique (MO) en domaine marin retentissent sur la composition isotopique du C de l'eau de mer, qui conditionne à son tour la composition isotopique des substances qui s'y forment : carbonates et MO marine [2,15]. En l'occurrence, l'EAO-2 correspond, dans plusieurs coupes à travers le domaine téthysien, à une augmentation du $\delta^{13}C$, observée sur les carbonates (+2,5 ‰ en moyenne) comme sur la MO (+4 ‰ en moyenne) [2,19,20,28,30]. Le calibrage biostratigraphique de la